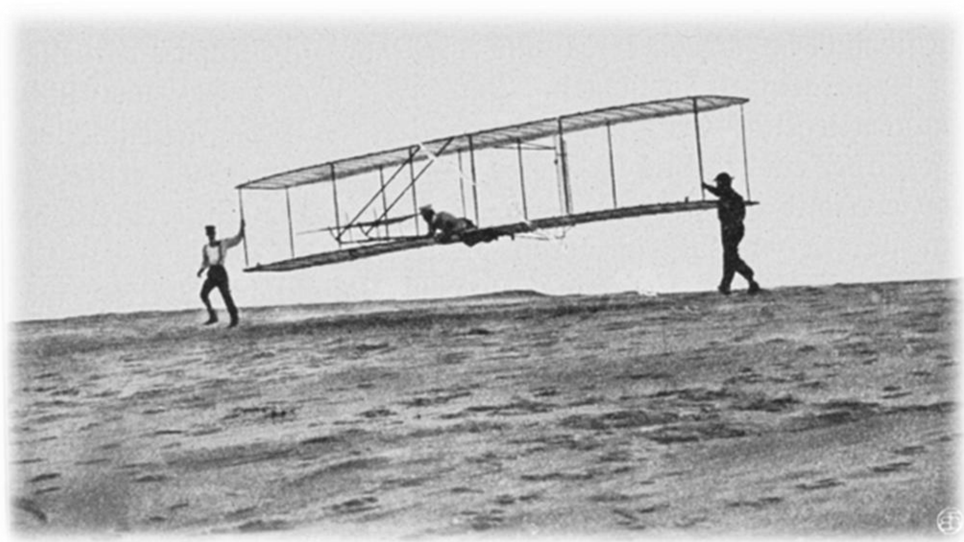
NORTHERN ARIZONA UNIVERSITY

Department of Mechanical Engineering

ME 476C Senior Design

Needs Identification



Group 10: "The Wright Stuff"

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October 5, 2012

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1. Introduction

This team has elected to participate in the Society of Automotive Engineers' Aero Design Competition (SAE ADC) for our 2012 Capstone project. As stated by the Brian A. Czapor, the SAE Rules Committee Chair, the competition provides students with an opportunity to demonstrate their ability to apply engineering knowledge and leverage towards their career goals. For this competition, the team will design, build, and test a remote-controlled aircraft with the intent being to accurately predict a maximum payload.

For the students, this project represents the culmination of our undergraduate careers and gives us exposure to the type of situations seen in the workplace. This competition is a test of analytical, design, teaming, and communication skills. This document provides an overview of specific needs this team has identified to successfully complete this project.

2. Needs Identification

For a nontraditional project such as this, we are constrained less by customer requirements than we are by project rules and guidelines. As this team has not been tasked with a customer's specific request, the major needs for our task have come from the generalized requirements laid out by the SAE ADC.

Per SAE requirements and group consensus, we realize that at present, current remote-controlled aircraft designs are not capable of carrying sufficient payload.

3. Problem Statement

Through exquisite engineering, the goal for the SAE Aero Design project is to design, report and manufacture an RC aircraft capable of carrying a maximized theoretical payload in order to win the competition.

i. Goal

Design a model aircraft to meet or exceed a 25lb payload and accurately predict this performance through solid proof of concept.

ii. Objectives

The team has developed objectives based upon its goals, each in terms of quantifiable properties. Table 1, shown on the following page, displays these objectives along with the basis and unit of measurement.

