NORTHERN ARIZONA UNIVERSITY

The Wright Stuff

Final Design Review and Project Proposal

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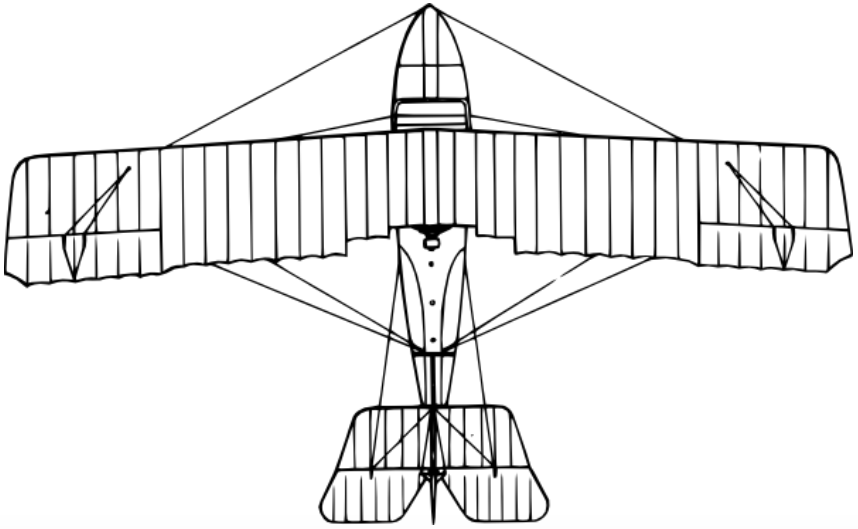
NORTHERN ARIZONA UNIVERSITY

Agenda

- Competition Overview
- Conceptual Design
- Engineering Analysis
  - Aerodynamics
  - Propulsion
  - Material/Structural
- Financial Overview
- Gantt Chart



Competition Overview

- **Customer**
  - Society of Automotive Engineers (SAE)
- **Project**
  - Aero Design West Competition
  - Self-motivated, self-funded project
  - Test of individual and group capabilities

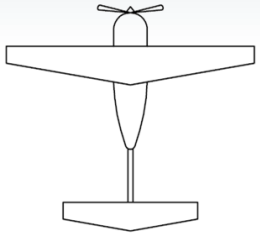
Problem Statement

- **Needs Identification**
  - Current remote controlled aircraft do not carry sufficient payload
- **Goal**
  - Introduce precision manufacturing techniques into RC aircraft design

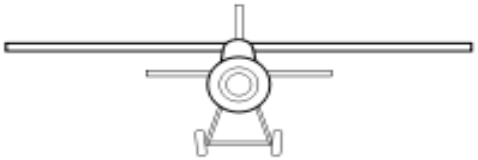
Design Constraints

- **Mission Objectives**
  - Flight Demonstrations
- **Design Limitations**
- **Test Environment**
  - Phoenix, AZ
    - equivalent atmospheric conditions

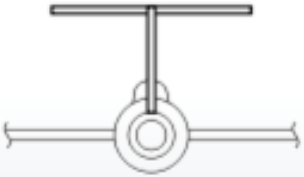
Conceptual Design



Tapered Planform



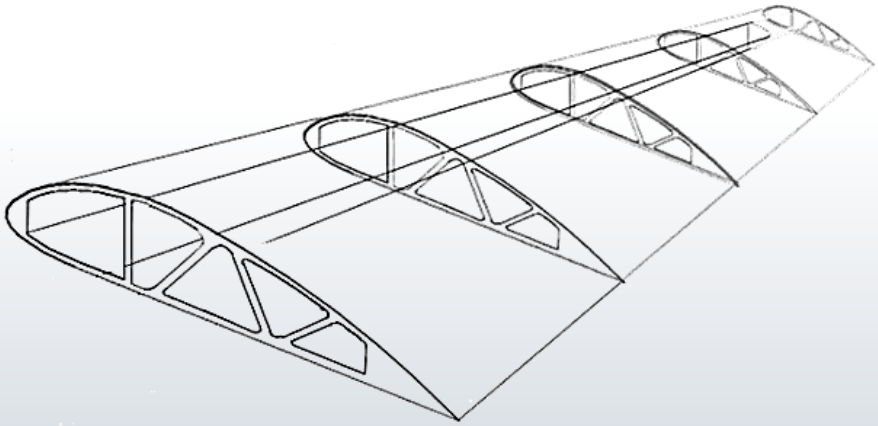
Single High Wings



T-Tail

Conceptual Design

- **Spars**
  - Wood tooled to precision
- **Ribs**
  - 3D printing with ABS polymer



