

A Thesis Presented to
The Faculty of Alfred University

Design and Manufacturing of a Baja Vehicle

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Introduction

Many consider the automobile to be one of the most influential and shaping inventions of the modern world. When one pictures a modern civilization they will most likely picture tall buildings and busy roads full of cars. Vehicles of all kinds are essential to the function of most of our everyday lives. Trucks are used to transport goods from factories to warehouses and on to stores. Public and private transportation is so fundamental to life in a contemporary society that any obstruction to this can lead to the shutdown the society's functionality. Beyond being a staple of the world we inhabit, vehicles serve as a complex example of the application of many areas of engineering.

Designing and building a complex vehicle of any kind serves as a daunting task. With this premise in mind, it was the intention and decision of the Saxon Racing Team to take on this task in the fall of 2016. The team would design, build, and test an off-road vehicle for entry into the 2017 Society of Automotive Engineer's Baja competition. The objective of this competition is to build an off-road vehicle under strict criteria from the SAE committee. Vehicles are then pitted against one another in various events to determine the overall best design. The team at Alfred consists of twenty-two seniors from Alfred University as well as numerous underclassmen. Most members are working on completing their Bachelors of Science in Mechanical Engineering. As project advisors, Dr. Joe Rosiczkowski and Jim Mighells guided and assisted the team members in their endeavor.

It was determined that the most efficient method of working on the design of the vehicle would be to construct teams for the various elements and systems. Each team was

tasked with researching and developing a design for components that are necessary for the proper function of their system. The teams that were formed are: Suspension, Maneuverability, CAD, Drivetrain, and Logistics and Safety. Each team was then assigned a team leader that would be responsible for reporting findings to the project advisors and other team leaders. The remaining students were then assigned to or chose a group with which they would be working.

The Suspension team was vital to the completion of designing a first-rate vehicle. Much of the design of surrounding components relies on the suspension system. This team was able to obtain an academic license of Lotus' Suspension Analyzer software. Using this software, they were able to test the system they had designed to verify that it would be successful.

It was the responsibility of the Maneuverability team to design the areas of the car that would make it agile and drivable. Steering and breaking were two of their main foci as those had the most influence on how the vehicle performed in certain events. Much of the design work done by the maneuverability team was completed through hand calculations and the use of Solidworks for the 3D design of the components.

As with any engineering project, simulation and modeling was essential to the success of the Baja project. These were the responsibility of the CAD team. This team assisted other teams in the modeling of components using Solidworks as well as completing the modeling of vital areas of the vehicle that other groups were not tasked with, such as the frame. The CAD team also conducted and aided in the use of Finite Element Analysis on many areas of the vehicle.

The Drivetrain team was tasked with designing and implementing the components of the vehicle that connect the engine to the tires and relating to the engine itself. The main priority of the team was the gearbox which would be a keystone of the completed vehicle. The completion of this vital component was incredibly important to the overall functionality of the Baja vehicle.

Logistics and safety may not be directly related to the design of the vehicle, but is nonetheless important. This team was responsible for making sure that the team followed all of the safety rules that the competition mandates as well as arranging travel to the competition. As the competition that the 2017 team competed in was held in Southern California, this was a very necessary task.

As well as the tasks and objectives of the individual groups, the team as a whole had objectives that they wished to complete. The engine for this competition is universal for all teams entering. Furthermore, there is a restriction on the maximum rpm a team can achieve. This means that the power output from the engine will be the same for all teams and they must design to maximize its use. Beyond the drivetrain being as efficient as possible, one of the simplest ways to maximize the use of this power is to reduce the weight of the vehicle. By reducing the mass of the Baja, the acceleration is increased substantially. It is for this reason that weight reduction was an important objective of the team. There were many methods of reducing the weight of the vehicle. Material selection was crucial. Finding materials that could withstand the various requirements of the components on the Baja while still weighing as little as possible served to be a challenge. The use of certain materials such as carbon fiber had to be

limited to reduce the price of the completed vehicle. Aluminum proved to be the optimal choice for many parts as it was cheap, strong, and light. Another method of weight reduction was being as efficient as possible with the material used. This meant designing methodically such that the parts would serve multiple purposes where possible and use as little volume of material to achieve the purpose as allowable. This also meant making challenging decisions. For many parts, a balance between factor of safety and strength of the part had to be reached. Often times it was the decision of one or more members of the team as to what this balance should be. The team achieved this through the use of hand calculations and software analyses to verify that parts would sustain the abuse of use in the vehicle while at this reduced volume.

Another main objective of the team was to design and produce as much of the vehicle as possible. Previous teams have used aftermarket or found parts extensively on their vehicles. This limits the design possibilities as the custom parts must mate to the pre-made parts. It also reduces the efficiency of the systems as the parts are not optimized to perform their task. Furthermore, these parts often weigh more as they are excessive for the use in a Baja vehicle. Designing and building the parts from scratch allowed the team to use parts that had as close to the ideal parameters as possible. The vehicle created uses more custom parts than it does aftermarket parts.

Perhaps the most important goal of the 2017 team was to improve over last year's team. The results of the 2016 team's vehicle were poor. They placed among the lowest positions and failed to compete in some competitions all together. It brings satisfaction and pride to the engineering department and Alfred University as a whole when a team succeeds in

a national competition. This is why it was important to the team to do as well as they could and earn a position among some of the most prestigious engineering schools as a competitor.

The Baja vehicle made by the 2017 Saxon Racing team was designed with an emphasis on weight reduction and the extensive use of custom parts. Each member of the team had their own responsibilities as well as sharing some responsibilities with the rest of the members. As each team member researched and designed within their assigned areas, they became specialized in those areas. It is not by any means an easy task designing and assembling a complex vehicle. This task is only made more difficult when parameters are added that must be met. Knowing this, the 2017 Saxon Racing team embarked on and accomplished this task.

The vehicle designed and built by the 2017 Saxon Racing team competed in Gorman, California in the SAE Baja Competition. It placed 25th out of 92 teams. This is an incredible improvement over last year when the team placed in 93rd place. It was not a simple task to design and build an off road vehicle within the restrictions set forward by the SAE committee, but the team nevertheless achieved it. A main goal was to reduce the weight of the vehicle when compared to previous years'. The completed vehicle this year weighed in at 380 pounds compared to last year's vehicle which weighed over 500 pounds. This weight savings was accomplished through many techniques on of which was the thorough designing and custom building of many parts. Increasing the number of parts on the vehicle that were custom designed and built was a second goal of the team. The number of parts on this year's vehicle that were designed and manufactured by the team was 18. Compared to last year, this number is more than tripled as the Baja from last year contained only five custom parts.

The 2017 Saxon Racing team worked tirelessly through the 2016-2017 academic year to bring to life a vehicle that would make them and their supporters proud. They encountered difficulties along the way, but managed to overcome them in creative, intelligent, and often unorthodox ways. The members of the team have learned very much from each other and many resources during the completion of this vehicle. The team set out on a journey in the fall of 2016 that took them to places that they did not expect, but ultimately, they finished where they intended.