Final Presentation

FCAAP: AIAA Design Build Fly

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FCAAP

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[4/18/13]

Presentation Outline

Project Overview

- AIAA "Design Build Fly"
- Competition Basics
- Specific Requirements

Design

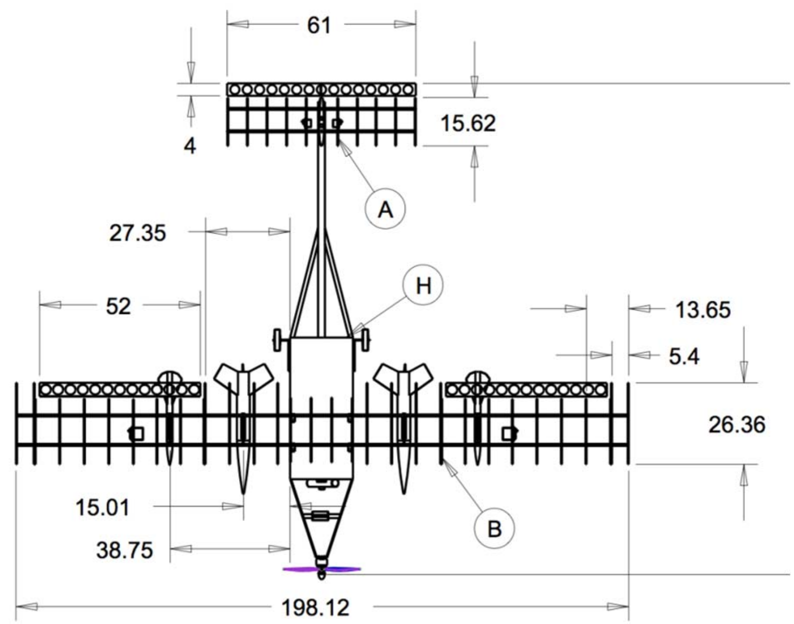
- Aircraft Components
- Sub Assemblies
- Propulsion Circuit
- Electronics

Build

- Construction Processes
- Completed Plane

Fly

- Final Results



Project Overview

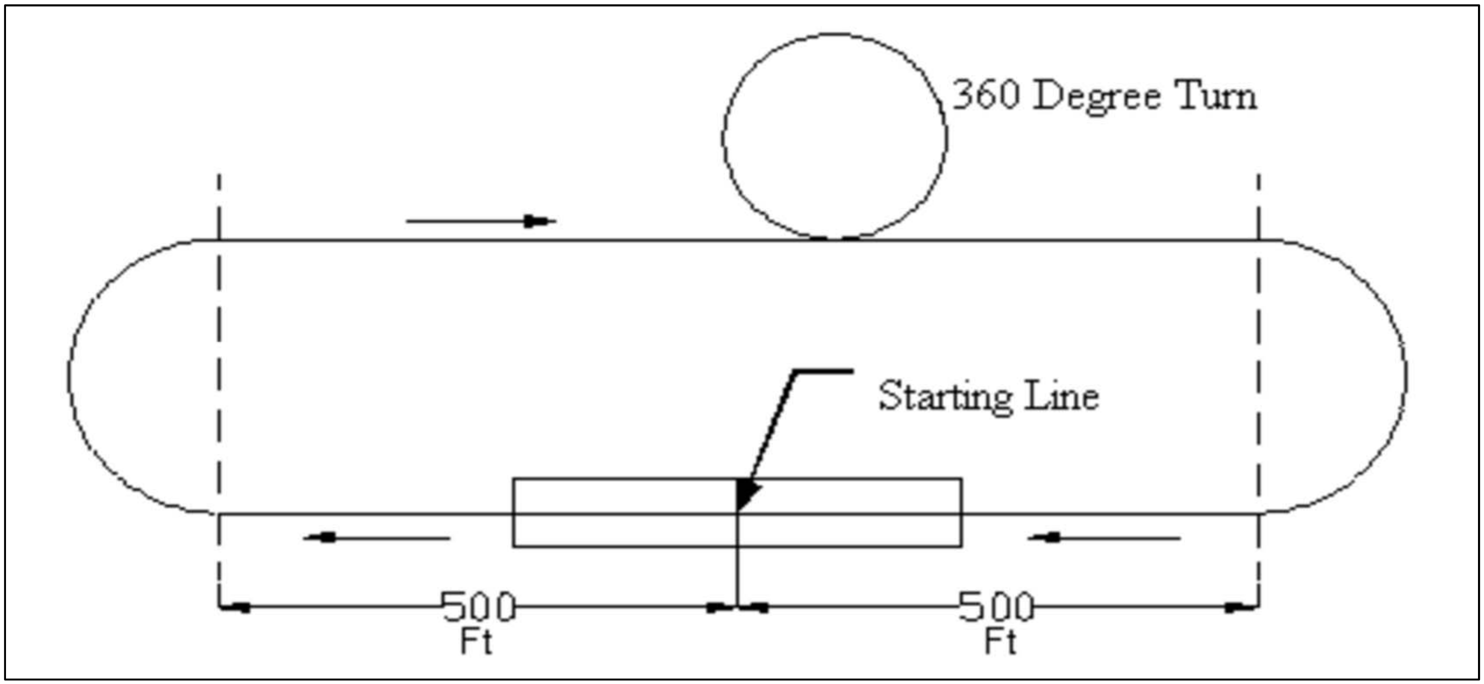
OBJECTIVES:

- Design and build an electrically powered RC aircraft
- Complete 3 flight missions directed by the AIAA Design/Build/Fly competition
- Create a precise written report documenting the process (scored along with flight missions)

Competition Basics

Mission 1:

- Take-off within the prescribed area
- Maximum number of complete laps within a **4** minute flight time
- Mission score: M1= **2** * (N_Laps_Flown/Max_N_Laps_Flown)



Competition Basics

Mission 2:

- Take-off within the prescribed area
- 3 Lap internal-stores flight
- Internal Store – MiniMax Rocket

MiniMax
0.25 lbs.