Conceptual Design

- Propeller selection based on motor and aircraft specs

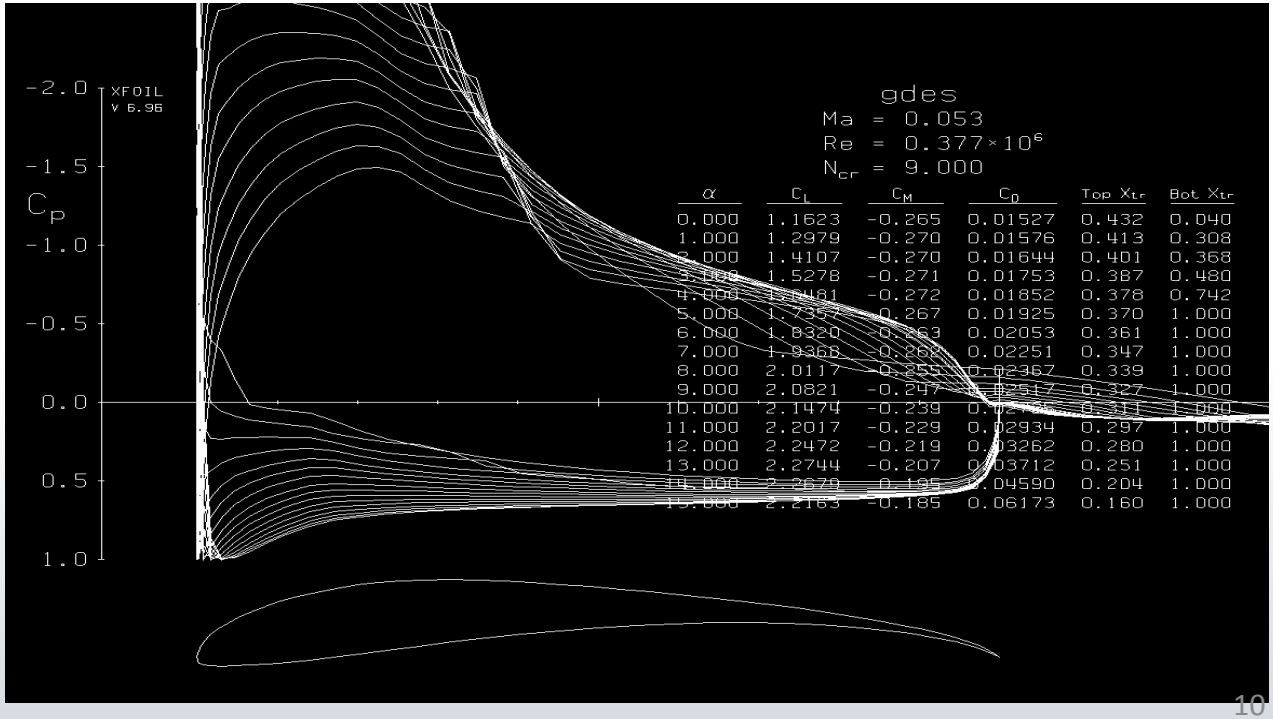
- Payload bay opens beneath
- Plate-based loading scheme

Aerodynamic Environment

- 282k > Reynolds Number > 450k
  - Laminar Flow
- Pressure drag more significant than skin friction
  - Airfoil Selection
- Mach Number=.053>>0.3
  - Incompressible Flow
- Wing Geometry
  - Aspect ratio and planform taper
    - Induced drag

