SAE Aero Design

Problem Definition and Project Plan

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Introduction

The SAE Aero Design Competition is an event that is held annually for college students. Teams from all over the country gather and compete in three unique classes: Regular, Micro, and Advanced. The capstone team is tasked with the design and construction of an airplane that adheres to the requirements of the Regular class competition. There are many constraints that the competition has to make the task complex and difficult. The competition provides a chance for engineering students to learn something about designing and building a product and having fun while doing it. Most learning has been done in the classroom, so this project gives engineering students the chance to get hands on experience which will help in the future for the engineering profession.

Need Statement

Northern Arizona University does not have an airplane design to compete in the SAE Aero design competition, so the team is tasked with the design and construction of the airplane.

Project Goals

The goal of this project is to design and build an airplane that satisfies all SAE Aero design competition requirements and bring it to competition. It is important to aim high when setting goals, so the team will aim to win the SAE Aero Regular class competition. This project will be very educational in the manufacturing process, as well as the design aspects that will be needed to complete the airplane. Writing a report and orally presenting the final product is required, so the team will compile an exceptional report and presentation detailing the design and manufacturing processes.

Objectives

Table 1 - Objectives

Objective	**Measurement**	**Unit of Measurement**
Carry max payload	Weight	Force pounds (lb)
Carry a payload from point A to B	Distance	Feet (ft)
Small turning radius	Distance	Feet (ft)

Table 1 contains the objectives that the team has decided are critical for the project.

Constraints

1. Aircraft Dimension Requirement

The dimension must not exceed 175 inches [1].

2. Material and Equipment Restrictions for Regular Class

The use of Fiber – Reinforced plastic (FRP) is not allowed, except in the motor mount, propeller, landing gear and control linkage component. Also, not allowed is the use of rubber bands to make the wing retain to fuselage. Furthermore, any types of gyroscopic or other stability assistance are not allowed [1].

3. Aircraft System Requirements

The airplane requires the use of a electric single motor, gearboxes, belt drive systems, and propeller shaft extensions are allowed in tow condition (one-to-one propeller to motor RPM should be maintained) and the prop(s) must rotate at motor RPM [1]. The battery should have: 6 cell (22.2 volt) Lithium Polymer (Li-Poly/Li-Po) battery pack. The minimum requirements for Li-Po battery are: 3000 mAh, 25c) and homemade batteries are prohibited [1]. A 2015 version

1000 watt power limiter from the SAE supplier is required and supplied by Neumoters.com [1]. For the radio system the battery should have a minimum capacity of 1000 mAh [1].

4. Payload Requirements

For the payload, the team will focus on the interior dimension and we must follow the requirements in Table 2 [1].

Table 2 - Length Width Height Tolerance For Payload Bay

Length	Width	Height	Tolerance
10.00	4.00”	4.00”	+ 0.125”, - 0.000”

The airplane should have one or more removable access for the payload bay. The payload interior surfaces have to be unbroken and smooth. The payload must also be secured to the airframe, as well as contain payload plates. The only penetrations are allowed in the payload bay surfaces is payload support assembly. The support assembly for the payload must be removable and the bay will never considered as payload [1].

5. Other Requirements

The airplane must take off within a maximum distance of 200 ft. Likewise, the airplane must land within a maximum distance of 200 ft. Also, the time to complete all aerial tasks must be no more than 180 seconds [1].

6. Quality Function Deployment and House of Quality

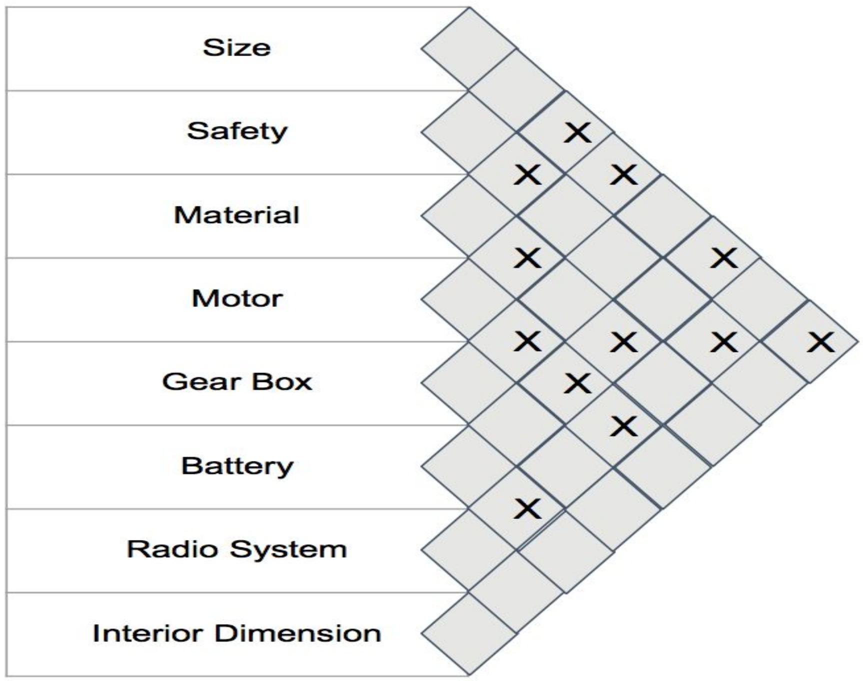
In Table 3 below, compared are the regular class design requirements with engineering requirements. These comparisons are given a score, then the engineering requirements are ranked by importance. Safety, material and motor were found to be the most important.