- Mission score:

M2= **4** * (#_Stores_Flown/Max_#_Stores_Flown)

Competition Basics

Mission 3:

- Take-off within the prescribed area
- 3 lap mixed-stores (internal & external) flight
- Mission score: M3= **6** * (Fastest_Time_Flown/Team_Time_Flown)

MiniMax
0.25 lbs.

Honest John
0.75 lbs.

Hi-Flyer
0.50 lbs

Der Red Max
1.0 lbs.

Specific Requirements

Competition Restrictions:

- Propulsion circuit battery pack must weigh ≤ 1.5 lbs.
- Batteries must be NiMH or NiCad
- Current draw limited to 20 Amps by inline fuse

Challenge:

- Power = Voltage*Amperage
- Available components utilize low voltage and high amperage
- 20 amp limit forces competitors to run excessive voltage to reach desired power level

Specific Requirements

Weight Vs. Power Concerns

- Internal/External Rockets + Battery Packs = 4.5 lbs.
- Max Power available ≈ 500 Watts
- General Power Rule: 220 Watts per pound → Allows only 2.4 lbs.!
- *** This DOES NOT include the additional weight of the aircraft itself

Aircraft Underpowered

- Tasked with designing/building a plane that is vastly underpowered
- Oversized due to the necessity of internal rocket storage
- While also high-strength to support internal/external rocket weights

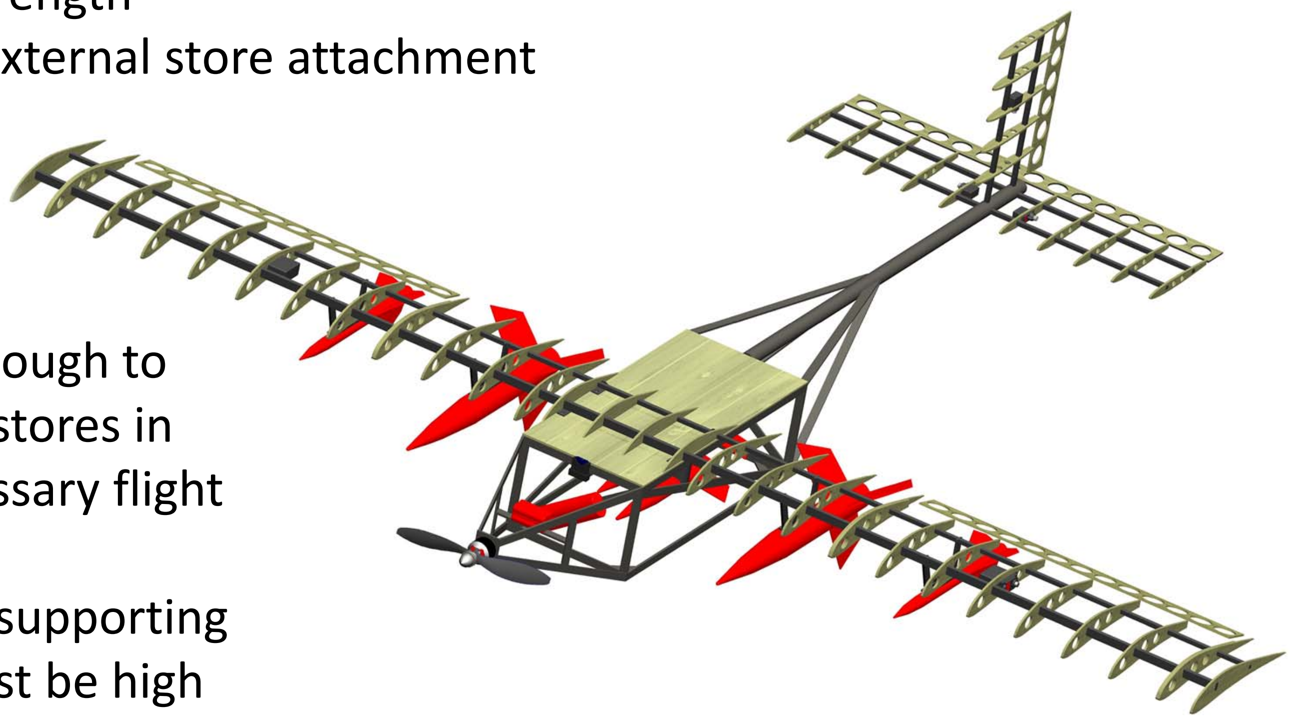
Aircraft Components

Wing

- Max Coefficient of lift
- Extremely light weight construction
- High material strength
- Must allow for external store attachment