Table 1 Table of Objectives

Objective	Basis for Measurement	Units
Sponsorship/Cost	Money	$
Maximum Payload	Weight	lb
Minimal Weight of Aircraft	Weight	lb
Aircraft Maneuverability	Turning radius	ft
Aircraft Take Off	Distance	ft
Aircraft Landing	Distance	ft
Safety/ Controllability	Injuries	N/A
Stability	Center of gravity	ft
Crash Durability	Broken parts	$
Payload Assembly	Volume/time to assemble	Ft^3/s
Payload Prediction	Lift	lb
Propulsion	Thrust	lb

iii. Constraints

Mission constraints

- Aircraft must accomplish a successful takeoff in at least 3 minutes.
- Aircraft must lift from the ground within a take-off distance of 200 ft (61m).
- Aircraft may not be pushed by helper during take-off other than engine run-up
- Aircraft must remain intact during takeoff and landing
- Aircraft must successfully complete one 360 degree circuit of the field
- Aircraft must touch down within the designated landing zone and remain on the runwaway between the landing limits of 400 ft (122m)
- Aircraft must be controllable in flight

Aircraft Class Constraints

- No lighter than air or rotary wing aircraft are allowed
- Aircraft shall not exceed a combined length, width and height of 255 inches
- Aircraft may not weight more than sixty-five (65) pounds with payload and fuel
- Aircraft must be identifiable by displaying team number on both the top and bottom of the wing, and on both sides of the vertical stabilizer or other vertical surface in 4 inch numbers
- Aircraft must clearly display the university name on the wings or fuselage.

- Aircraft engine must be unmodified O.S 61FX with E-4010 muffler or the Magnum XLS-61A
- Aircraft engine may not have any muffler extensions or headers
- Aircraft may not have a fuel pump
- Aircraft may make use of gear boxes, drives and shaft as long as a one to one propeller to engine RPM is maintained
- Aircraft fuel tank must be accessible to determine contents during inspections and may be pressurized by a stock fitting on the engine muffler only.
- Aircraft may not have any type of gyroscopic assist
- Aircraft payload must consist of a support assembly and payload plates. All payload carried for score must be carried within the cargo bay. The support assembly must be constructed so as to retain the weights as a homogeneous mass.
- Aircraft payload must be secured to the airframe to ensure the payload will not shift or come loose in flight
- Aircraft design must be capable of loading and securing payload in less than 1 minute
- Aircraft design must be capable of unloading the payload in less than 1 minute
- Aircraft is required to use a 2.5 GHz radio
- Aircraft battery pack may be no less than one thousand mah capacity
- Aircraft must utilize either a spinner or a rounded safety nut

Material Constraints

- Aircraft may not use metal propellers
- Aircraft may not contain any lead
- Aircraft may not use any Fiber-Reinforced Plastic (FRP) except in the use of a commercially available engine mount and propeller.

iv. Test Environment

The competition will be held in Van Nuys, California on April 12-14, 2013. According to wunderground.com, historically, Van Nuys has a mean temperature of 50 degrees Fahrenheit, barometric pressure of 29.86 inches of Mercury and max wind speeds of 23 mph. This team as noted that Phoenix, Arizona holds similar air densities as the competition location and will be the most comparable site for testing.

v. Recapitulation

The SAE ADC requires the design and manufacturing of a remote-controlled aircraft to present in competition in Van Nuys, California. Per imposed design constraints, the aircraft is restricted in size, material, and demonstration.

4. Criteria and Criteria Tree

Establishing the prime objectives in a project is essential to success. Project objective help provide an outline to follow by breaking down the each aspect into specific criteria. Many of the project objectives are chosen to best fit the project guidelines listed by SAE ADC. To achieve a high maximum payload, a wing must be properly designed. The accurate prediction of the max payload can only be achieved by executing correct engineering analysis. As seen below, Table 2 has a detailed list of the project objectives along with the correlating criteria.

Table 2: Customer Objectives vs. Engineering Criteria

Objective	Criteria
Maximum Payload	**Wing Design**
Minimal Weight of Aircraft	**Material/Design**
Aircraft Control	**Maneuverability**
Safe Landing	**Landing Gear**
Propulsion	**Motor and Propeller**
Aircraft Shipment	**Transportation**
Crash Durability	**Material/Design**
Part Removal and Replacement	**Aircraft Design**
Payload Prediction Accuracy	**Engineering Analysis**
Sponsorship	**Cost**

The objectives for the project can also be broken down into a detailed design criteria tree. This criteria tree can be in figure 1 below.

