LUMBERJACK MOTORSPORTS

SAE Mini Baja
2017-2018

Front End, Rear End, Drivetrain, and Frame Teams

October 2, 2017

Project Description

- Society of Automotive Engineers (SAE) sanctioned event.
- The competition is broken down into multiple design and dynamic events where the team will be graded based on performance.

Dynamic Events

- Maneuverability
- Hill Climb
- Acceleration
- Rock Crawl
- Endurance

Design Events

- Sales/Cost Presentation
- Design Evaluation

- Sponsors for the competition include: SolidWorks, Honda, Briggs and Stratton, Polaris, Cummins, Volvo, Space X, ANSYS, and more.

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Customer and Engineering Requirements: Design Requirements

- Collegiate teams are tasked with designing and building a single – seat, off road prototype vehicle capable of handling difficult terrain including but not limited to rocks, logs, sand, mud, and shallow water.
- "The vehicle is to be a prototype for a reliable, maintainable, ergonomic, and economic production vehicle which serves a recreational use market, sized at approximately 4000 units per year." [1]

QFD

System QFD		
Project:	SAE Baja	
Date:	10/2/2017	

Correlation	
++	Strong Positive
+	Positive
	No Correlation
-	Negative
--	Strong Negative

	Wheelbase	Trackwidth	Ground Clearance	Horsepower	Torque	Weight	Strength	# of Parts	Turning Radius	Cost
Wheelbase										
Trackwidth										
Ground Clearance										
Horsepower										
Torque				++						
Weight	+	-								
Strength			+			++				
# of Parts						+	+			
Turning Radius	++	--								
Cost	+	-		+	+	--	++	+		

Technical Requirements

Customer Needs	Customer Weights	Wheelbase	Trackwidth	Ground Clearance	Horsepower	Torque	Weight	Strength	# of Parts	Turning Radius	Cost
Durable	9			7	1		4	9			
Maneuverable	5	9	7	8			7			9	
Reliable	10			5				8			
Maintainable	9								9		4
Velocity	6				9	7	7				
Acceleration	8				7	9	9				
Ergonomic	7			3					5		
Economic	8										9
Safety	10				4			9			
Lightweight	6	1	2				9	7	6		
Ease of Manufacturing	5						4		9		8
Inexpensive	4						7	7	5		9
Mass Producable	8						3		8		4
Technical Requirement Units		in.	in.	in.	ft-lbf/s	ft-lbf.	lb.	psi	#	in.	$
Technical Requirement Targets		58	50	11	40	TBD	315 w	TBD	TBD	108	20,000
Absolute Technical Importance	1719	51	47	174	159	114	311	321	281	45	216
ATI (percent)		2.97	2.73	10.1	9.25	6.63	18.1	18.7	16.3	2.618	12.565
Relative Technical Importance		8	9	5	6	7	2	1	3	10	4

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Front-End Preliminary Design

SAE Mini Baja 2017-2018

Zachary Rischar, Dylan Cappello, Reid Johnson

Customer and Engineering Requirements: Engineering Requirements

- Through meeting with our client and assessing past competition results/data, we created a list of goals we believed would result in a successful Baja vehicle.
- Using the rulebook and our customer's requirements as a guideline, we transformed these goals into five engineering targets.
    - < 10 foot turning radius
    - Maintain tire patch through body roll
    - Minimize tire scrub through articulation
    - Minimize bump-steer
    - 10”+ wheel travel

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Designs Considered (Suspension)

