SAE Mini Baja

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Team 19

Problem Formulation and Project Plan - Report

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1. Introduction

The SAE Baja project is initiated and sponsored by the Northern Arizona University (NAU) SAE group. The client and instructor in charge of the senior design project is Dr. John Tester, a Mechanical Engineering professor at NAU located in Flagstaff, Arizona.
The goal is to design, analyze, and build an off-road capable mini-baja vehicle for use in the SAE Baja Competition which will be held in El Paso, Texas.

2. Recognizing the Need

When concerning the suspension and steering portion of the SAE Baja project, the main objectives for improvement on the last Baja design are the maneuverability and weight reduction of the off-road vehicle. To accomplish these two main objectives, the suspension and steering team need to analyze the last design and find the elements that can be improved towards the design of the new Baja. More specific details with a statistical perspective will be explained in later sections such as the Quality Function Deployment section.

The client of the SAE Baja project has mainly requested that the maneuverability and the weight of the Baja be drastically changed because of maneuverability and weight of the Baja in last year's competition. This was because the weakness of the design was mainly in the large turning radius and the heavy weight of the Baja vehicle. While keeping the vehicle able to sustain rugged terrain by making a design for ample off-road suspension, the Ackerman angle among other geometries towards steering and suspension need improvement during design.

Not only will the drive train and the frame effect the weight reduction but it will also be a factor that can be affected by the design of the steering. So there are many options that need to be compared for the lightweight design versus maneuverability and durability. This decision will be analyzed statistically in the Quality Function Deployment portion of the report.

3. Defining the Problem

3a Goal

Goal Statement: To design an off-road racing suspension system for use in the CBaja competition.

Scope: The scope of the goal statement is to provide an inexpensive, durable off-road vehicle for use in the SAE Baja Competition. The vehicle will have a suspension system that will be able to handle varying terrain and obstacles as well as an efficient steering system.

3b Objectives

The objective is to design a suspension system, with steering, that can remain light while being durable, turn within 66% of the current vehicles turning radius and be able to absorb a 3ft drop without major damage to any component or driver. All while being relatively inexpensive to produce and competitive in an off-road race setting.

Objectives

- Increase individual component strength while decreasing weight
- Decrease turning radius
- Inexpensive to produce

Table 1: Objectives and Measurement Basis

Objective	**Measurement Basis**	**Units**
Inexpensive	Material cost and component manufacture should be within the groups budget for suspension	$
Turn within 66% of the current vehicles turning radius	Measure the full lock turning radius on the completed baja and compare to the current vehicles recorded turning radius	ft
Remain light	All individual components weight, combined, should not weigh more than the frame. Strength versus wall thickness will favor the lighter material	lbs
Components should be durable	Component strength will be based off of Ultimate Tensile Strength and Yield Strength	Psi

3c Constraints

3c.1 Relative to Client:

Relative to the client, the design for the suspension and steering are constrained by the following parameters. For the steering design, the team must design a functional steering system which will allow the driver to maneuver the vehicle. Also, the turning radius must be no more than that of the previously designed mini-baja (approx 15 ft). Furthermore, the weight of the steering system cannot exceed the weight of the previous steering system for the previously designed mini-baja.

For the suspension design, the team must design a suspension system that will be able to continue functioning after a 4ft drop.

3c.2 Relative to SAE rules:

The design of the mini-baja suspension is constrained by the rules of the SAE Baja Competition. These rules state that the maximum width can be no more than 64 inches. The suspension must be designed to have adequate ground clearance and traction in order to safely operate over rough land terrain including obstructions such as rocks, sand jumps, logs, steep inclines, mud and shallow water in any or all combinations and in any type of weather including rain, snow and ice. The suspension must also be designed to work for any driver from the smallest 5th percentile female to the largest 95th percentile male. This means that the suspension must be capable of supporting up to a 250lb person. The fabrication and assembly of the suspension and steering system must be done using the correct materials and fasteners as specified in the rules.

3.d Test Environment

In order to test the final product's off-road and racing capabilities the team will use two testing environments; a rugged environment with varying terrain and conditions as well as a man made race course that resembles the competition course in El Paso, Texas. The physical location of this 'real-time" testing has yet to be determined. Ideally, the testing environment should resemble the same type of climate and terrain characteristics as the competition site in El Paso, Texas.

Before physical testing of the final build various computer programs and analytical methods will be used. The computer simulation test environment will help the team test designs and find any flaws that will arise before a final product is built.

