SAE Aero Design

Concept Generation and Selection

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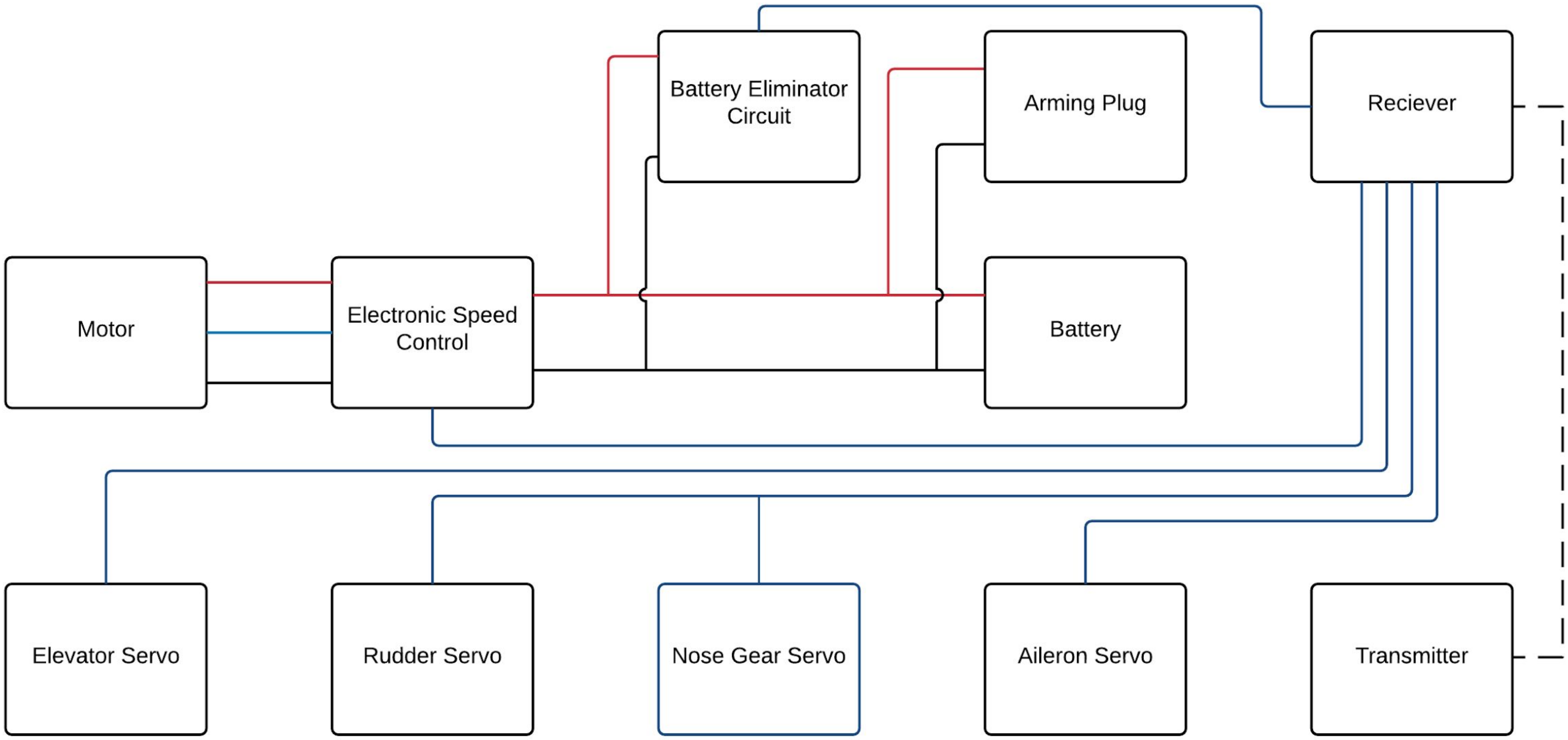
Overview