- Equal- and Unequal-Length Double A-Arms
- Twin I-Beam
- McPherson strut



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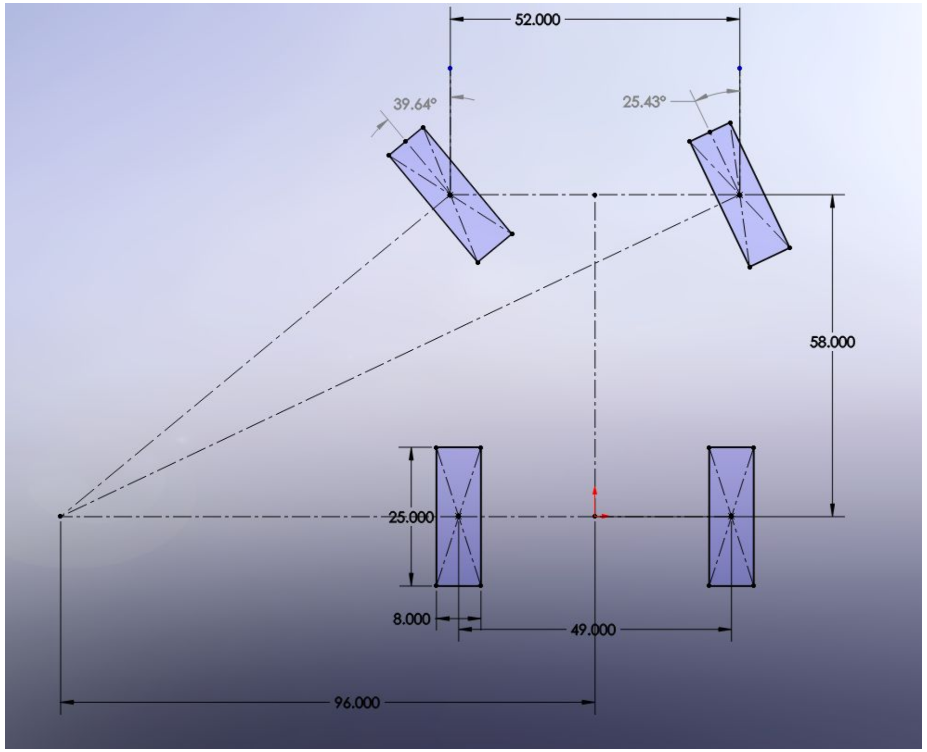
Designs Considered (Steering Geometries)

- Ackerman
  - Different Wheel Angles for inside and outside tires
  - Slow speed
  - Tight-radius maneuvering
- Parallel
  - Equal wheel angles for both outside and inside tires
  - High speed
  - Large-radius maneuverability
  - Causes outside tire to understeer heavily in cornering



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Schedule and Budget

Schedule

- Design for Frame Pickup Points: 10/16
- Spring Rate Calculations: 10/23
- Final Design in SolidWorks: 10/31

Budget

- Machining: $2000
- Material: $800
- Hardware: $200
- Shocks: $2000
- Rack and Pinion: $500

- Total: $5500

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Rear-End Preliminary Design

SAE Mini Baja 2017-2018

Marco Sliva, Brooks Grivet, Jordan Sundin

Customer and Engineering Requirements: Engineering Requirements

- Through meeting with our client and assessing past competition results/data, we created a list of goals we believed would result in a successful Baja vehicle.
- Using the rulebook and our customer's requirements as a guideline, we transformed these goals into five engineering targets
  - 0-5 degrees toe in
  - 0-12 degrees of negative camber
  - Rear Track Width 47-52 inches
  - At least 6" of travel
  - %5 - %15 Sag

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Designs Considered

- Trailing Arm
- Semi Trailing Arm
- Double Wishbone
- 4-Link
- 3-Link
- Solid Rear Axle



Moving Forward

- Rear End Geometry
- Brake Calculations
- Shock Location and Spring Calculations
- 3-D CAD Model

Schedule and Budget

Schedule

- Brake Design Calculations: 10/6
- Shock Mounting Locations: 10/6
- Spring Rate Calculations: 10/16
- Final Design: 10/31

Budget

- Less than $2500

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Drivetrain Preliminary Design

SAE Mini Baja 2017-2018

Rhyan Brogmus, Sam Hunker, David Woods

Engine

- Four-cycle, air cooled, Briggs & Stratton 10 HP OHV Vanguard Model 19
- Mechanical governor
- 305 CC
- 10 HP
- 3,800 RPM
- 57 lbs.