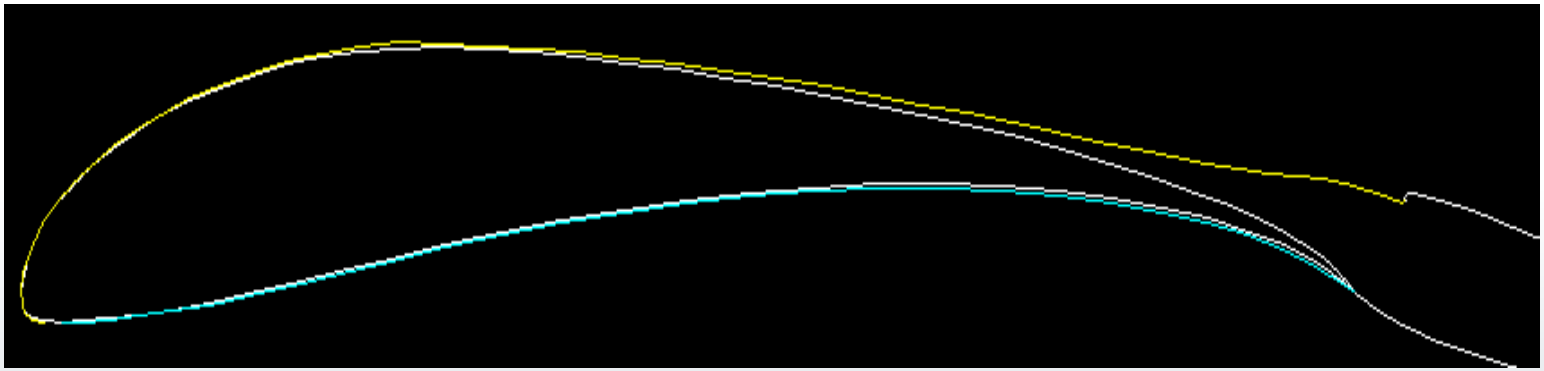
XFOIL Analysis

- MIT-Professor: Mark Drela/Harold Youngren
- Inputs:
  - Airfoil shape, Chord length, Re#, Mach#, Angle of attack
- Outputs:
  - C_L
  - C_P
  - C_D



Airfoil Selection

- Maximum Lift
  - Minimize drag by reducing flow separation and pressure drag
- Airfoil Selection:
  - S1223



Geometry

- Assumed Flight Velocity
- Aspect Ratio & Taper Ratio Optimized
- Matlab Optimized Wing

Summary of Wing Geometry

Chord at Root [ft]	Taper Ratio	Chord at Tip [ft]	Wingspan [ft]	Wing Planform [ft^2]	Aspect Ratio
1.0	0.5	0.50	8.8	6.6	11.73

Performance Characteristics

cl	cd	delta	AoA	Flight Speed [m/s]	Reynolds number	CL	cD induced	cD 3D	CD	Lift [lbs]	Drag [lbs]
2.247	0.033	0.03	12.0	17.88	3.77e+05	2.247	0.142	0.143	0.284	60.00	7.59

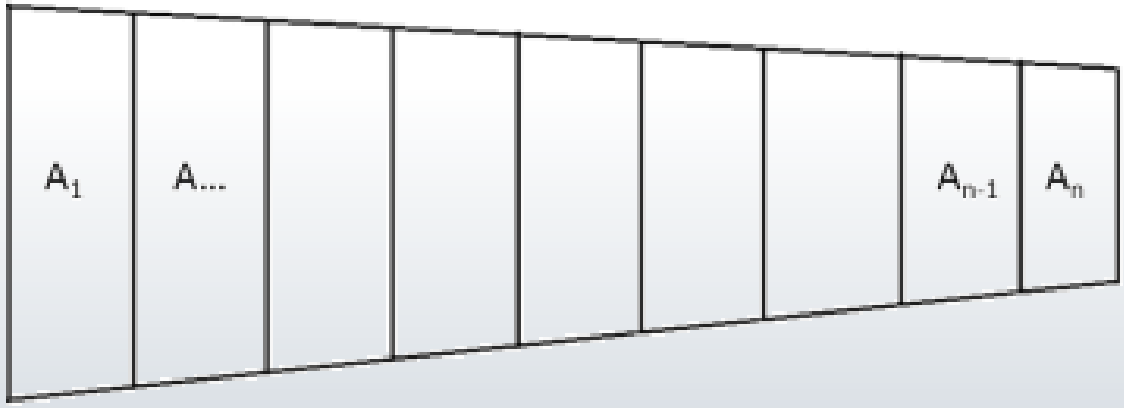
Materials

- Utilize rapid prototyping for ribs
- Acrylonitrile Butadiene Styrene (ABS)
  - Polymerization of Acrylonitrile, Butadiene, Styrene monomers.
  - High impact and mechanical strength