- Introduction
- Functional Diagram
- Criteria
- Relative Weights of Criteria
- Concept Generation
    - Sketches and Pictures
    - Decision Matrices
- Updated Project Plan
- Conclusions

Introduction

- The aircraft must take off with a payload, complete a 360 degree circuit and land
- Adheres to the SAE Aero competition requirements
- Constraints include a maximum combined dimensions of 175 inches, specific payload bay area volume, and must have a 1000 watt power limiter
- Implementation of cutting edge design software
- The team has created decision matrices and concepts for the most critical functionalities to determine the best design alternatives

Functional Diagram



Criteria

Airfoil

- Coefficient of Lift (max)
- Design Lift Coefficient
- Coefficient of Drag
- Lift-to-Drag Ratio
- Lift Curve Slope (max)
- Pitching Moment Coefficient
- Stall Quality

Vertical and Horizontal Stabilizers

- Stability Coefficient
- Pitching Control
- Yaw Control
- Weight

Wing Placement Configuration

- Weight
- Loading
- Coefficient of Lift (max)
- Coefficient of Drag (min)
- Lift-to-Drag Ratio

Landing Gear Configuration

- Weight
- Strength
- Coefficient of Drag
- Control

Fuselage Design

- Weight
- Strength
- Coefficient of Drag
- Length

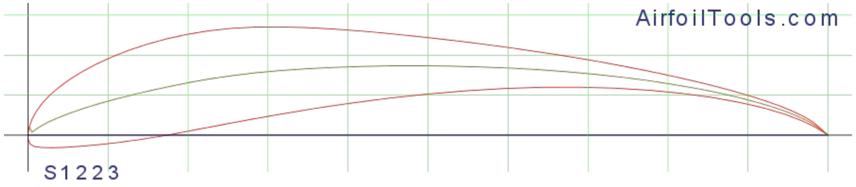
Payload Configuration

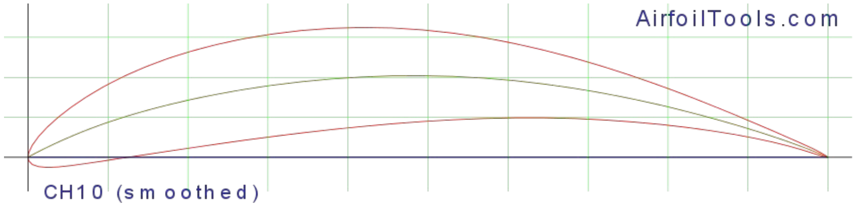
- Payload
- Weight
- Cost
- Ease of Construction

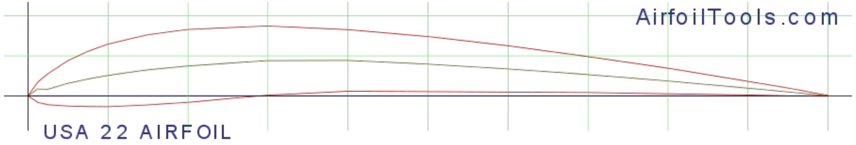
Relative Weights of Criteria - Landing Gear

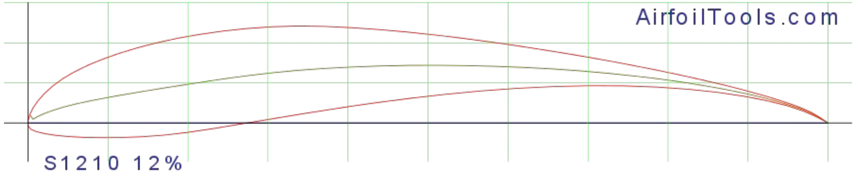
Criteria	Weight	Strength	Coefficient of Drag	Control	Raw Total	Normalized Weights
Weight	-	0	1	0	1	**0.166666667**
Strength	1	-	0	0	1	**0.166666667**
Coefficient of Drag	0	1	-	0	1	**0.166666667**
Control	1	1	1	-	3	**0.5**