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Continuously Variable Transmission (CVT)

- Gaged CVT
- GX9 Loaded PLUS
- Enduro Belt PLUS
- GE/SS Back Shifter
- Final ratio 6.0-7.0
- Helical Gears

Engine (rpm)	3600															
CVT Ratio	1															
Reduction Ratio	Tire Size (in)															
Max Speed (mph)	16	18	19	20	21	22	23	24	25	25.5	26	26.5	27	28	29	30
30	5.711986643	6.425984973	6.782984138	7.139983304	7.496982469	7.853981634	8.210980799	8.567979964	8.92497913	9.103478712	9.281978295	9.460477877	9.63897746	9.995976625	10.35297579	10.70997496
32	5.354987478	6.024360912	6.35904763	6.693734347	7.028421064	7.363107782	7.697794499	8.032481217	8.367167934	8.534511293	8.701854651	8.86919801	9.036541369	9.371228086	9.705914803	10.04060152
34	5.039988214	5.669986741	5.984986004	6.299985268	6.614984531	6.929983795	7.244983058	7.559982321	7.874981585	8.032481217	8.189980848	8.34748048	8.504980112	8.819979375	9.134978638	9.449977902
36	4.759988869	5.354987478	5.652486782	5.949986086	6.247485391	6.544984695	6.842483999	7.139983304	7.437482608	7.58623226	7.734981912	7.883731564	8.032481217	8.329980521	8.627479825	8.92497913
38	4.509463139	5.073146032	5.354987478	5.636828924	5.91867037	6.200511816	6.482353262	6.764194709	7.046036155	7.186956878	7.327877601	7.468798324	7.609719047	7.891560493	8.17340194	8.455243386
40	4.283989982	4.81948873	5.087238104	5.354987478	5.622736852	5.890486225	6.158235599	6.425984973	6.693734347	6.827609034	6.961483721	7.095358408	7.229233095	7.496982469	7.764731843	8.032481217
42	4.079990459	4.589989267	4.84498867	5.099988074	5.354987478	5.609986881	5.864986285	6.119985689	6.374985093	6.502484794	6.629984496	6.757484198	6.8849839	7.139983304	7.394982707	7.649982111
44	3.894536347	4.381353391	4.624761913	4.868170434	5.111578956	5.354987478	5.598395999	5.841804521	6.085213043	6.206917304	6.328621565	6.450325825	6.572030086	6.815438608	7.05884713	7.302255651
46	3.72520868	4.190859765	4.423685308	4.65651085	4.889336393	5.122161935	5.354987478	5.58781302	5.820638563	5.937051334	6.053464105	6.169876876	6.286289648	6.51911519	6.751940733	6.984766275
48	3.569991652	4.016240608	4.239365087	4.462489565	4.685614043	4.908738521	5.131862999	5.354987478	5.578111956	5.689674195	5.801236434	5.912798673	6.024360912	6.247485391	6.470609869	6.693734347
50	3.427191986	3.855590984	4.069790483	4.283989982	4.498189481	4.71238898	4.926588479	5.140787979	5.354987478	5.462087227	5.569186977	5.676286726	5.783386476	5.997585975	6.211785474	6.425984973

$$\omega_{Engine} = \omega_{Wheel} \times R_{CVT} \times R_{Gearbox}$$

$$\omega_{Wheel} = \frac{63360 \times V_{max}}{D_{Wheel} \times \pi \times 60}$$

Drive Axle

- U-Joint

  - Low cost
  - Possibility of manufacturing in house
  - 30 degree maximum operating angle
  - Relatively tough
  - More constrained

- CV Joint

  - Higher cost
  - Outsource (RCV Performance)
  - Higher operating angles – up to 80 degrees
  - Higher efficiency
  - Extremely tough
  - More design flexibility

Schedule and Budget

Schedule

- Determine Gearbox Features: 10/2
- CVT Purchase: 10/6
- Design Joints/Axles: 10/22
- Design Gearbox: 10/22
- Final Design: 10/31
- On schedule

Budget

- CVT + Back-Shifter: $2100
- Custom Gears: $1000
- Axles and Joints: $600

- Total: $3700

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Frame Preliminary Design

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Koali'I Ladao, Richie Lonzaga, John Rankin

