Aero Micro Design

Team Post Mortem Analysis of ME 476C

Team 19F11: The Prop Dogs

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Introduction

This report contains a post mortem analysis of the SAE Aero Micro capstone in ME 476C. Beginning in August 2019, our team was tasked with designing and manufacturing a small, fixed-wing aircraft that meets the requirements for the SAE Aero Micro competition in April 2020. Throughout the Fall 2019 semester, critical decisions and actions were taken by our team that contributed to the overall success of the project. Conversely, our team under-performed in various areas. So, the goal of this post mortem analysis is to identify and analyze contributors to project success, as well as opportunities for improvement.

Contributors to Project Success

The purpose of our team stated in the team charter is as follows:

> "This SAE Aero Micro design team seeks to represent NAU in good standing at the undergraduate research symposium on April 24th, 2020. Our team purpose is to gain a deeper understanding of engineering research and design during the capstone project, while showcasing engineering abilities gained during the undergraduate progression."

Our team successfully completed our purpose during the fall semester. The team's primary focus was to represent NAU in good standing at UGRADS, and at the end of the fall 2019 semester, our team was on track for presenting at UGRADS. In order to achieve or primary focus, the team's purpose was to gain a deeper understanding of engineering research and design during the fall semester. Through individual learning exercises and technical analyses, we successfully gained deeper knowledge for engineering research and design. Examples of the self-learning and technical analysis include finite element analysis (FEA) and computational fluid dynamics (CFD). Finally, by applying previous knowledge and learning new skills, we successfully prepared our team to showcase our engineering abilities at UGRADS.

Next, the goals of our team stated in the team charter are as follows:

> "The goals that our team has agreed on are to design and manufacture a functioning aircraft that abides by the rules of the competition. The quality goals are to meet requirements such as Customer Needs and SAE Competition Requirements. The manufacturing goals are to construct the plane within budget, while also demonstrating an ethical design that does not endanger others."

Most of the goals stated in the team charter are in regards to manufacture, which did not take place in ME 486C. However, our design from ME 476C successfully meets the rules of competition and customer needs. Furthermore, our design strictly adheres to the budget and safety concerns. Thus, upon the manufacture of our Fall 2019 design, the plane will also meet the manufacturing goals stated in the team charter.

The four major ground rules set in the team charter are for each team member to attend all meetings, communicate in a timely manner, to contribute fairly, and complete his share of the work. These ground rules were met throughout the semester and therefore contributed to the overall success of the project. The most important ground rules were for each teammate to contribute fairly and complete their work.

Without exception, these two ground rules were met during ME 476C. As a direct result, the team completed all reports and presentations successfully.

The main coping strategy to avoid the barriers to success in the team charter was simply to communicate any issues. This coping strategy was used effectively throughout the semester. Rather than the entire team experiencing problems in ME 476C, it was often one person. When this person communicated their problems, the team always solved the issue.

When it came to aspects of project performance such as time management, the team was able to always have a finished project the night before the due date for reports and presentations. Zach was also able to run meetings smoothly by always informing other teammates of what was going to be covered in the meeting as well as having action items for each team member to accomplish for the upcoming meeting. Accompanying the great time management skills, the team also was able to submit quality reports by having each of the team members read over and edit before submission. This did not only help with grammar errors and understandable writing but also kept the team up to date on other members parts of the project.

Opportunities for Improvement

In any engineering problem or manufacturing team there will be difficulties that the group must handle, this could be due to lack of understanding, lack of cooperation, among various other factors. Throughout the semester, there were many individual problems and group problems that surfaced. This section will cover what difficulties the team as a whole had to address during the semester and why did those problems occur.

The SAE Micro Aero rules are different each year, so benchmarking because a task because were needed to compare the design that we created and compare it to designs that had several modifications because of previous rules. For example, in 2015 the SAE Micro Aero teams aircraft was required to fit into a cylindrical tube, but now our aircraft must fit into a box that is 12x13x4 cubed inches. This can create massive differences in the final result. We combatted this specific example by examining the drive components (i.e. prop, motor, esc, and battery) because the thrust generated by these components were the most critical engineering requirements for our design. The most significant problem that the team needed to handle was the uncertainty behind the SAE guidelines. We were never informed whether or not we were competing based on the waitlist. No emails or notifications were sent stating the status of our registration as a team. We understood that we would not be representing NAU if we did not attend the competition, but we did not expect the level of dubiety that registering for the competition would have on us.

From the start of the semester the group created a google drive and were able to communicate very effectively. We later learned that separating certain documents, creating folders, and labeling the documents is the most efficient way of becoming organized. For example, the creation of Presentation 1 consisted of QFD charts, engineering requirements, benchmarking, among other documents that we would need to copy for Presentation 2 (another folder in the drive). When a task begins it is very simple and not overwhelming, but after more developments continue that task is complicated. Being organized

in a google drive, whether that is purchase receipts, CAD models, or presentations can be very forward thinking into benefiting the team later on.

In order to manufacture a fixed wing aircraft the members must be proficient in CAD, such solidworks, and with that software students must be able to do analyses as well. These analyses can be as simple as whether or not the parts with become a full assembly or as advanced as a Finite Element Analysis. Members of the group are required to understand the mathematics of lift, thrust, and drag. These variables dictate whether the aircraft will maintain an angle of attack, and if not it will lose control. The group gained access to the machine shop in 98C, which is critical to the manufacturing of this capstone project.

When it came to project performance team had a few areas to improve upon including ordering parts, creating prototypes, and solutions for fastening parts of the plane. The team procrastinated ordering parts during the first semester. By doing this the team is left without being able to begin manufacturing until the parts come in about two weeks after the beginning of the spring semester. When it came to prototyping the team was only able to accomplish physically seeing the dimensions of the plane and how it would fit in the box as well which is helpful, but it does not help with the success of flying the aircraft. One of the biggest challenges that the team has faced is to fasten each of the components such as the wings and fuselage to each other. This is difficult because these components are made of different materials so they cannot be welded like you would with steel or aluminum. The team has left that solution to be solved during this semester leaving little time to complete the task.

The team used different methodologies and practices to arrive at our final design with most of these methods being successful and others not exactly accomplishing much. For our design selection the team came up with three different designs for our five different subsystems which included the wings, landing gear, propulsion, maneuvering devices, and the fuselage design. Three different final design concepts were created but the problem the team had with this method of selection is that we already had in our heads what would be the best design would be which somewhat deemed this process useless. An improvement that the team should have done to speed up the process of designing the plane would have been creating the design of the wings, fuselage, and empennage before designing the drive system. The team selected the drive design prior to desiging the plane itself which made calculations somewhat backwards and the team had to retrace our steps elongating our process.

Conclusion

The final capstone project for graduating seniors is usually a fluctuating period of emotions, because of the time constraints, reports, and the design/manufacturing of the project. Our group made mistakes and learned from mistakes every week throughout the semester. There was not one member of the group that decided to become lax throughout the semester. ME 476C is designed for members to prevail at overcoming resistance, such as assignments or project due dates; this is done with the members not having the same schedule or workload. Our group had issues in regards to the actual registration and then how to actually design the aircraft. However, we have realized our mistakes and have discussed how to combat them for this upcoming semester.