Tail

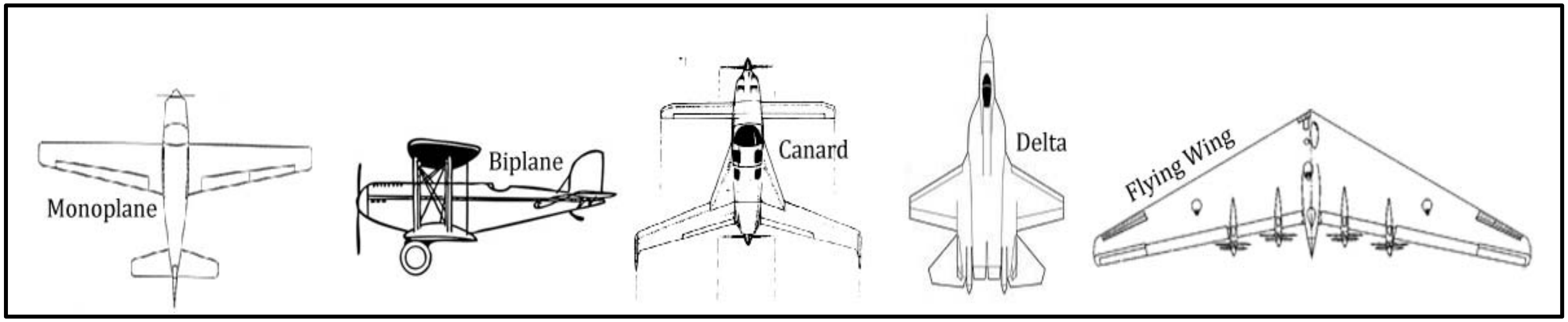
- Defines flight stability and control



Fuselage

- Must be large enough to contain internal stores in addition to necessary flight components
- Acts as skeleton supporting entire plane, must be high strength

Wing Selection



Monoplane:

- Stable flight characteristics
- Exterior storage capacity
- Less complexity

Airfoil	Max Cl	Stall Angle (deg)	Max Aerodynamic Efficiency (Cl/Cd)	α at Max Eff (deg)	Cl at α
NACA 4412	1.55	12.00	70.60	6.00	1.20
NACA 65-418	1.45	9.00	48.30	6.00	0.97
Eppler 422	1.474	17.00	85.29	6.00	1.45
DAE 11	1.78	15.00	56.00	10.00	1.56

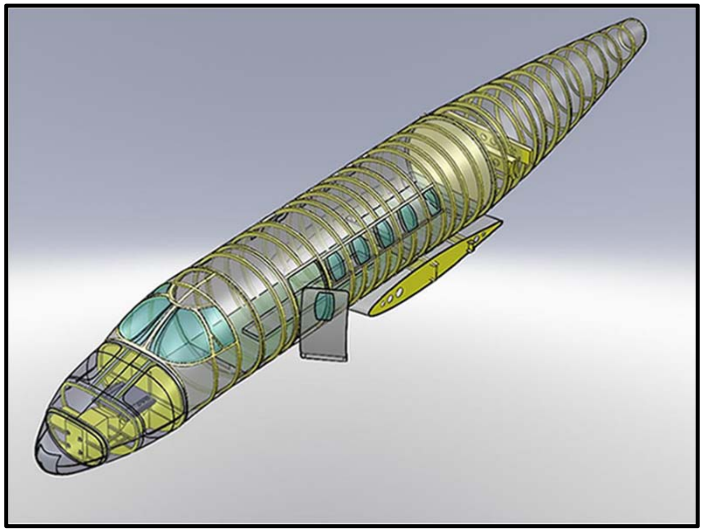
Fuselage Selection

Single Boom:

- Largest interior storage capacity
- Less overall drag and weight
- Less design complexity

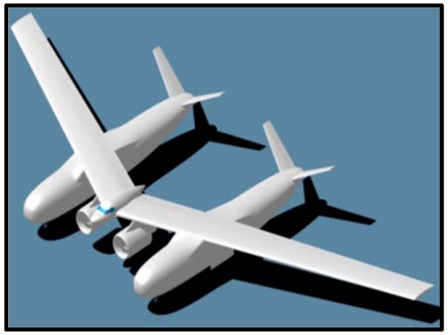
Figure of Merit	Weighting Factor	Double Boom	Single Boom	Blended Body
Weight	0.40	1	3	4
Drag	0.20	2	4	5
Durability	0.10	3	4	5
Storage Capacity	0.30	5	4	1
Total	**1.00**	**2.6**	**3.6**	**3.4**

Single Boom

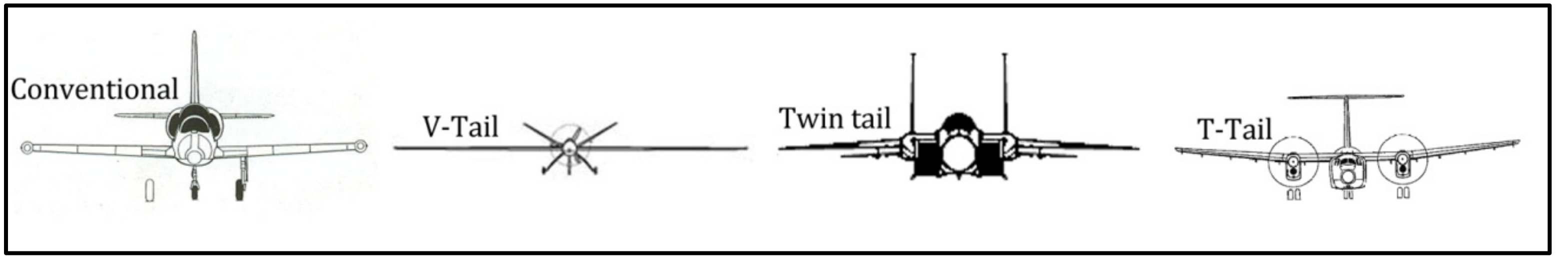


Blended Body

Double Boom



Tail Selection



Conventional Tail:

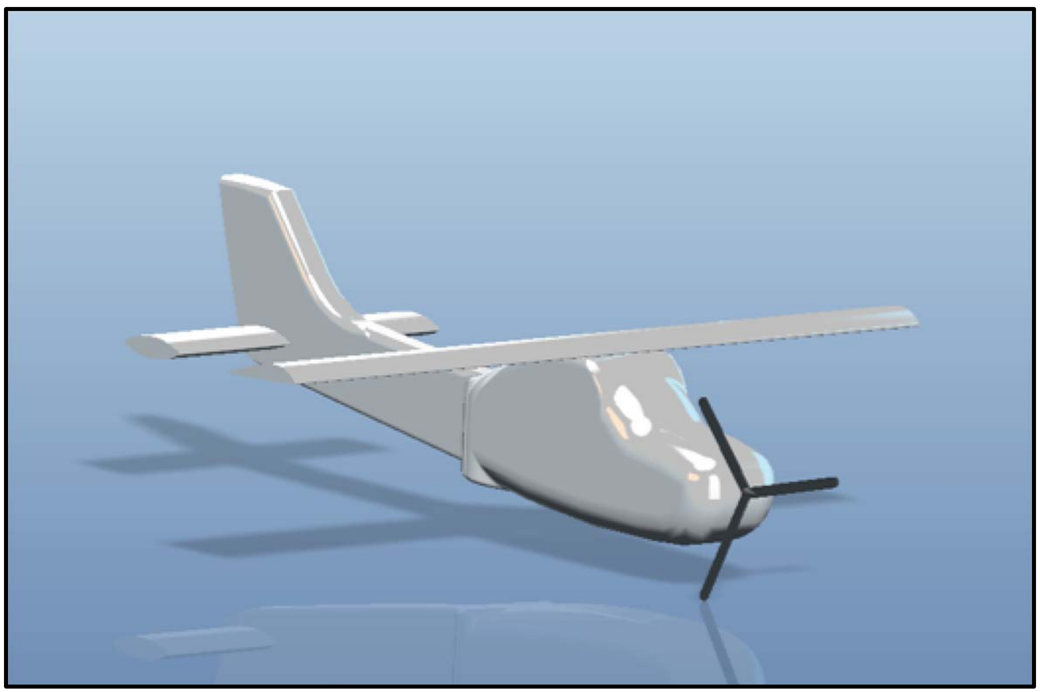
- Stable flight characteristics
- Less design complexity

Figure of Merit	Weighting Factor	Conventional	V-Tail	Twin Tail	T-Tail
Weight	0.15	3	4	3	3
Drag	0.20	4	5	3	3
Stability	0.35	5	2	3	3
Maneuverability	0.20	5	2	4	4
Manufacturability	0.10	4	2	3	3
Total	**1.00**	**4.40**	**2.90**	**3.20**	**3.20**

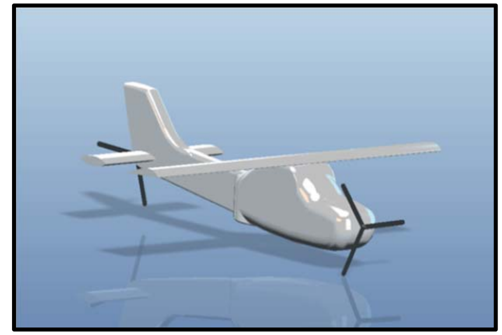
Propeller Configuration

Tractor:

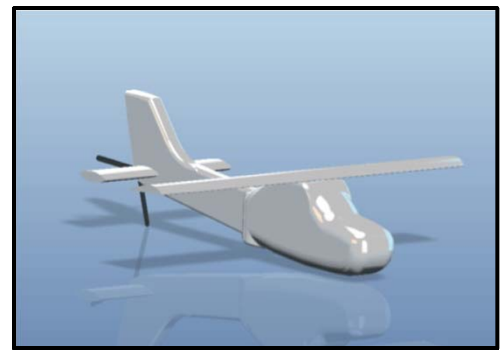
- Efficient propulsion
- Increased controllability
- Better performance