Background and Benchmarking

Current State of the Art

- 4130 Chromoly Steel Tubing
- Safety Standards
- Space Frame Concept

Existing Designs

- Front Braced Frame

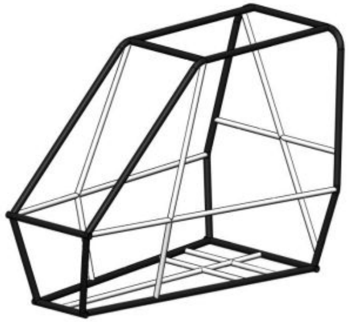
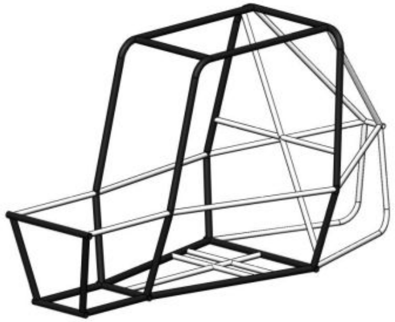


Figure B-3: Roll Cage, Primary Members (filled in black), Front Braced Frame

- Rear Braced Frame



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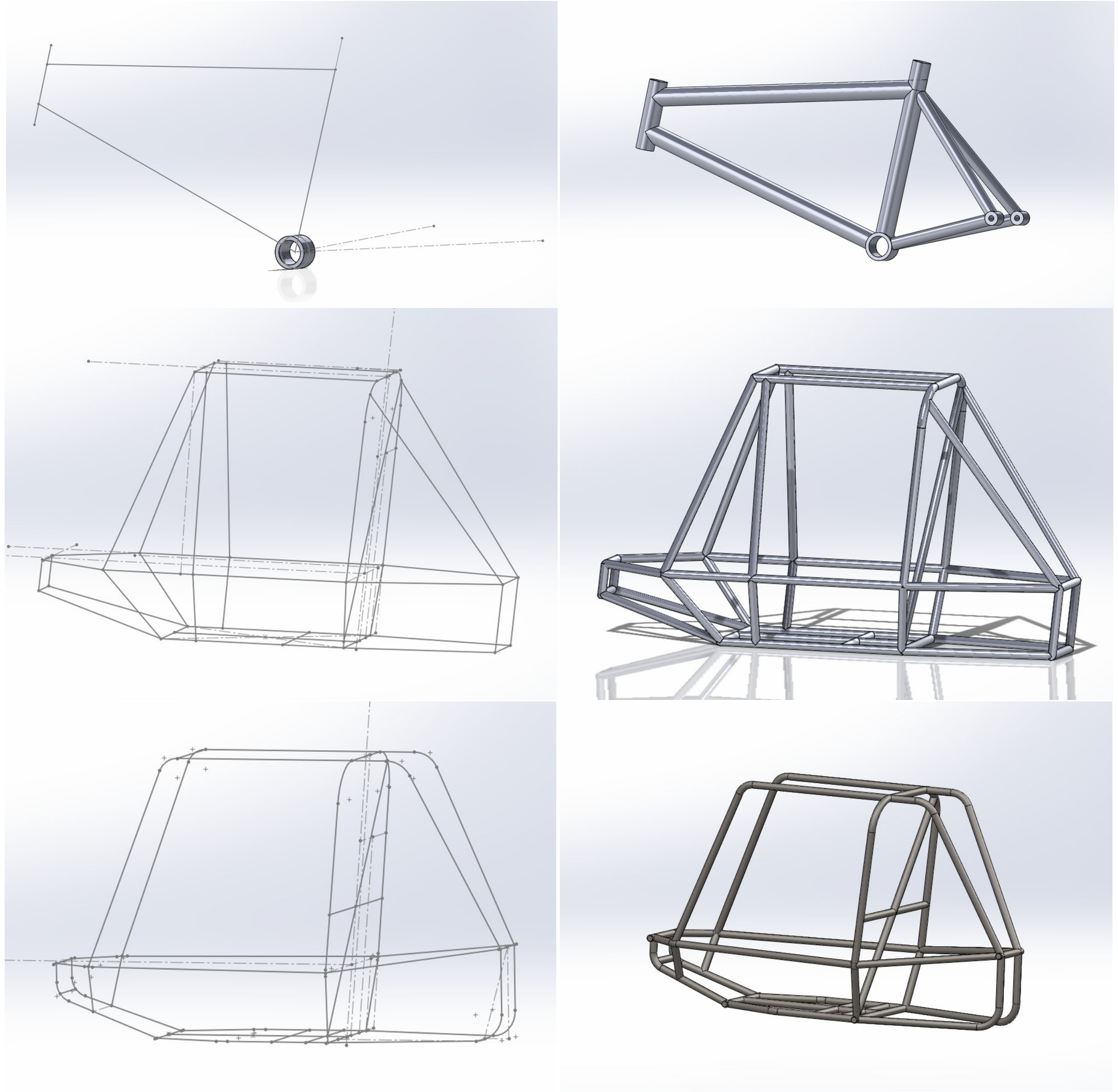
Customer Needs and Engineering Requirements