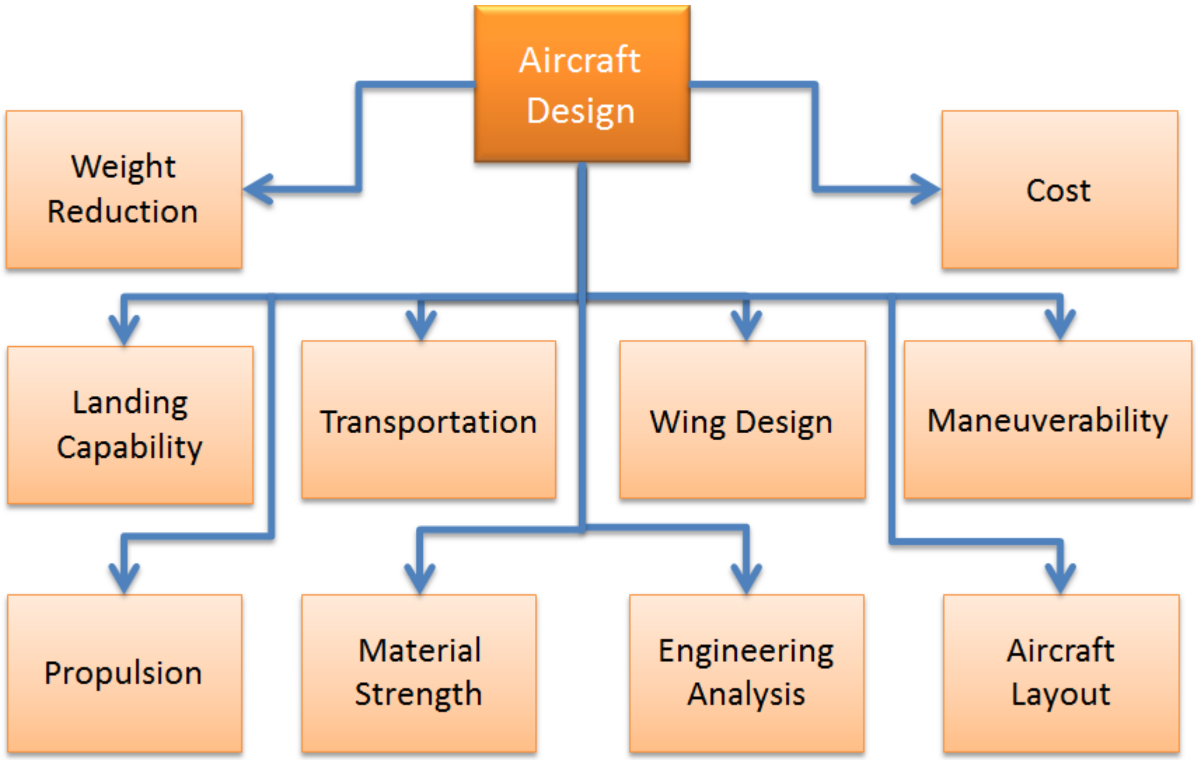

Figure 1: Aircraft Design Criteria Tree

5. Functional Diagram

Outlining of a project can also be assisted by detailing a step-by-step process of the test environment. Figure 2 below shows a function diagram used of the competition process expected. Each step represents a key component needed to complete a successful run within the competition.

