2015-16 SAE Baja

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Section 3

Problem Definition and Project Plan

Document

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1. Introduction

Senior Engineering students at Northern Arizona University (NAU), are given a multitude of opportunities to demonstrate their knowledge related to engineering design and practices. One project in particular is the Mini Baja Project sponsored by the Society of Automotive Engineers (SAE) International, and advised by Dr. John Tester. This project in particular demonstrates engineering design and implementation related to the automotive industry through a competition between university groups from across the world.

1.1 Problem Statement

The automotive industry is one of the most competitive and discussed industries in the United States. Constant research and development for new and improved vehicles is required to keep this industry thriving. In order to pursue and develop new technology in an ever-expanding field, it is important to inspire upcoming engineers to learn the concepts related to the automotive industry. The Society of Automotive Engineers has recognized the importance in educating young engineers for the automotive industry and are challenging students from across the world to test their abilities by developing a mini baja vehicle for a worldwide competition.

1.2 Background

SAE International has had a presence at NAU for 15 years [1]. The following defines the role of SAE International with universities across the world: "SAE International is the leader in connecting and educating engineers while promoting, developing and advancing aerospace, commercial vehicle and automotive engineering" [2]. Since 1976, SAE has sponsored an annual Mini Baja competition, Dr. Tester has served as the advisor to the Mini Baja project at NAU since 2000 [1]. Under Dr. Tester's advisement the Mini Baja senior capstone group will propose and implement a design for competition as per SAE International rules and regulations.

2. Problem Statement

2.1 Problem Definition

The SAE club, advised by Dr. Tester does not have an operational mini baja vehicle to compete in the SAE competition. The goals of the SAE mini baja group, shown in Table 1 is to build an operational baja vehicle using the frame from last year's design that will place in the top ten for the SAE competition. In order to be successful the project must serve as a learning opportunity and inspire teamwork related to engineering design and practices.

Table 1: SAE Baja Goals, Objectives, and Constraints

Goals	Objectives	Constraints
Make Design Operational	Increase Acceleration	Fully Operational March 1, 2016
Learning Opportunity	Increase Speed	Minimum 2 forward gears and 1 reverse
Inspire Teamwork	Make Lightweight	Cannot exceed 108" in length of 64" in width
Re-use Frame	Improved Traction	Weigh between 400 and 800 lbs
	Make Safer	10 hp Briggs and Stratton engine
	Increase Ergonomic Capacity	

2.2 Design Objectives

To accomplish our goal of placing in the top ten at competition, the SAE baja team has established multiple objectives related to the performance of the vehicle. Based on the current state of the baja from last year's design, the mini baja group wants to increase the speed and the acceleration of the vehicle by improving the performance of the transmission. In order for the vehicle to be competitive the group wants to decrease the weight of the vehicle and improve the traction. Finally, group also wants to make the vehicle safer while also expanding the ergonomic capacity for the driver.

2.3 Design Constraints

From our objectives, and under the advisement of Dr. Tester, the team agreed on multiple constraints that will help guarantee the baja's success. To ensure completion and to provide adequate time for testing, the group must have a fully operational vehicle by March 1. Additionally, this fully operational baja must utilize a minimum of two forward gears and one reverse gear, must incorporate a standard 10 hp Briggs and Stratton engine, and cannot exceed 108 inches in length or 64 inches in width. In order to be competitive, the team is hoping to have a vehicle weight between 400 and 800 pounds.

3. Quality Function Deployment

3.1 Engineering and Customer Requirements

Given our objectives and constraints, we came up with customer and engineering requirements and created a Quality Function Deployment. These will influence our design choices while completing the mini baja. In addition, the Quality Function Deployment helps us see the relationships between customer needs and engineering requirements to make our mini baja competitive. Through our QFD we found that transmission, dimensions, factor of safety, and body weight are the most important engineering requirements that we want to focus on for our design.