	Specific Gravity	Tensile Strength (Mpa)	Tensile Modulus (Mpa)	Flexural Strength (Mpa)	Flexural Modulus (Mpa)
ABS P400	1.04	22	1,627	41	1,834

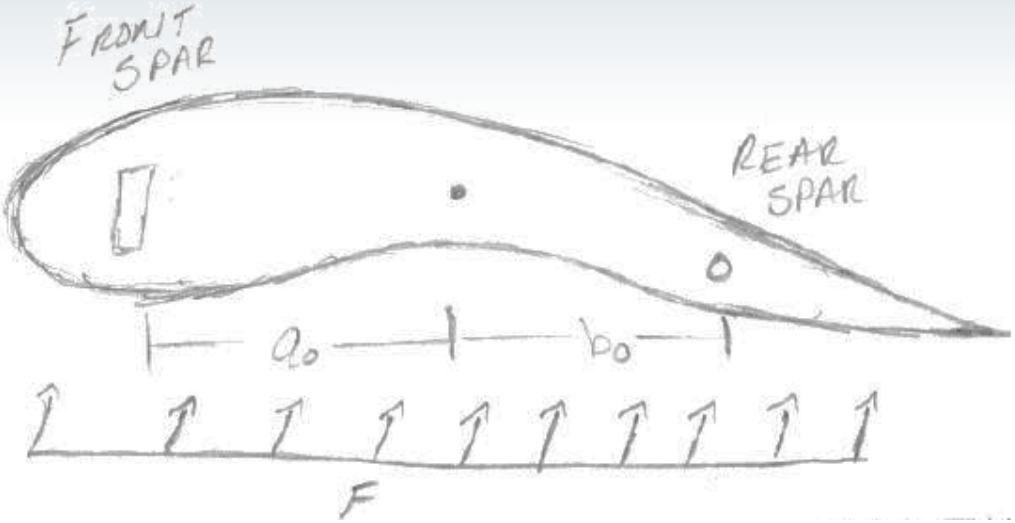
Structural Analysis

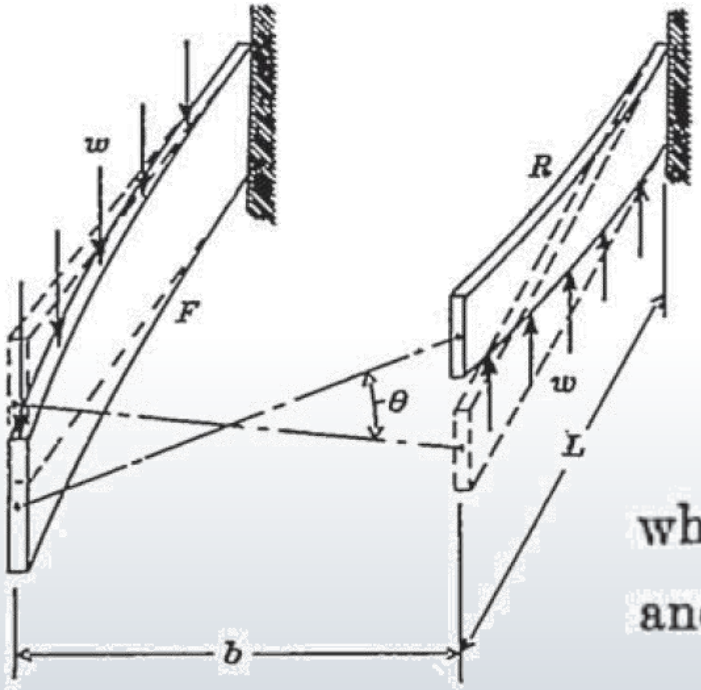
- Discretization of wing
  - Several sub elements from A_0 to A_N
- Lift per sub element
  - Based on percent Area
  - Acts at Center of Gravity