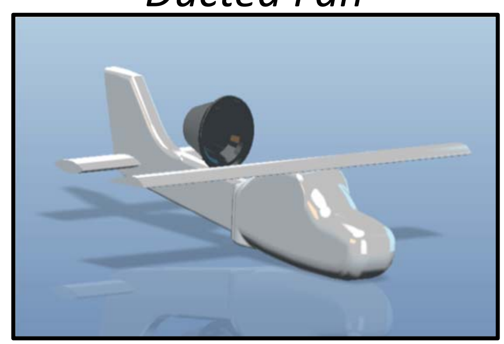
Pusher - Puller



Pusher

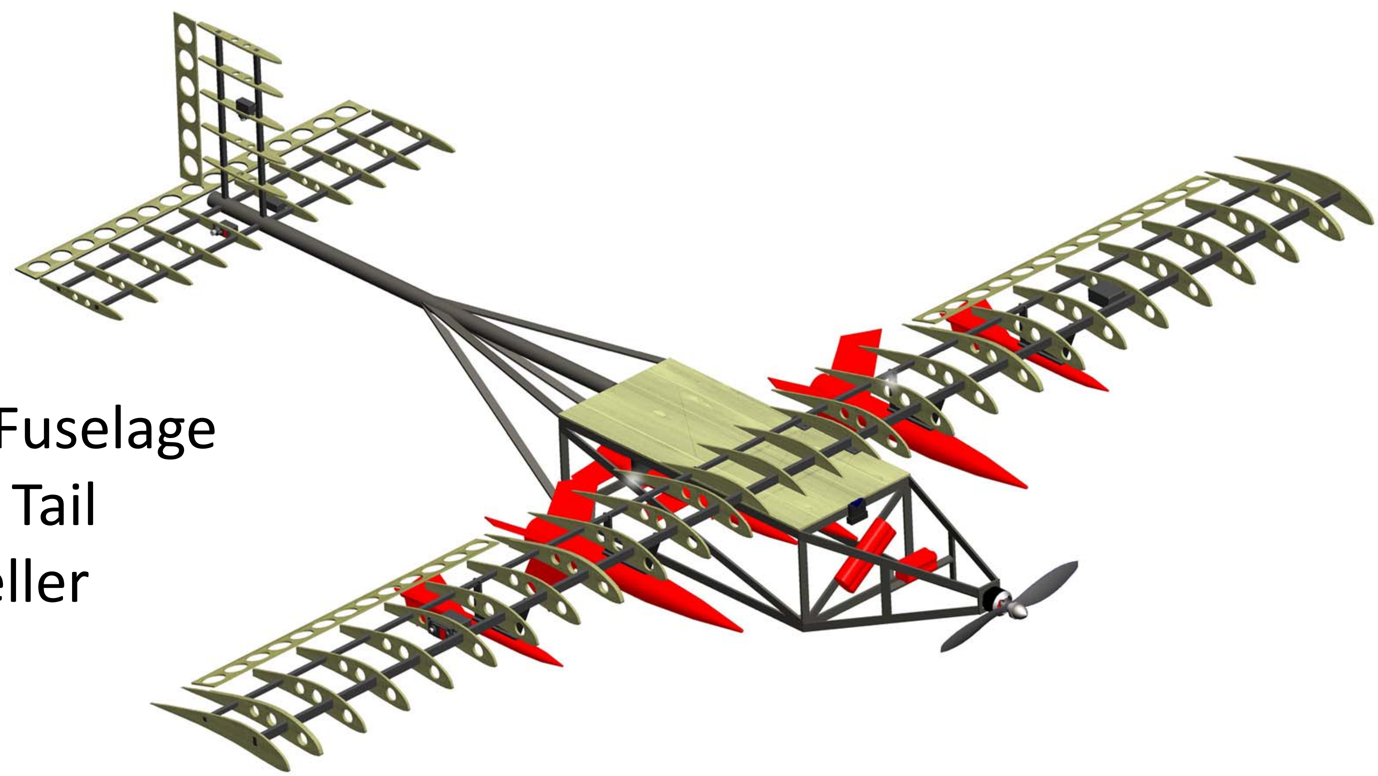


Ducted Fan



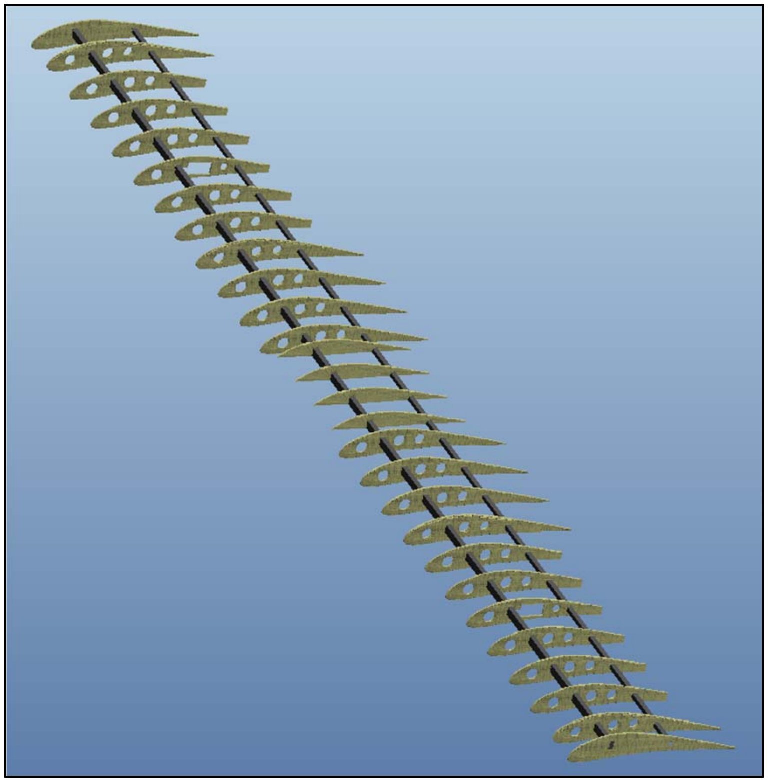
Overall Aircraft Configuration

- Monowing
- Single Boom Fuselage
- Conventional Tail
- Tractor propeller



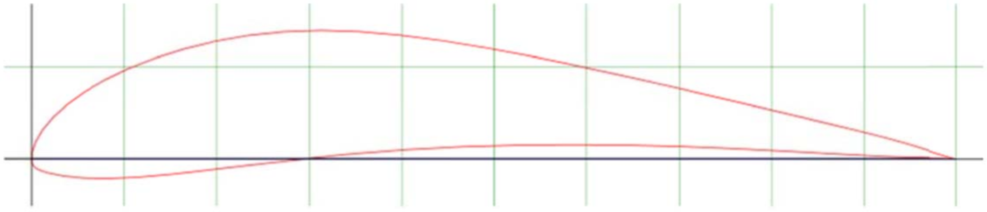
Wing - Eppler 422

- High lift at low Reynolds numbers
- Low drag at cruising state