Concept Generation - Airfoil





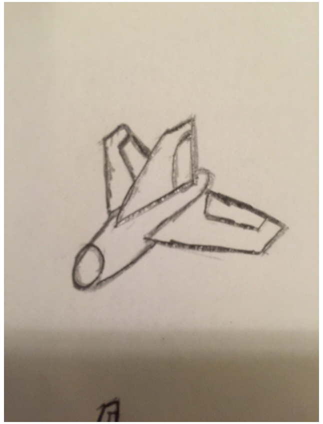




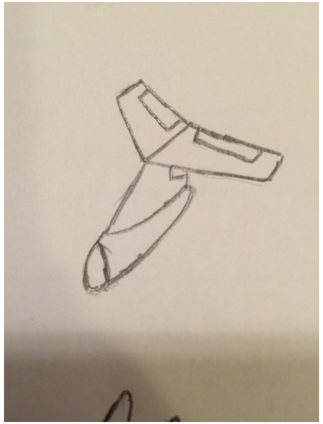
Airfoil Weighted Decision Matrix

Decision Factors		S1223	CH10	USA22	S1210		
Criteria	Wt.	1	2	4	5	Criteria	Definition
Coefficient of Lift (max)	0.2	5	4	4	2	Coefficient of Lift (max)	The airfoil with the highest maximum lift coefficient
Design Lift Coefficient	0.1	4	3	2	2	Design Lift Coefficient	The airfoil with the proper ideal or design lift coefficient
Coefficient of Drag (min)	0.1	2	4	3	1	Coefficient of Drag (min)	The airfoil with the lowest minimum drag coefficient
Lift to Drag Ratio	0.3	5	2	5	5	Lift to Drag Ratio	The airfoil with the highest lift-to-drag ratio
Lift Curve Slope (max)	0.1	5	5	1	3	Lift Curve Slope (max)	How much flexibility of site layout is possible without CSS and PHP code
Pitching Moment Coefficient	0.1	4	2	2	2	Pitching Moment Coefficient	The airfoil with the lowest (closest to zero; negative or positive) pitching moment coefficient
Stall Quality	0.1	5	2	2	4	Stall Quality	The proper stall quality in the stall region (the variation must be gentle, not sharp).
Weighted Scores		4.5	3.0	3.3	3.1		

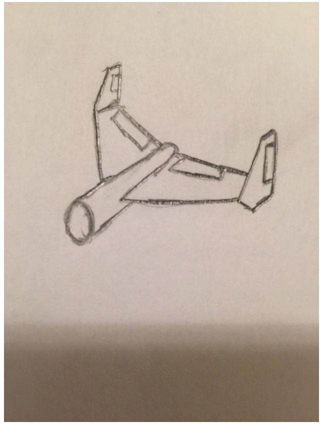
Concept Generation - Vertical and Horizontal Stabilizers