Elastic Center

$$EC = \frac{a_0}{b_o} = \frac{E_{FS}I_{FS}}{E_{RS}I_{RS}}$$

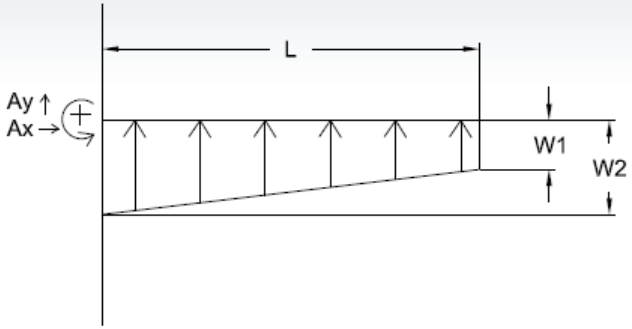


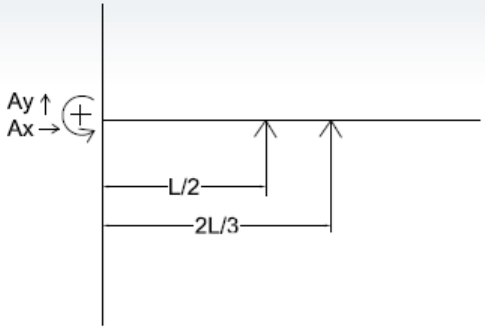


$$\theta = \frac{wL^4}{8bA_0}$$

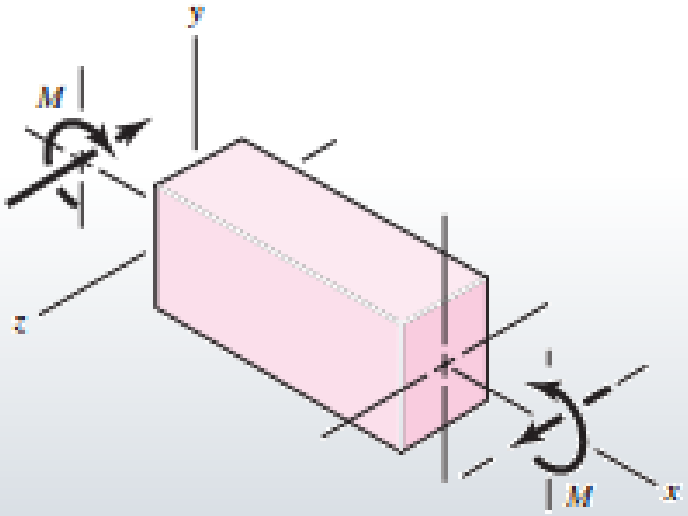
where A_0 is defined by $\frac{1}{A_0} = \frac{1}{A_F} + \frac{1}{A_R}$, $A_F = EI_F$, and $A_R = EI_R$.

