2021 SAE Baja #20F01

ME486C-01

ME476C Team Postmortem Analysis

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Introduction

After the Baja team's first semester, it is important to look back and reflect on how the team performed. This allows the team to identify areas in need of improvement and adjust accordingly in the second semester. There are multiple factors that will affect an overall team's success. These factors will be discussed within the body of this postmortem.

Contributors to Project Success

At the beginning of the semester, our team discussed our purpose and goals in our team charter. Reflecting on whether our team achieved our purpose and goals, our team can see that the work we put into semester one has set us to be on track during this semester. We had desired to begin manufacturing based off a team assembly in Solidworks by the end of last semester, and we accomplished that. Our purpose is to successfully design a vehicle to compete in the 2021 SAE Baja competition, and we are still on track to do so as well.

The most critical ground rule that our team developed in the team charter is the importance and need for effective communication. As a result, our team used Google Hangouts for a quick way to communicate across any cellular device, and that has shown to work for our team. We also agreed to use Microsoft Teams as a collaborative space to upload and edit our work, as well as hold virtual meetings.

There were a few areas in which project performance by the team was carried out well. All members would show up to weekly set team meetings outside of our capstone class. In these meetings, sub team leaders would update the team on each subcomponent's progress, as well as discuss what they wish to accomplish in the near future. After each sub team lead updated the group on where their team was at to allow for better integration down the road, the sub teams would usually break off to discuss and work on specific subcomponents. These weekly team meetings have helped the team to stay consistently in touch. Furthermore, most of the team would put in many hours to working on their sub-components which made beginning the manufacturing process quite natural and smooth. Although complications arise as our team progresses, it is important that our team began manufacturing early. Another pro to our team beginning the manufacturing process early was taking advantage of the resources provided to us by the school. By also beginning the process of ordering parts early on, our team realized the amount of hiccups and jumps we would have to make in order to successfully place any order. It hasn't been a smooth process, however since we began the process early on, we were able to realize this sooner rather than later.

What specific technical lessons did you learn?

During the first semester, the Baja team had designed well over 300 parts for the Baja vehicle. Throughout these designs, we learned and implemented a large amount of technical knowledge. The first lesson that became the most critical early in the design process was material optimization and the associated weight savings. Using Solidworks shape optimization features and engineering fundamentals learned in mechanics of materials and solid mechanics, each sub-team reduced weight by cutting lightening holes and implementing truss-like structures in each part design. For example, although previous Baja teams have always made mounting tabs from a solid piece of steel with a fully enclosed loop, our team decided to reduce the weight by only using a half circle to mount onto the frame. Additionally, after using the Solidworks shape optimization features, it was determined that the central material in the tabs was not necessary to the overall strength of the design and it was also removed.

The team also experimented with strength of materials by running analyses on vital components using various materials. During shaft analysis of the gearbox, the drive train team concluded that, although specific components needed to be manufactured out of 300M alloy steel, several shafts could be manufactured out of titanium for a similar strength at a significantly lighter weight. Additionally, although chain drive systems would typically use steel sprockets, after analyzing the difference in material properties versus applied load, the drive train team decided to use aluminum sprockets which would lead to a reduced safety factor but a lighter-weight system.

By using finite element analysis (FEA) tools, the front and rear end suspension teams learned that suspension components were much stronger when tube members were only subjected to tensile and compressive loads. The front-end team implemented triangulated control arms that reduced the bending and torsion forces experienced by the tubes and instead directed forces in parallel load paths. FEA could then validate the designs by applying specific load cases and determining factors of safety.

Through the first semester, we had all utilized the Finite Element Analysis tools in Solidworks to both validate and improve various components for this project. These tests have aided in saving weight, where we could retain the relative strength of various parts while removing material and weight. This had also validated the strength behind the design of the chassis, by applying exaggerated loads throughout the chassis for various scenarios that may be encountered.