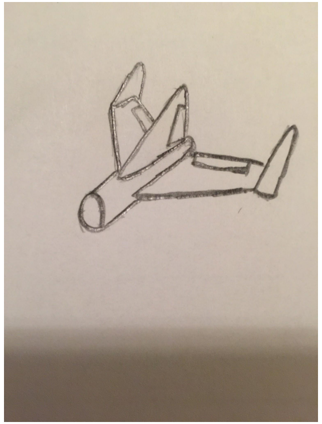
Conventional Tail



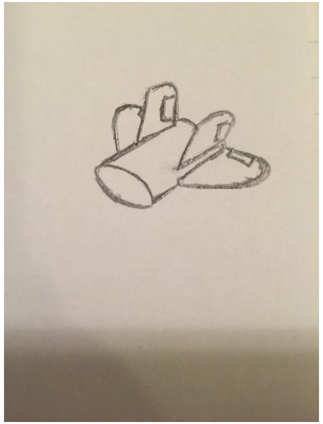
T-tail



Dual Tail



Triple Tail



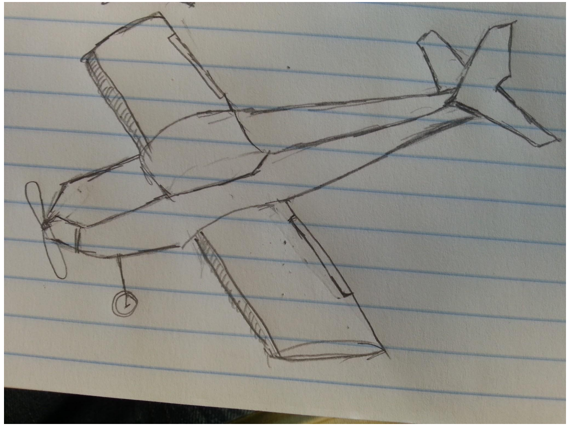
Twin Tail

Vertical and Horizontal Stabilizers Decision Matrix

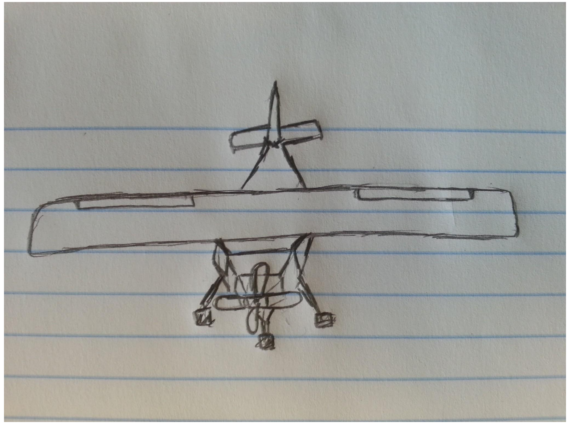
Decision Factors		Conventional Tail	T-tail	Dual Tail	Triple Tail	Twin Tail		
Criteria	Wt.	1	2	3	4	5	Criteria	Definition
Stability Coefficient	0.30	4	3	3	3	4	Stability Coefficient	The higher the stability coefficient, the straighter the airplane will move
pitching control (up and down)	0.25	4	4	3	2	4	pitching control (up and down)	The horizontal stabilizer prevent up and down motion of the nose of the airplane
yaw control (right and left)	0.25	4	4	3	3	5	yaw control (right and left)	The vertical stabilizer prevent the airplane from swinging side to side
Weight	0.20	4	4	3	2	3	Weight	The weight of the tail
Weight Scores		4.0	3.7	3.0	2.6	4.1		

Scale: 1 - 5, 5 being the best

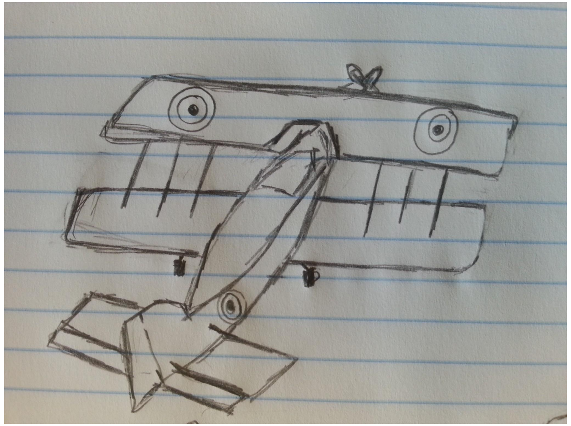
Concept Generation - Wing Placement Configuration