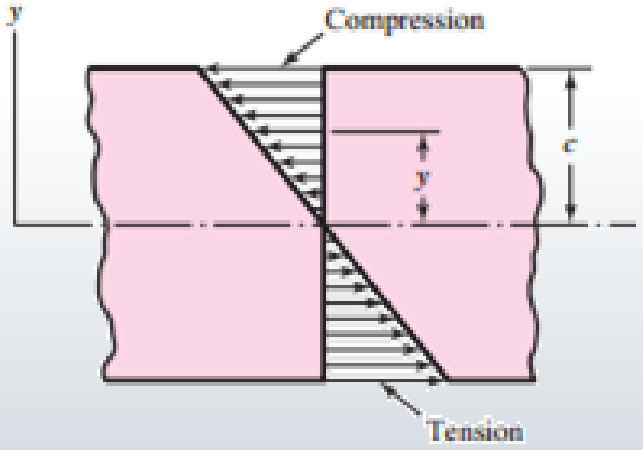
Mechanics of Materials





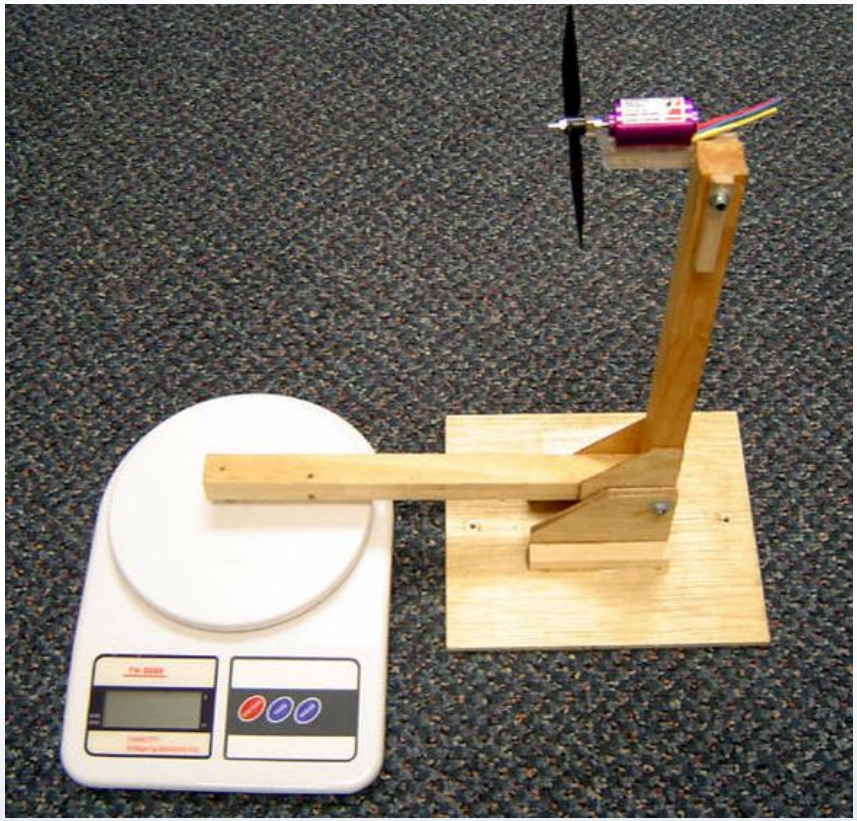
$$\Sigma M_A = \frac{L}{2}(W_1 L) + \frac{2L}{3}\left[\frac{(W_2 - W_1)L}{2}\right]$$





Propulsion Systems

- High diameter, low pitch
  - High thrust design
- Propeller Range
  - 11 X 7 ➔ 13 X 6
- Test stand will be constructed
  - Static Thrust
  - RPM



Budget

Competition Expenses	
Registration	650
SAE Membership	100
Other	120
	870

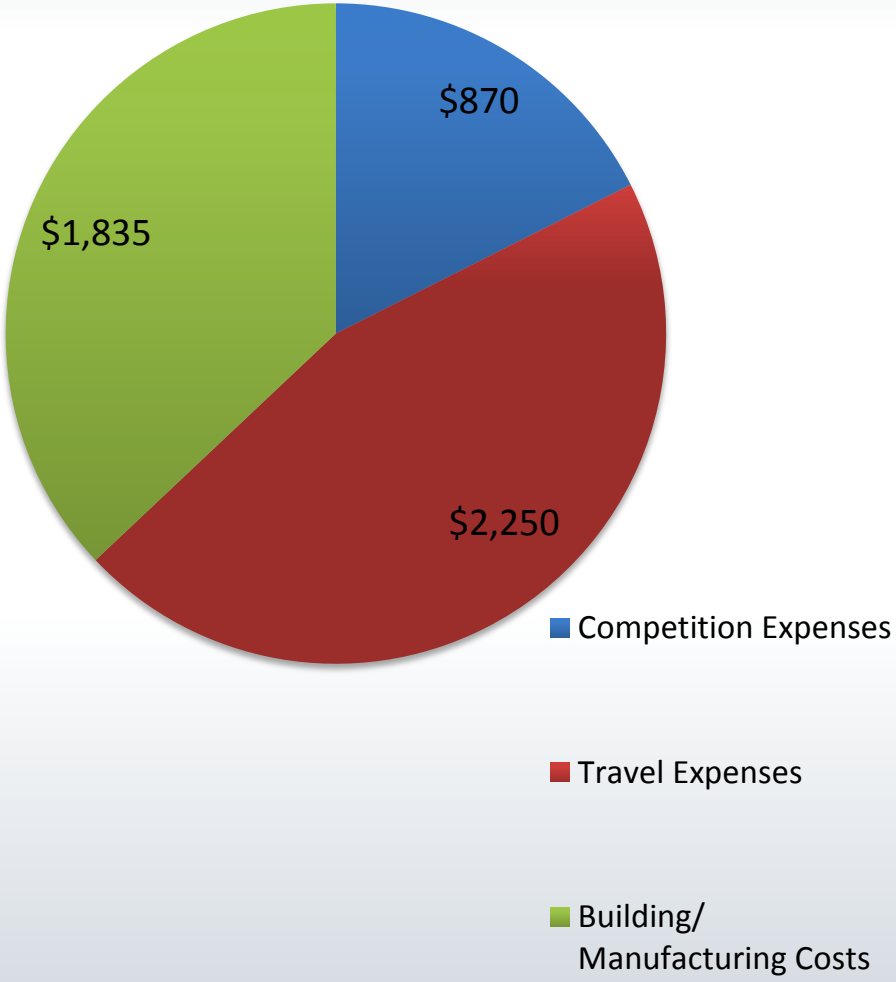
Travel Expenses	
Lodging and Food	1200
Van Rental	600
Fuel	450
	2250