3.2 House of Quality

The House of Quality (Appendix A) shows the correlation of each functional requirement in reference to the other function requirements. By referencing these to each other we are not

only able to see how they will directly impact each other but how influential they are to the project as a whole. For example Young's Modulus will be positively impacted by the thickness of the frame while causing the safety factors as well as the overall price to go. The bodyweight of the cart is affected by the dimensions of the baja. As the frame thickness and factor of safety rise with the body weight the speed is affected negatively which should analysed during the build. The negative correlation between the body weight and the transmission is due to the added stress that will be put on the transmission therefore causing a lower output efficiency. The transmission has a strong correlation with the speed of the baja because it is the direct linkage between the power output and movement. The dimensions of the cart are proportional to the frame thickness, exhaust pipe, as well as the overall cost. As the frame thickness is adjust the pricing of the project will change drastically. Although not initially guessed as a correlation , the stiffness of the suspension used affects the overall cost of baja , but more importantly the safety factor. A more expensive suspension design will cost more but will keep the driver safe while in a competition that is based off road with large obstacles and dropoffs. Last but not least, the engine power ,used in conjunction with the transmission, proportionally affects the speed of the baja which is crucial during the main races of the baja competition.

4. Project Plan

The mini baja capstone group has developed a project plan in the form of a Gantt chart, located in Table 2 of Appendix B, the Gantt chart is mainly composed of 4 parts. The first part is the problem definition and the project planning. During the first 4 weeks, we are to contact our clients and collect information, we also make the planning for the overall project. The second part is concept generation and selection, which is from week 5 to week 8. The team members are to apply the requirements and constraints to the actual design, do research and analysis, to find a solution to the problem. The third part is the concept prototype, which is from week 9 to week 12. During these 4 weeks, team members are starting to order materials and actually build the prototype. The last part is to write the project proposal, which is from week 13 to week 15. The task for the last 3 weeks is to finalize the project and test the Baja.

5. State of the Art

Due to the multiple features on the mini baja there are many state of the art components to analyze. However, the only factor currently disabling the baja is due to the transmission, therefore the capstone group has chosen to focus our state of the art research on improving the functionality of the transmission to get the gaja in working order.

5.1 Centrifugal Clutch

Uses a centrifugal spring mechanism to engage the motor with the drivetrain[5]. The centrifugal clutch is the simplest and cheapest of all the options. This clutch mechanism has many drawbacks. The clutch wears out very fast with higher horsepower motors such as the mandatory 10 horsepower one we are using. The clutch also restricts the baja to one gear ratio.

5.2 Continuously Variable Transmission (CVT)

The CVT uses belt driven pulley mechanisms to engage the engine to the drivetrain[3]. The CVT is slightly more complex than the centrifugal clutch, but is more applicable for our application. The CVT changes gear ratios as the baja increases speed. The CVT is also automatic and doesn't have to be shifted into gear. Some drawbacks of the this transmission are, high torque causes heat and belt damage[4], the driver can't select a certain gear ratio for an event, large amounts of slippage if any fluids get on the belt.