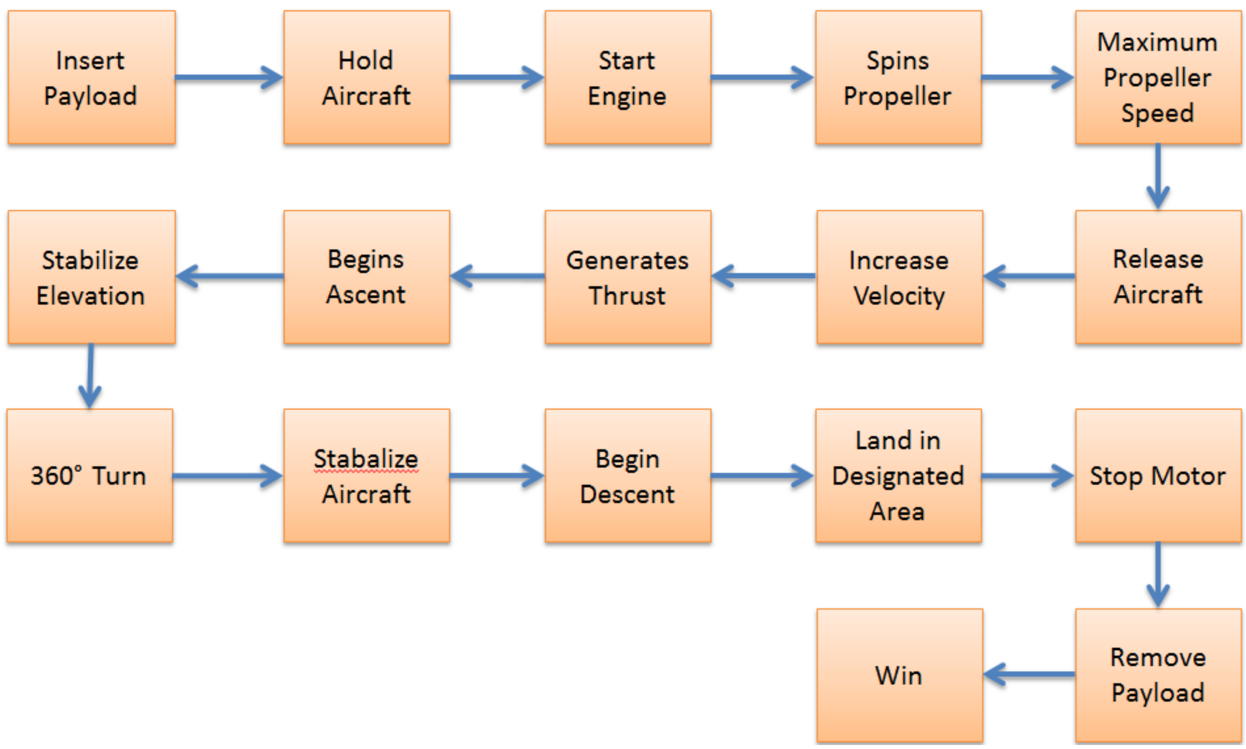

Figure 2: Functional Analysis Diagram

6. Quality Function Deployment with House of Quality

In order to succeed in the stated goal, it will be essential for the team to correlate the requirements laid out by the customer with concrete engineering requirements. Table 3 below presents the fundamental engineering requirements compiled for this purpose. Here, the yield strength is influential in fulfilling nearly all the customer requirements, as the aircraft needs to withstand all applied loads. The location of the center of gravity affects the ability of the aircraft to maneuver and land, thus enhancing its stability. Lift and drag considerations are fundamental to nearly all requirements, especially in the objective of carrying load. In order to generate lift and achieve takeoff, the aircraft requires sufficient thrust. The weight of the aircraft interacts directly with its load-bearing ability and its cost. The turning radius of the aircraft allows it to maneuver and remain stable. Finally, a low-cost product constitutes an inexpensive design.