MONOWING LOW PLACEMENT



MONOWING HIGH PLACEMENT



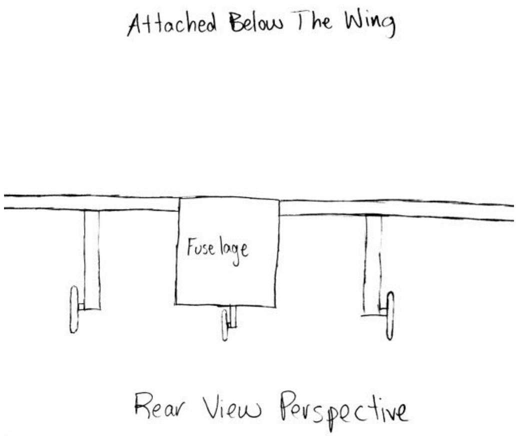
BIPLANE

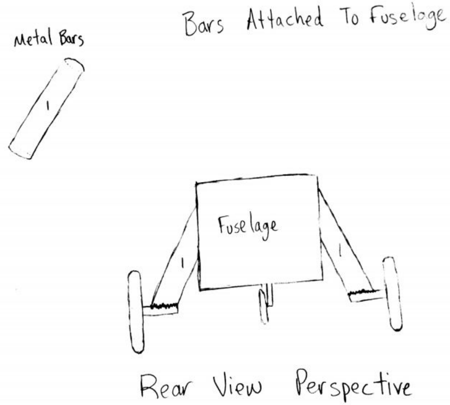
Wing Placement Configuration Weighted Decision Matrix

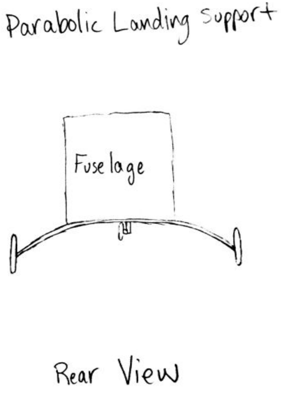
Decision Factors		MONOWING LOW PLACEMENT	MONOWING HIGH PLACEMENT	BIPLANE		
Criteria	Wt.	1	2	3	Criteria	Definition
Weight	0.1	5	4	2	Weight	overall wing weight
loading	0.1	4	5	3	loading	Eases and facilitates the loading and unloading of loads and cargo into and out of cargo aircraft
Coefficient of Lift (max)	0.2	5	4	5	Coefficient of Lift (max)	The wing configuration with the highest maximum lift coefficient
Coefficient of Drag (min)	0.2	4	5	3	Coefficient of Drag (min)	The airfoil with the lowest minimum drag coefficient
Lift to Drag Ratio	0.4	4	5	2	Lift to Drag Ratio	The airfoil with the highest lift-to-drag ratio
Weighted Scores		4.3	4.7	2.9		

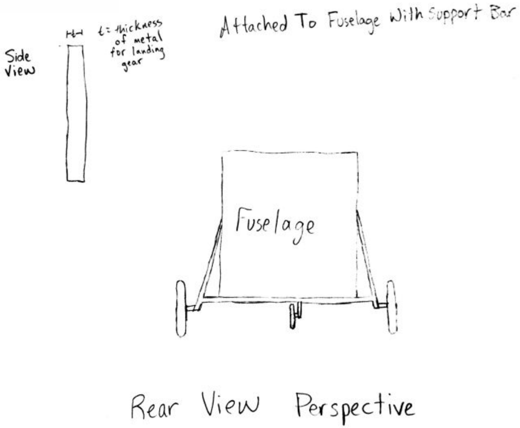
Scale: 1 - 5, 5 being the best

Concept Generation - Landing Gear









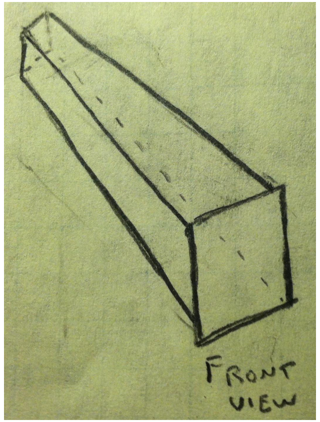
Landing Gear Configuration Weighted Decision Matrix