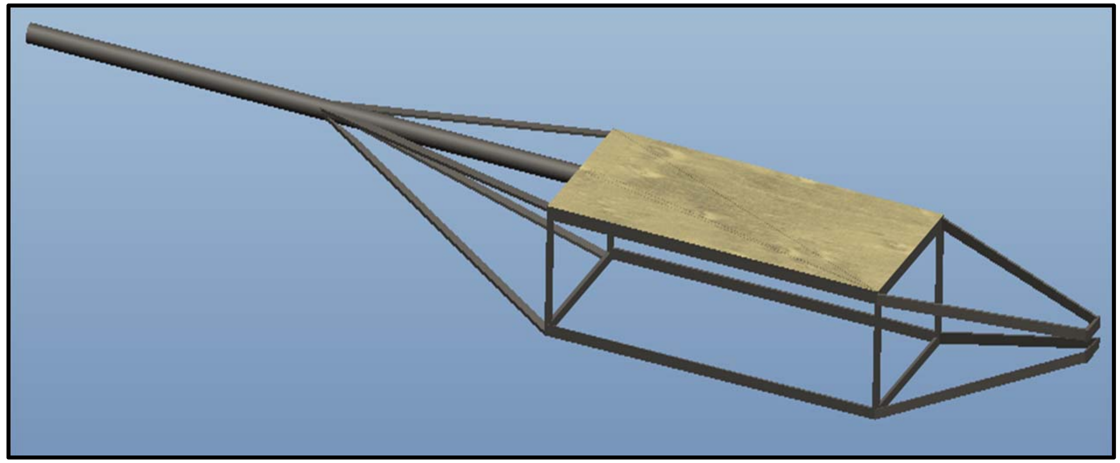
Wing Area (S)	806.4 in^2
Span (b)	77.77 in
Chord (c)	10.37 in
Aspect Ratio (AR)	7.5
Minimum Takeoff Speed	21.387 mph

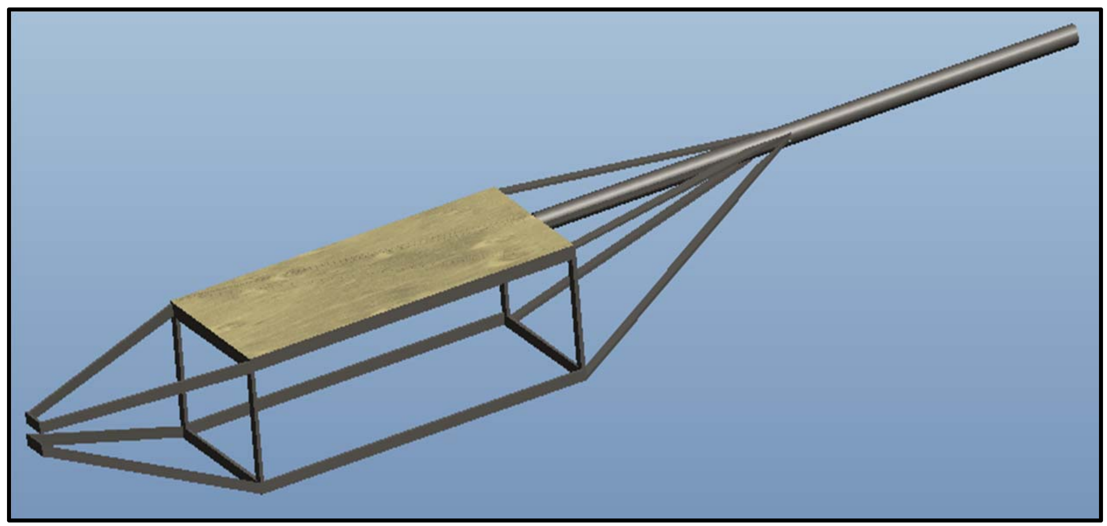
Airfoil Profile



Fuselage

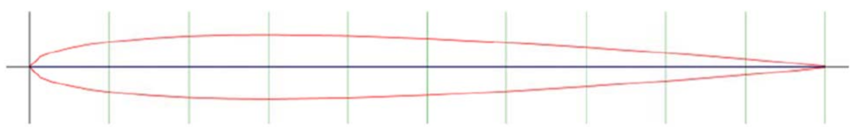
- Constructed with combination of high strength / light weight materials
- Carbon Composite
  Density: 1.6 g/cm^3
- Bass Wood
  Density: 0.3 g/cm^3