Building, Misc. Expenses	
Raw Materials	1535
Software Licensing	100
Outsourced Components	200
	1835

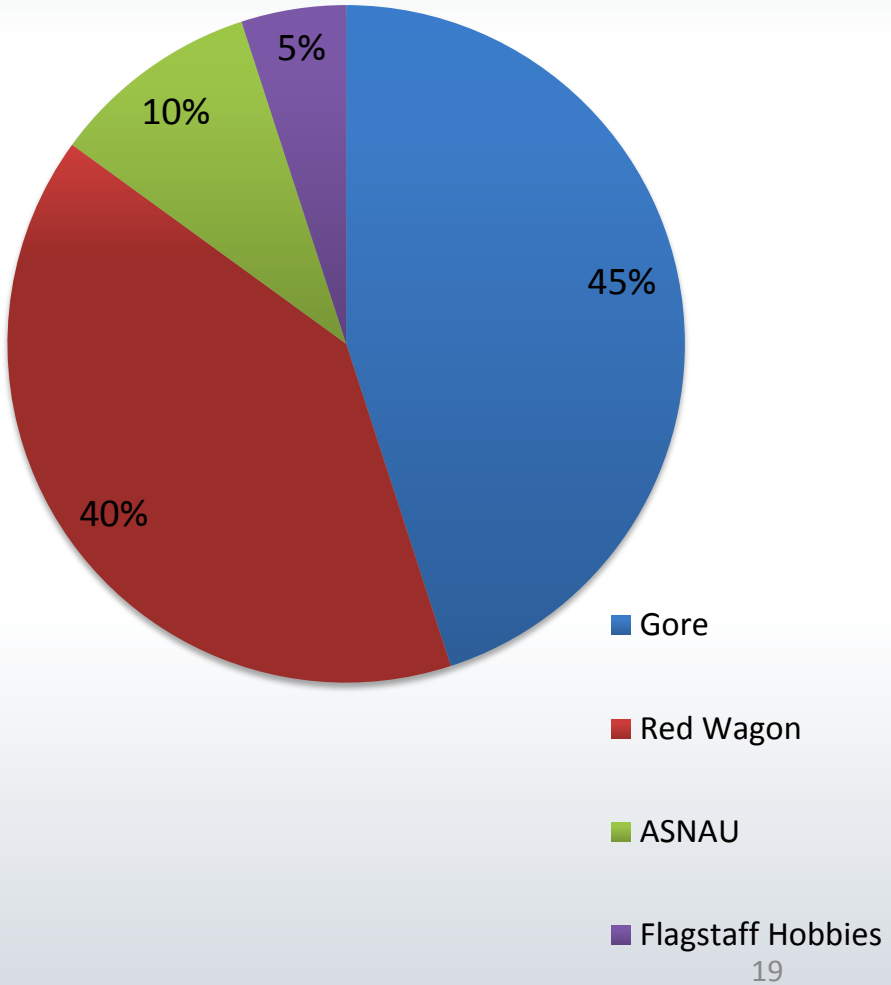
Grand Total	$4955

Sponsorship Breakdown

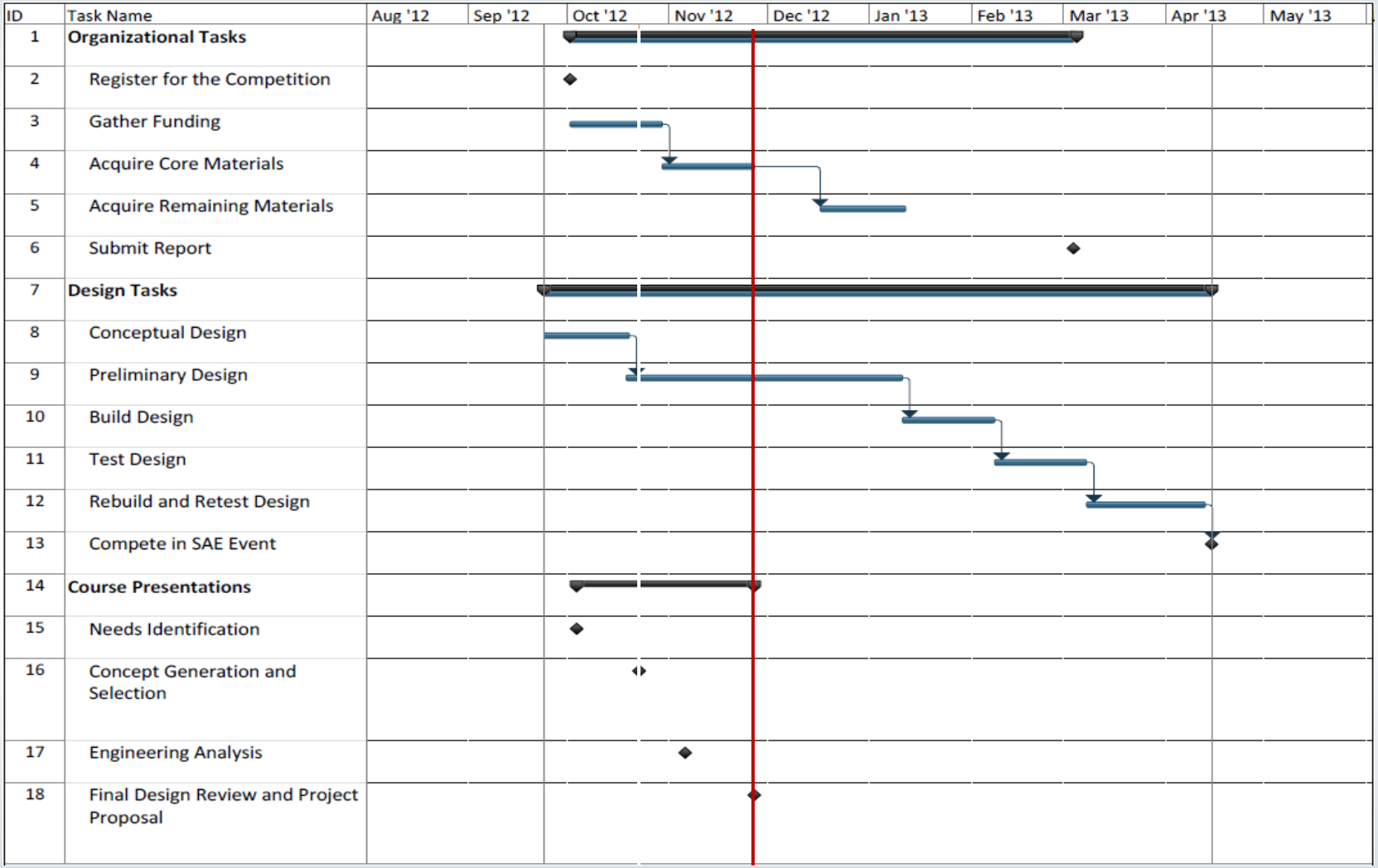
Budgeted Costs



Sponsorship Contribution



Project Timeline



ID	Task Name
1	**Organizational Tasks**
2	Register for the Competition
3	Gather Funding
4	Acquire Core Materials
5	Acquire Remaining Materials
6	Submit Report
7	**Design Tasks**
8	Conceptual Design
9	Preliminary Design
10	Build Design
11	Test Design
12	Rebuild and Retest Design
13	Compete in SAE Event
14	**Course Presentations**
15	Needs Identification
16	Concept Generation and Selection
17	Engineering Analysis
18	Final Design Review and Project Proposal

Questions?