Decision Factors		Tail Dragger	Attached Below The Wing	Bars Attached To Fuselage	Parabolic Landing Support	Attached to Fuselage With Stabilizing Bar		
Criteria	Wt.	1	2	3	4	5	Criteria	Definition
Weight	0.16	5	1	1	4	3	Weight	Overall weight that the landing gear adds to the plane
Strength	0.16	3	4	3	3	5	Strength	The amount of force that the landing gear can withstand in landing and taking off
Coefficient of Drag	0.16	5	1	2	4	2	Coefficient of Drag	The landing gear with the lowest minimum drag coefficient
Control	0.5	1	5	4	2	4	Control	How easy the pilot can control the plane while it is on the ground
Weighted Scores		2.6	3.5	3.0	2.8	3.6		

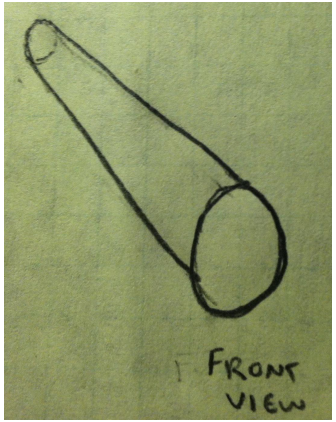
Scale: 1 - 5, 5 being the best

Concept Generation - Fuselage Design

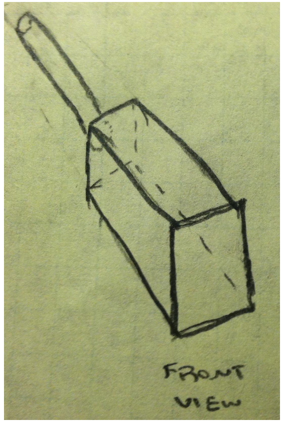
Design 1:
Rectangular Prism



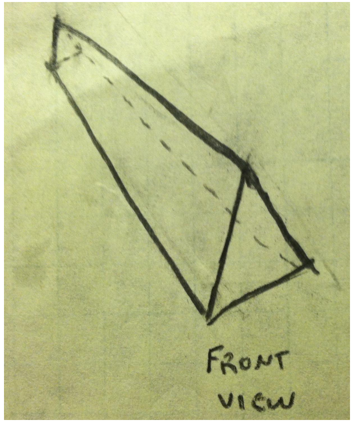
Design 2:
Cylinder



Design 3:
Bar



Design 4:
Triangular Prism

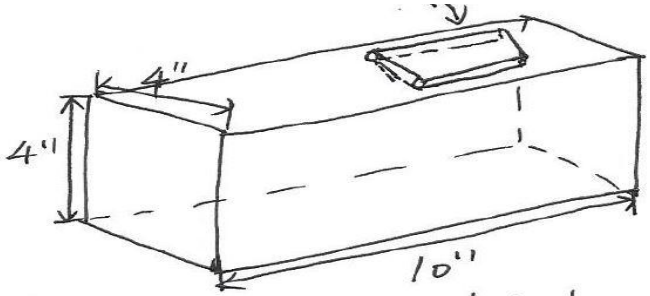


Fuselage Design Weighted Decision Matrix

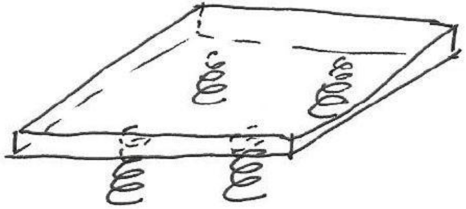
Decision Factors		Rectangular Prism	Cylindrical	Bar Design	Triangular Prism		
Criteria	Wt.	1	2	3	4	Criteria	Definition
Weight	0.3	5	5	2	5	Weight	Overall weight that the fuselage adds to the plane
Strength	0.3	4	2	3	5	Strength	How much force the fuselage design can have exerting on it before it breaks
Coefficient of Drag	0.3	4	5	2	3	Coefficient of Drag	The fuselage with the lowest minimum drag coefficient
Length	0.1	5	4	3	4	Length	The shortest fuselage the plane can have
Weighted Scores		4.4	4.0	2.4	4.3		