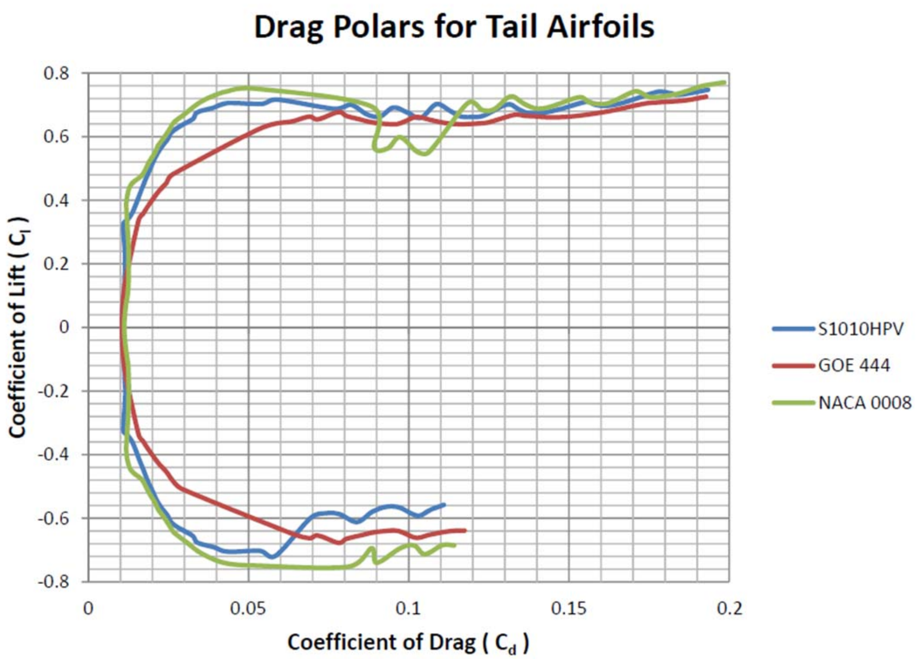


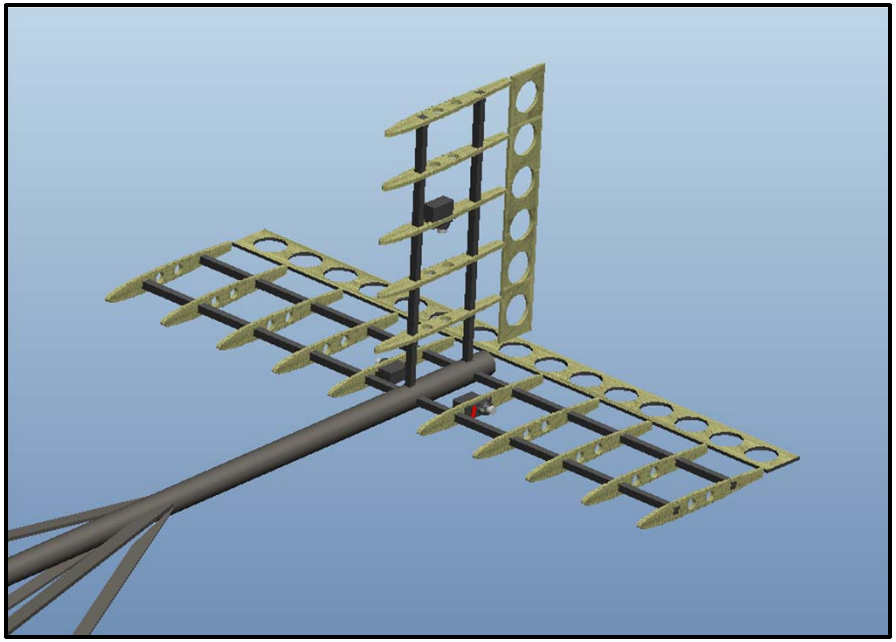


Tail – NACA 0008

- Low drag at high coefficients of lift





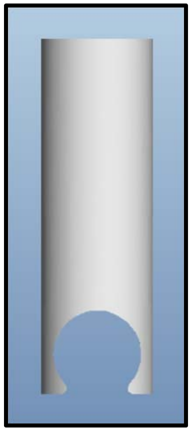
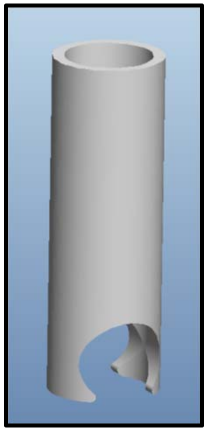
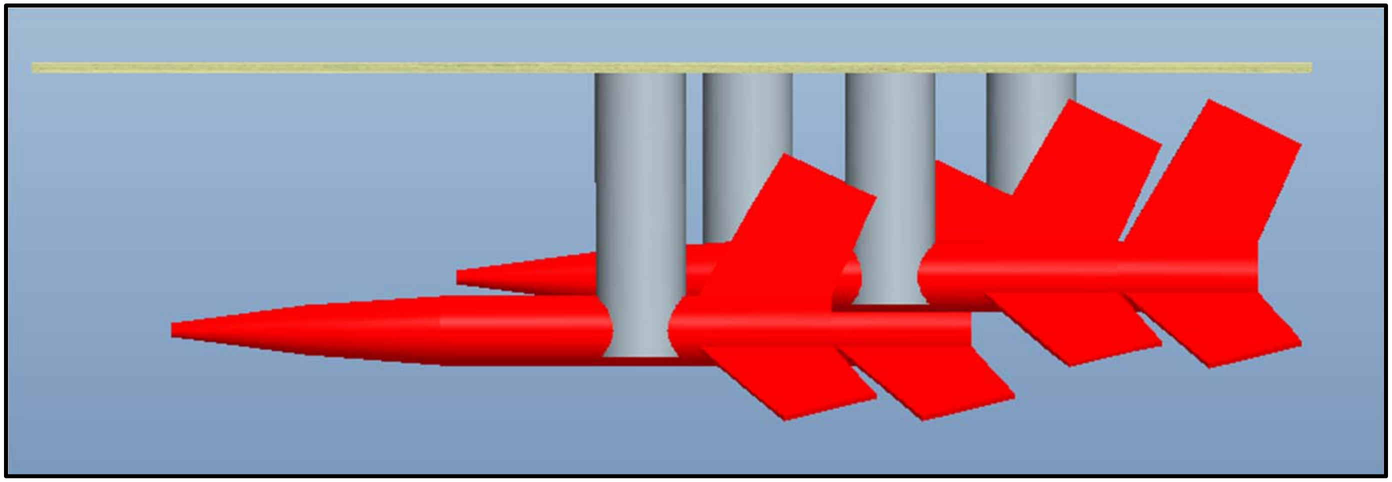


Vertical Span	10.239 inches
Vertical Chord	7.9 inches
Horizontal Span	23.76 inches
Horizontal Chord	7.9 inches
Moment Arm	31.107 inches