- Use of space frame concept (truss – like structure)
- Must maintain a minimum space around driver for ensured safety [1]
- Must be built out of steel tubing [1]
- Structure must be built to SAE Baja Rules and Specifications
- Total frame weight goal = 70-80 lbs

Concept Generation

- 1. Bicycle frames were used to introduce the use of the Weldments tool in SolidWorks
- 2. Rough Baja frames were then used to practice building complex frames in SolidWorks
- 3. Realistic Baja frames capable of giving valuable practice with ANSYS static and dynamic modeling
- 4. Future iterations of the frame will take information gained from the use of ANSYS to adapt and refine the design



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Design Consideration

Designs

- Front Braced Frame
- Rear Braced Frame

Advantages

- Rear braced frame allows for more room
- Better mounting options

Evolving Design

- Minimalistic design
- ANSYS / SolidWorks Dynamic FEA

Schedule and Budget

Schedule

- Oct. 13 – first iteration of FEA testing
- On schedule

Budget

- Total Frame Budget: $700
- Anticipated Expenses: $600
- Expenses to Date: $0
- Resulting Balance: $700

Preliminary Design

SolidWorks / ANSYS

- Smart design
- Reference Plane geometry interaction
- Creating custom tubing for weldments
- Importing SolidWorks file into ANSYS
- Seeing stress concentrations and deformations of frame
- Adapt design to improve performance
- Complete many iterations

Rules

- Must be followed perfectly or technical inspection will result in failure
- Restrict design but also allow for some decisions to be made for us
- **There are 20 pages of rules specifically for the frame of the BAJA**

Smart Design

- Design in a way that creates the least amount of merging errors when modifying frame design
- Create a design that mimics the way the frame will be built in real life allowing for the final design to act as a schematic
- Recognizing that the front suspension mounting structure, seat mounting, and engine mounts experience the amount of stress during impacts allows for us to design in a way that will accommodate it.

Our Interaction

Within the Team as a Whole

- FRAME design depends on the designs of the other sub teams, DRIVE, FRONT, REAR
- Ideas for different suspensions cause need for ideas for different designs
- Adaptations of FRAME designs to accommodate the developing vehicle

Within the Vehicle

- FRAME connects each design to create the final BAJA
- Protects the driver
- Mounting points for suspension , motor, and drive train

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Goals

Before Build

- Mastery of SolidWorks and ANSYS
- Use iterations to find the best tubing size
- Develop a factor of safety for the frame and ensure it will hold up during competition
- Mastery of the rules
- Fundraise ~ $22,000 to build a dream BAJA

By Final Design Build

- Ability to build and test a completely new FRAME design in SolidWorks / ANSYS within 6 hours
- Realize mounting points for each component based on other sub-teams final designs
- Final FRAME design gained by many testing iterations and improvements

Fundraising

Funding Sources

- GoFundMe Page
- Corporations (Honda, Toyota etc.)
- Small Businesses (Gaged CVT, Primo’s etc.)
- Personal contacts

Why Fundraise?

- Without enough fundraising the entire project will fail. If we cannot allocate the costs to create a basic BAJA then we will not go to competition.

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References

- [1] - Baja SAE Collegiate Design Series, Baja SAE Rules – 2018