Table 3: Quality Function Deployment

		Engineering Requirements						
		Yield Strength of Aircraft Components	Location of Center of Gravity	Aerodynamic Lift and Drag	Thrust	Aircraft Weight	Turning Radius	Cost
Customer Requirements	Carries Load	X		X	X	X		
	Maneuvers Through the Course		X	X			X	
	Takes Off from Runway	X		X	X			
	Lands on Runway	X	X	X				
	Safe, Stable, and Controllable	X	X	X	X		X	
	Predictable Payload			X				
	Crash Durability	X						X
	Inexpensive	X		X		X		X
	Units	psi	ft	lb	lb	lb	ft	$

In Figure 3 below, correlations between key engineering requirements are drawn. Here, the team has decided that the yield strength of aircraft components positively correlates with both the aircraft weight and its cost. An accurate location of the center of gravity leads to the generation of aerodynamic lift and an adequate turning radius. Effective production of lift and reduction of drag positively affects the aircraft's turning radius, negatively correlates with its weight, and depends on thrust in a more complicated sense.

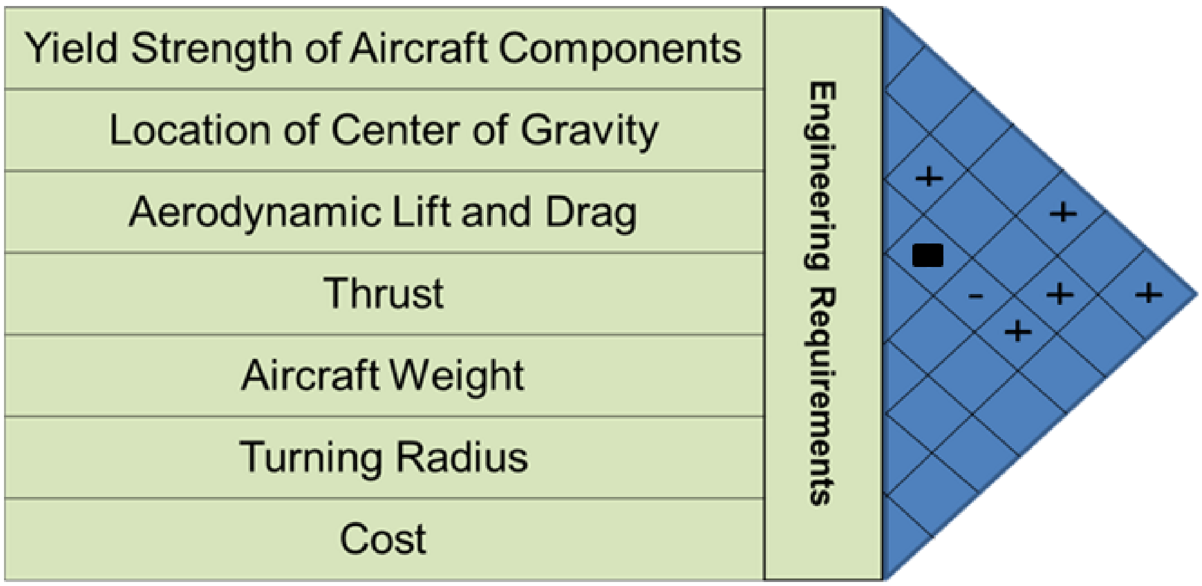

Figure 3: House of Quality

7. Project Plan Gantt Chart

Task Name	Duration	Start	Finish
Organizational Tasks	**110 days**	**Tue 10/2/12**	**Mon 3/4/13**
Register for the Competition	0 days	Tue 10/2/12	Tue 10/2/12
Gather Funding	1 mon	Tue 10/2/12	Mon 10/29/12
Acquire Core Materials	1 mon	Tue 10/30/12	Mon 11/26/12
Acquire Remaining Materials	1 mon	Mon 12/17/12	Fri 1/11/13
Submit Report	0 days	Mon 3/4/13	Mon 3/4/13
Design Tasks	**146 days**	**Mon 9/24/12**	**Sun 4/14/13**
Conceptual Design	1 mon	Mon 9/24/12	Fri 10/19/12
Preliminary Design	3 mons	Fri 10/19/12	Thu 1/10/13
Build Design	1 mon	Fri 1/11/13	Thu 2/7/13
Test Design	1 mon	Fri 2/8/13	Thu 3/7/13
Rebuild and Retest Design	26 days	Fri 3/8/13	Fri 4/12/13
Compete in SAE Event	0 days	Sun 4/14/13	Sun 4/14/13