4. Quality Function Deployment and House of Quality

The following section relates the customer needs to the engineering requirements for the suspension and steering sub-systems of the SAE mini-baja vehicle. Figures 1 and 2 below show a Quality Function Deployment (QFD) and House of Quality analysis for these two sub-systems. These visual tools provide a better understanding for the design requirements that directly relate with the customer needs/requirements, and each other.

The QFD charts show the team's chosen engineering requirements and the effect they have on the customer requirements. Figure 3 shows the House of Quality diagram which relates the engineering requirements to each other, and the positive or negative influences they have on one another.

- (+) : positive influence
- (-) : negative influence

Suspension	Engineering Requirements for given design								
	Customer Needs	**Customer Weights**	Ground Clearance	Suspension Travel	Y.S.	Stiffness	Spring Rate	Cost	Weight
	1. Lightweight	10					3	3	9
	2. Maneuverability	10	9	9		3	9	3	9
	3.Relatively inexpensive	6		1				9	
	4. Must be safe	7	3	1	9	3		1	
	5. Must be durable	8			9	9		3	
	6. Transportable	8	3	3					3
		Raw score	135	127	135	123	120	145	204
		Relative Weight	14%	13%	14%	12%	12%	15%	21%
		Unit of Measure	in	in	in	lb	lb/in	$	ft
		Technical Target							

Figure 1 - Suspension QFD

Steering	Engineering Requirements for given design								
	Customer Needs	**Customer Weights**	Y.S.	Caster Angle	Ackerman Angle	Turning Radius	Cost	Bolt Shear Stress	Width
	1. Lightweight	10					3	1	
	2. Maneuverability	10		9	9	9			9
	3. Relatively inexpensive	6	9				9	3	
	4. Stable/safe	9		9	9	3			9
	5. Must be durable	8	9				9	3	
	6. Transportable	8				3			3
	Raw score		126	171	171	141	156	52	195
	Relative Weight		12%	17%	17%	14%	15%	5%	19%
	Unit of Measure		psi	degrees	degrees	ft	$	psi	lb
	Technical Target								

Figure 2 - Steering QFD

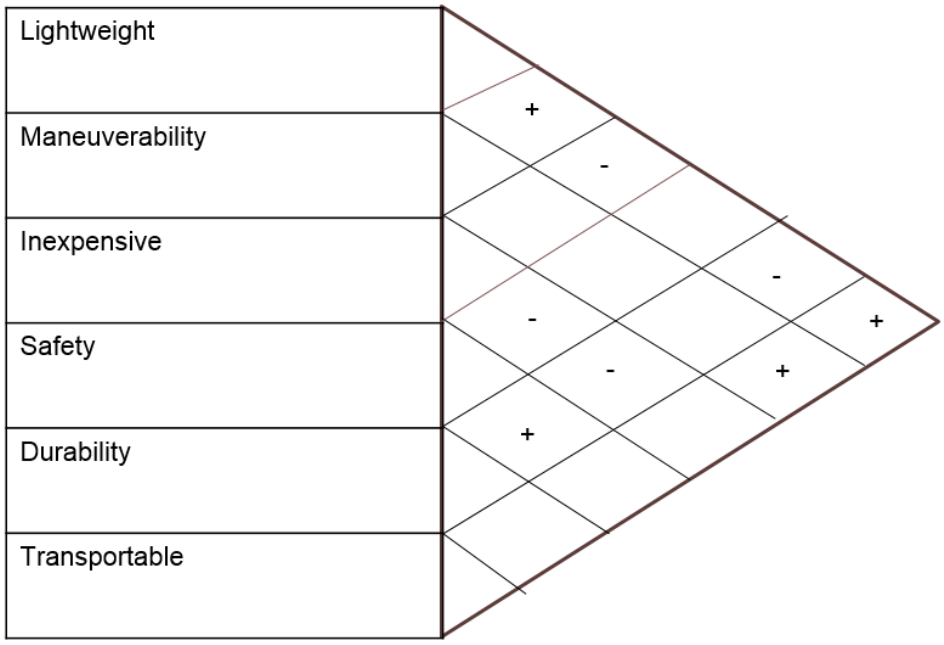


Figure 3 – Steering/Suspension House of Quality

5. Conclusion

In this report, the team stated "The Needs" of the project which then bridged onto stating the problem of the project. The project was broken up into four division: Goals, Objectives, Constraints, and Test Environment. The goals were defined by the needs provided by our client which we then set as objectives to follow for the project. With these objectives, the team was able to provide design constraints in order to satisfy the client/SAE's needs. Furthermore the team agreed on a test environment on which the mini baja would be used for our design. With the problem being defined, the team was able to create a house of quality and a quality function deployment in order to see what requirements were more important when designing the mini baja.