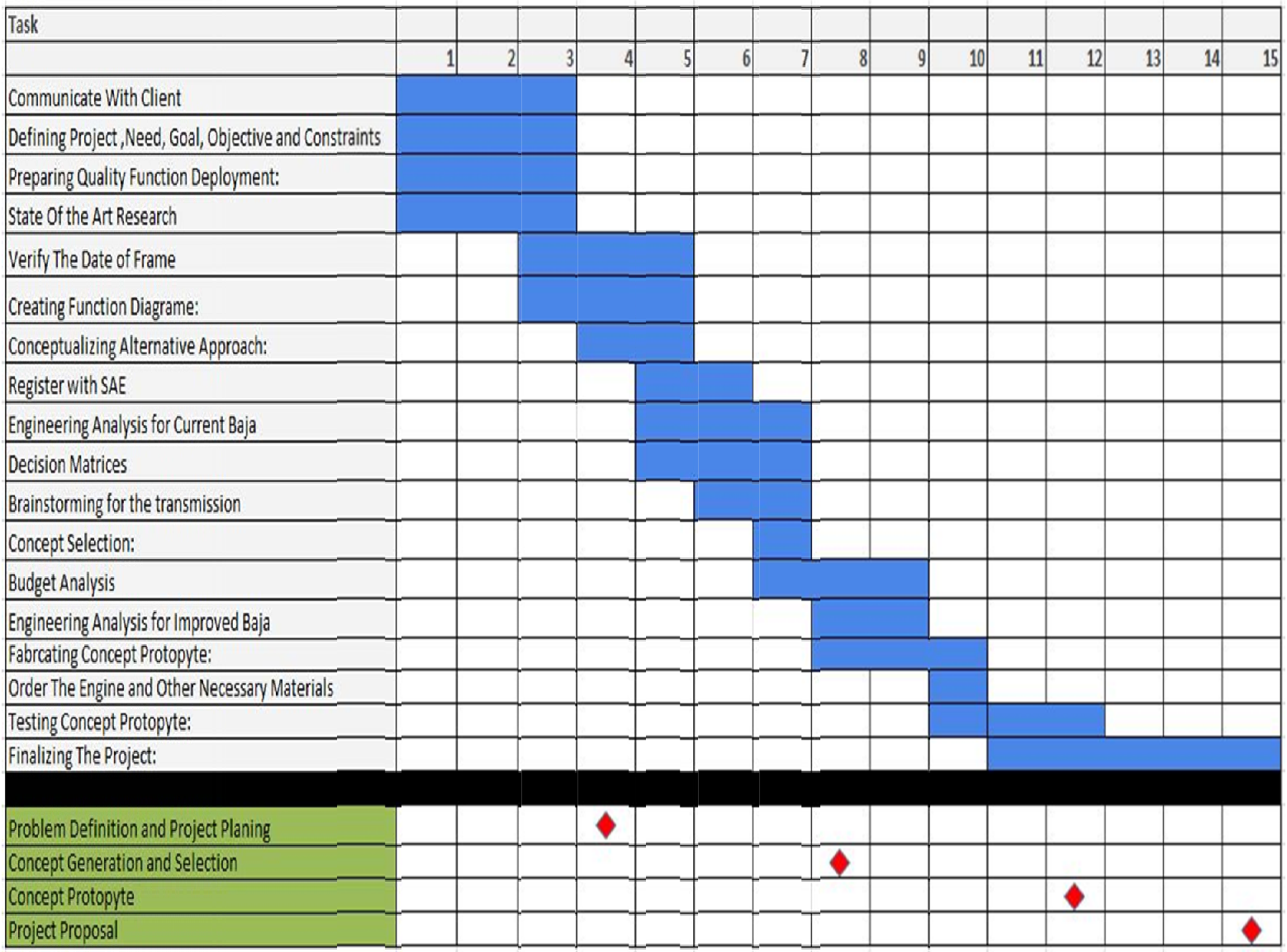
5.3 Sequential Gearbox

Our team has decided that the sequential gearbox is the best choice for the baja. The gearbox allows us to have a selection of drive and reverse gear ratios. We can implement a low gear ratio for acceleration and hill climb testing. It will also allow for higher ratios for the endurance and suspension test. This gearbox is also filled with fluids to keep the friction and heat down[5]. It is also serviceable with common supplies at any auto parts store. Some drawbacks of this transmission is that the gears are custom machined and the driver needs an understanding of using hand clutch and shifting levers while driving and maneuvering the course.

Appendix A

Appendix B

Table 2: Mini Baja Gantt Chart


Task
1
2
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Communicate With Client
Defining Project ,Need, Goal, Objective and Constraints
Preparing Quality Function Deployment:
State Of the Art Research
Verify The Date of Frame
Creating Function Diagrame:
Conceptualizing Alternative Approach:
Register with SAE
Engineering Analysis for Current Baja
Decision Matrices
Brainstorming for the transmission
Concept Selection:
Budget Analysis
Engineering Analysis for Improved Baja
Fabrcating Concept Protopyte:
Order The Engine and Other Necessary Materials
Testing Concept Protopyte:
Finalizing The Project:
Problem Definition and Project Planing
Concept Generation and Selection
Concept Protopyte
Project Proposal

References

[1] J. Tester, 'SAE Presence', EGR Building, 69, 2015.

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[3] Erickson, Wallace D. *Belt Selection and Application for Engineers*. New York: M. Dekker, 1987.

[4] Naunheimer, Harald. *Automotive Transmissions Fundamentals, Selection, Design and Application*. 2nd ed. Berlin: Springer, 2011.

[5] Panchal, D.. *Two and three wheeler technology*. New Delhi: Asoke K. Ghosh. 2015.