Scale: 1 - 5, 5 being the best

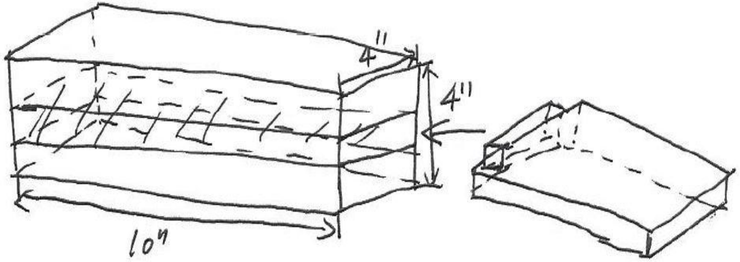
Concept Generation - Aircraft Payload



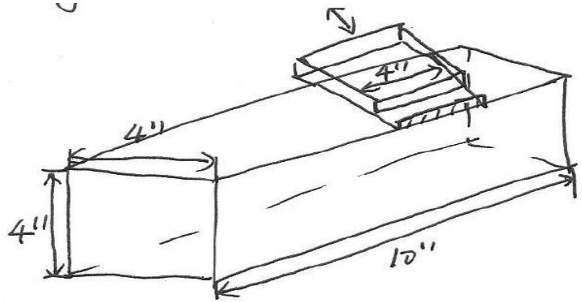
design 1: box hinged Lid.



design 2: spring Load plate.



design3: removeable center seam box.



design4: box sliding lid.

Payload Configuration Weighted Decision Matrix

Decision Factors		Box w/ Hinged Lid	Spring Loaded Plates	Removable Center Seam Box	Box w/ Sliding Lid		
Criteria	**Wt.**	**1**	**2**	**3**	**4**	**Criteria**	**Definition**
Payload (max)	0.15	3	3	3	3	Payload (max)	Overall payload weight
Weight	0.40	3	2	1	4	Weight	Total weight of configuration
Cost	0.30	2	1	3	2	Cost	Cost of payload configuration material
Ease of Construction	0.15	4	1	3	4	Ease of Construction	Time required to construct
Weighted Scores		2.9	1.7	2.2	3.3		

Scale: 1 - 5, 5 being the best

Updated Project Plan

Task	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	W 15
Client meeting															
Define problem and layout project plan															
Research design															
Research protocol writing															
Research parts of design															
Functional diagram															
Concept Generation															
Decision Matrix															
Sketch Parts															
Pick a final design (decision matrix)															
Proof of Concept Discussion															
Project Proposal Discussion															
Finalize design															
Problem Definition and Project Plan Presentations				◆											
Concept Generation and Selection Presentations								◆							
Proof of Concept Demonstrations											◆				
Project Proposal Presentations														◆	

Conclusions

- The functional diagram illustrates the overview of the electronic aspect of the remote control aircraft
- The team used decision matrices to determine the best alternatives for the airplane design with the chosen criteria
- For the airfoil, the team will use the S1223.
- For the vertical and horizontal stabilizers, the team will use the twin tail
- For the wing placement configuration, the team will use the high placement monowing

Conclusions

- For the landing gear configuration, the team is attaching the landing gear to the fuselage with a stabilizing bar.
- For the payload bay configuration, the team will use a box with a sliding lid.
- The project plan shows that the team is on track and progressing throughout the schedule

References

[1] *What-When-How, “Tail design”, Conventional Tail, T-tail, Dual Tail, Triple Tail and Twin Tail. Available: what-when-how.com.*

[2] *National Aeronautics and Space Administration, ”structures and materials”, aircraft background, P3-4.*

[3] *P. J. Pritchard, Introduction to Fluid Mechanics 8th Edition. Fox and McDonald. Wiley, 2011.*

[4] *M. H. Sadraey, Aircraft design: a systems engineering approach. Hoboken, New Jersey: Wiley, 2012.*

[5] *“Airfoil Tools,” Airfoil Tools. [Online]. Available at: http://airfoiltools.com/. [Accessed: 2015].*