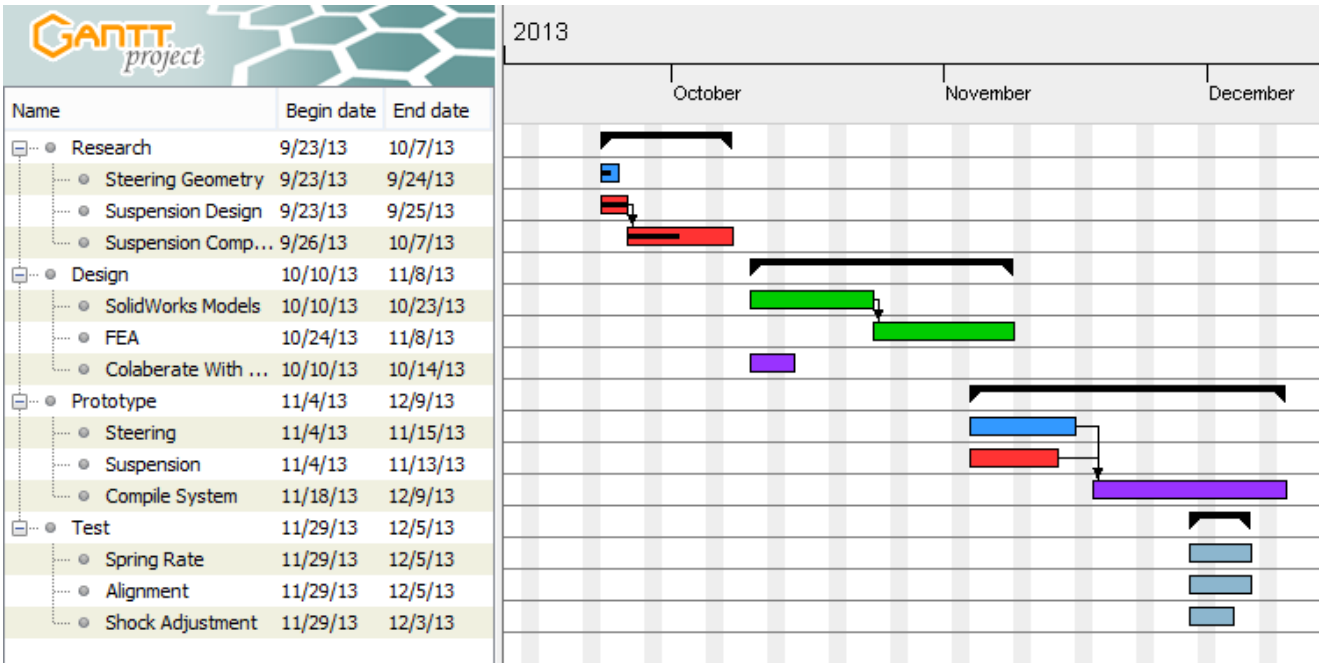
6. References

1.) 2014 Baja Rules
- SAE International 2014 Collegiate Design Series
  - Baja SAE Rules
    - http://www.sae.org/students/2014_baja_rules_8-2103.pdf

2.) Dr. John Tester

- College of Forestry, Engineering and Natural Sciences
  - **http://nau.edu/CEFNS/Engineering/Mechanical/Faculty-Staff/John-Tester/**

Appendix A


GANTT project
Name
Begin date
End date
Research 9/23/13 10/7/13
Steering Geometry 9/23/13 9/24/13
Suspension Design 9/23/13 9/25/13
Suspension Comp... 9/26/13 10/7/13
Design 10/10/13 11/8/13
SolidWorks Models 10/10/13 10/23/13
FEA 10/24/13 11/8/13
Colaberate With ... 10/10/13 10/14/13
Prototype 11/4/13 12/9/13
Steering 11/4/13 11/15/13
Suspension 11/4/13 11/13/13
Compile System 11/18/13 12/9/13
Test 11/29/13 12/5/13
Spring Rate 11/29/13 12/5/13
Alignment 11/29/13 12/5/13
Shock Adjustment 11/29/13 12/3/13
2013
October
November
December