Table 3: Quality Function Deployment

Regular Class Design Requirements	Weights	Size	Safety	Material	Motor	Gear Box	Battery	Radio System	Interior Dimension
AIRCRAFT DIMENSION REQUIREMENT	5	9	1	0	0	1	0	0	9
MATERIAL AND EQUIPMENT RESTRICTIONS FOR REGULAR CLASS	5	3	9	9	9	1	3	3	1
AIRCRAFT SYSTEM REQUIREMENTS	5	3	9	3	9	1	9	9	0
PAYLOAD REQUIREMENTS	5	3	3	9	3	1	3	0	9
	Raw score	90	110	105	105	20	75	60	95
	Scaled	1	1	1	1	1	1	1	1
	Relative Weight	14%	17%	16%	16%	3%	11%	9%	14%
	Rank	5	1	2	2	8	6	7	4

In the house of quality, Table 4 below, the team took the engineering requirements from the Quality Function Deployment, Table 3, above to compare them with each other. The comparison will help the team know which requirements are related with the others.

Table 4: House of Quality



Project Plan

Every engineering team needs a project plan for their projects. In this project the team divided tasks to get them each done in several weeks. This semester contains fifteen weeks that the team can achieve these tasks. In the last week the team must complete the Project Proposal Presentation. At this point the team should have completed the decision matrix and final design. The Gantt chart below shows how the team divided the tasks throughout the fifteen weeks.

Table 5: Gantt Chart

Task	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Client meeting		■													
Define problem and layout project plan			■	■											
Research design			■	■											
Research protocol writing			■	■											
Data collection					■	■									
Select a sample						■	■	■							
Pick a final design (decision matrix)									■	■	■	■			
Finalize design												■	■	■	■
Problem Definition and Project Plan Presentations				#											
Concept Generation and Selection Presentations								#							
Proof of Concept Demonstrations												#			
Project Proposal Presentations															#

State of the Art Research

State of the art techniques are essential for a project to be on the cutting edge of design and manufacturing. 3D printing has become an essential part of prototyping and for the manufacture of small projects [2]. Innovating filaments that are available for 3D printing has become extensive in the past couple years. ABS and PLA plastics are some of the most widely available plastics. PLA is made from corn starch and is renewable. ABS is not renewable and is a petroleum based project but it does have a higher ultimate tensile strength pound for pound. Another interesting filament is called Ninjaflex. It is a rubber based substance that is printable. This filament could be used for the tires of the aircraft. Carbon fiber and fiberglass filaments are also available. These filaments would be great for use in wing rib structures as well as the fuselage structure.

In order to use these 3D printer a slicing software is needed in order to transform your 3D modeled part into a 3D readable GCODE file [3]. One of the most expansive and innovating slicing softwares on the market currently is Simplify3D. This product separates itself from the competition because of its support structures [3] . They have a unique design that allows the printer to print object with extreme over hangs and yet the support structure is easily removed with little to no trace that it was even there [3].

Cutting edge computer aided software will also be implemented in this project. The most current versions of autodesk products will be used. One useful product that autodesk offers is Inventor [4] . This project has been around for several years and has been updated several times with a large user base. It is useful for 3D modeling a part that you would like to use. Fusion 360 is another very useful product that is offered. Fusion 360 is very similar to Inventor except that is a lot more design on the spot friendly [4]. Autodesk also offers a computational fluid dynamics software. This software would be an exceptional use in this project because it could be implemented to find the lift of the aircraft and how aerodynamic it is in different situations and loading [4].

Conclusions

In conclusion, the Northern Arizona University SAE Aero senior capstone team will design and build an aircraft to compete, as representatives of Northern Arizona University, in the SAE Aero design competition. The capstone team will design and build an aircraft that adheres to the SAE Aero competition requirements and constraints. The aircraft entered into the competition will carry a max payload while completing tasks like take off, a 360 degree circuit, and landing. The capstone team will compile an excellent report detailing the design and manufacturing processes and orally present the final design. During the design process, the team will implement cutting edge softwares, building processes and materials in order to surpass the competition.

References

[1] students.sae.org, ‘SAE Aero Design - SAE Collegiate Design Series - Students - SAE International’, 2015. [Online]. [Accessed: 24 Sep 2015]

[2] "Robo3D," 25 September 2015. [Online]. Available: www.robo3d.com.

[3] "Simplify3D," [Online]. Available: www.simplify3d.com. [Accessed 25 september 2015].

[4] "Autodesk," [Online]. Available: www.autodesk.com. [Accessed 25 September 2015].