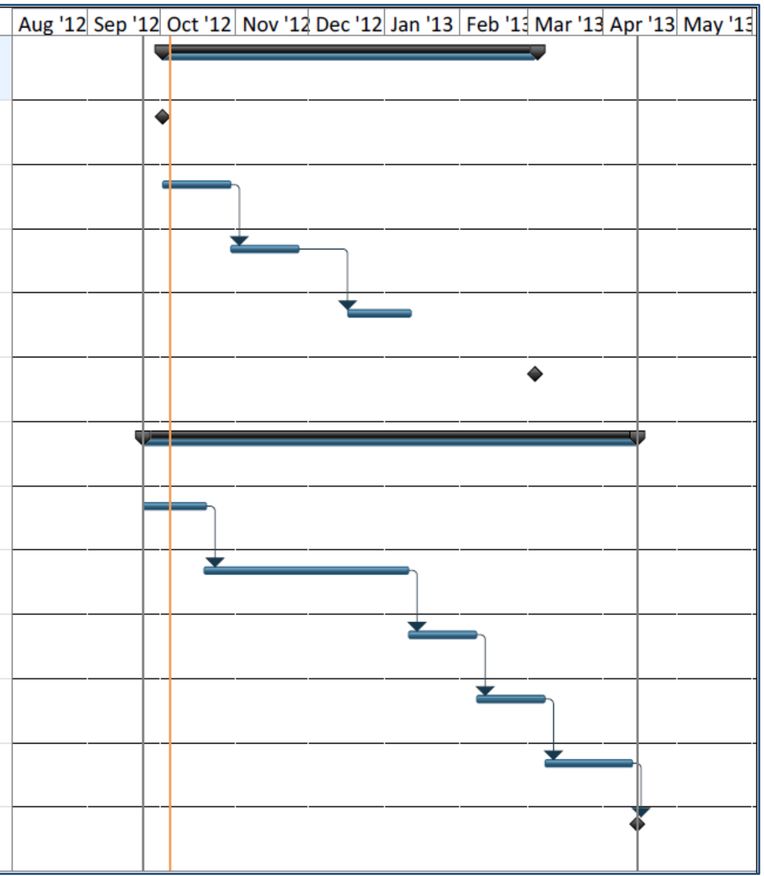

Figure 4: Project Plan Gantt Chart

Figure 4 above is the Gantt chart developed for this project's key deadlines and requirements. Our group has derived data from previous years schedules and determined the amount of time required for completing tasks. Our first accomplished milestone was completed on October 2nd when our team successfully registered for the 2013 Aero Design West Competition. Overall our tasks have been broken down and other key milestones have been identified on our Gantt chart.

8. Conclusion

In Conclusion “The Wright Stuff” will be competing in the 2013 Aero Design Competition for our capstone project. For this project the team will design, build, and test a remote-controlled aircraft with the intent being to accurately predict a maximum payload. Our customer will be SAE because the major needs for our task have come from the generalized requirements laid out by the SAE ADC. Per SAE requirements and group consensus, we realize that at present, current remote-controlled aircraft designs are not capable of carrying sufficient payload. One of the unique characteristics of this project is that all of the constraints and design criteria are specifically laid out in the SAE ADC Rule book. Based upon the needs identification the goal for the SAE Aero Design project is to design, report and manufacture an RC aircraft capable of carrying a maximized theoretical payload in order to win the competition. Overall the needs identification has been completed for the SAE ADC.

9. References

[1] Weather Underground (www.wunderground.com)

[2] SAE International 2013 Collegiate Design Series: Aero Design® East and West Rules