Opportunities/Areas for Improvement

Some problems which the team encountered were specific sub team designs would interfere with another design feature due to multiple constraints on the Baja. Things such as spacing and frame positioning would strongly determine a specific design and both sub teams involved would collaborate with one another and determine a proper solution to the challenge. For example, with the vehicle being four wheel drive this year, there are many components such as driveline, steering rack, pedals, and brake reservoir that need to be held in the nose of the vehicle. These pars have a high chance of interfering with each other in such a small space. We know as a team that these challenges will continue to occur as we began our manufacturing process and with maintaining proper communication and collaboration the execution of this build will be successful.

An area where project performance can be improved is meeting specific deadlines set during team meetings. The organizational actions that can be taken to improve this performance is keeping people accountable through assigning specific dates and initials to specific tasks. As a result, our team has made a physical list on a white board with items, dates, and people who are responsible for said items. Seeing this chart physically will help keep the team on track instead of treating deadlines softly as we had in the past. Having a physical place to check our progress will also be a better addition to just using an electronic calendar during the first semester.

Engineering analysis was difficult because load cases were developed only by hand calculations using vehicle specifications. Successful teams in the competition use data acquisition systems to collect dynamic vehicle loads and develop mathematical models to ensure parts do not fail. Another way to improve the first semester is to perform design failure mode and effect analysis (DFMEA) on old vehicles to understand where parts can be improved for the next year. It seemed as if a lot of design decisions were made with little knowledge to the actual loads and actual size of the structure.

Most of the issues faced by the team can be improved or solved through regular and detailed communication. We already have accommodations for communications between sub-team members in the form of GroupMe and Microsoft Teams, so the overall focus should be encouraging team members to collaborate and work with others outside of one’s sub-team. The regular team meetings will also improve this, allowing for team members to meet in person in a controlled environment that allows for

collaboration. This environment, being either the NAU machine shop projects room or the NAU College of Engineering, will allow for team members to meet and use Solidworks together, allowing for a smoother and more personal experience compared to working via online platforms.

As for challenges that the team may face, the major focus of this semester will be the manufacturing of the Mini Baja vehicle. In the early weeks of the semester, there will be less demand for other teams to use the NAU machine shop, but as the semester progresses, there will be a greater demand for the tools, resources, and space that the machine shop offers. This increase in demand is predicted to begin around early February. Because of the current situation with COVID-19, the number of students and teams allowed in the machine shop will be closely controlled. This means that the Baja team, which has one of the largest and most complex projects, will need to complete most of the manufacturing as soon as possible. Luckily, the team has already completed some major manufacturing milestones, such as assembling the frame and machining some of the more critical components. Because of its vital role in the project, the frame's completion timeline will determine the timeline for completing the rest of the sub-team manufacturing.

The Baja team hopes to complete as much machining as possible before demand to use the machine shop increases. By focusing on major components and equipment-dependent work such as CNC machining, the team can put themselves in a better position for final assembly and testing before having to compete with other teams for shop space. The team hopes to have most of the sub-systems of the vehicle mostly completed by the beginning of February, allowing for more time for assembly, testing, and finishing. Not only does this allow for other capstone teams to use the machine shop, but also allows for the Baja team to work out any issues in their design before competition at the end of April.

Conclusion

With the team charter and ground rules put in place at the beginning of the semester, the Mini Baja team has been on track to complete our design well before the competition date. This will allow us to test the integrity of our design before competing. Testing the integrity of our design will allow our team to identify failures that could have occurred further down the road and will provide our team more opportunities to alter our mini off-road vehicle. We were able to stay on track through the whole semester by having strong and constant communication between our four sub-team leads and with the members of those sub teams. Our team also stayed on track not only within our expectations for competing in the SAE 2021 Baja competition, but within our ME376C capstone class as well. However, even with these rules put in place, complications still may happen. Specifically, designs in different sub teams would occupy space needed for other aspects of the design, and this goes back to integration being one of the most critical aspects of our design process within the four sub teams. These minor issues did not end up slowing down the progress of the car substantially and were resolved at the weekly team meetings. Complications could have been resolved much faster and our design would have been much more streamlined with more effective deadlines and communication. Therefore, it is critical that our team maintains set deadlines, as well as proactively contacting and communicating with different sub team members. Overall, our team had great chemistry from the start of the project but could have been more efficient with the deadlines put in place. We anticipate learning from our first semester and look forward to having a successful second semester.