Internal Store Attachment

Light weight plastic tubing

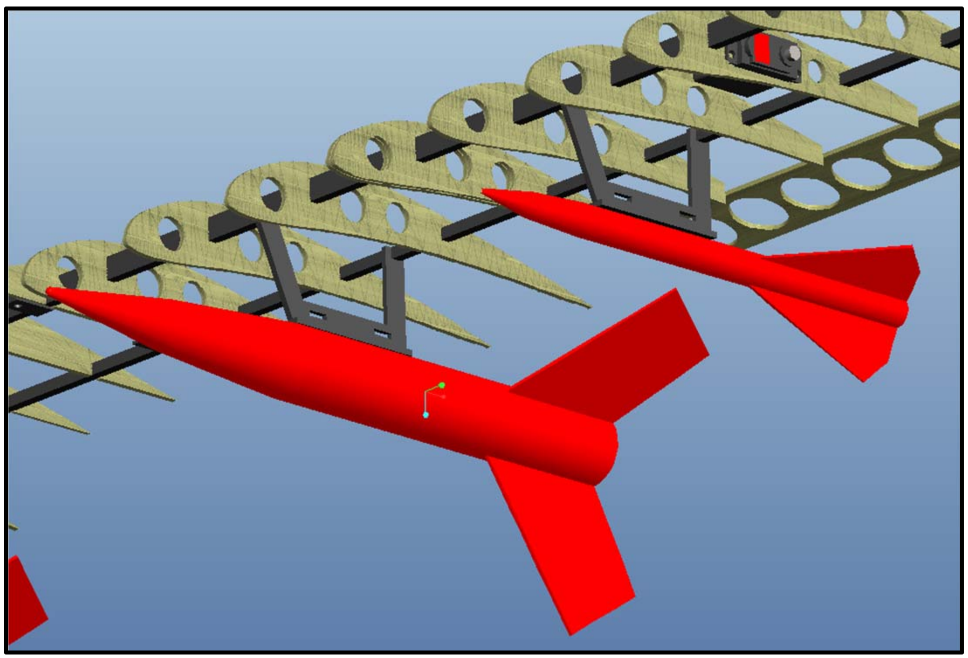
- Single piece design eliminates complicated attachment mechanisms
- Provides secure grasp on outer surface of Minimax internal stores
- Prevents unwanted axial motion during flight

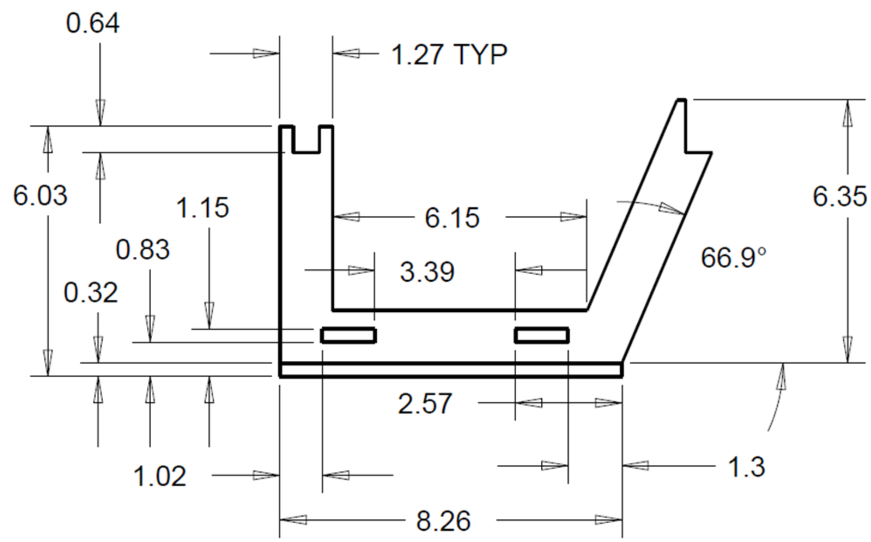




External Store Attachment

Carbon Composite Extensions

- Permanently affixed to primary and secondary main wing spars
- Provide additional wing reinforcement
- Simple tie-strap connection between composite and external rocket





Units (cm)

Aircraft Detailed Design – Propulsion

Battery Requirements:

- High discharge rate
- Eliminates many smaller, higher voltage cell types

Battery Selection:

- 20 A limit requires maximum voltage possible
- Optimal cell type:
  - **Size – 2/3 A**
  - **Volt – 1.2 V**
  - **Capacity – 1500 mAh**

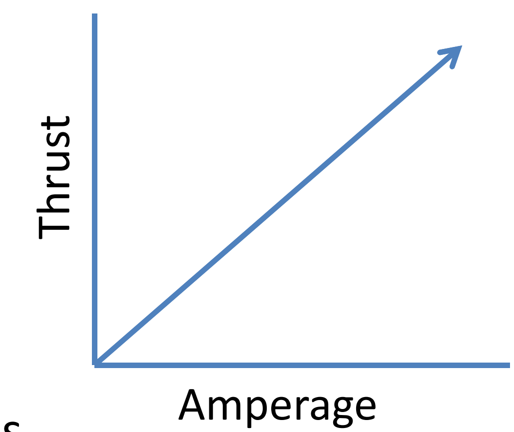
- Pack will yield 26.4 Volts at just under 1.5 lbs.
- Max Power = 528 Watts

Figures of Merit	Supercharge Orion 1500	Speedpack 2400	Traxxis Power Cell 6 Cell 1500	Speedpack 1800	Individual Cell Elite 1500
Cell Voltage	7.2 V	7.2V	7.2V	7.2V	1.2V
Amp-Hours	1600 mAh	2400 mAh	1500 mAh	1800mAh	1500mAh
Weight	8.6 oz	12 oz	8 oz	10.4 oz	0.81 oz
Dimensions (in^3)	4.4 x 2.2 x 0.9	7.7 x 2 x 1	5.6 x 3 x 1	7.6 x 2.1 x 1.2	1.13 x 0.66 x 0.66
Cost	$21.15	$20.81	$11.09	$11.68	$2.75

Aircraft Detailed Design – Propulsion

Velocity and Thrust Requirements

- Wing Loading = 25.73 oz/ft^2
- Stall Speed = 25.36 mph
- Max Speed ≈ 65 mph
- Thrust must be > ½ Total Aircraft Weight



Effect of Thrust on Current Draw

- Increased thrust = Larger pitch = Higher Amps
- Motor / Prop combinations providing necessary thrust draw too much amperage
- **Competition has 20 Amp limit**

Solution

- 2.5:1 Gear box
- Provides mechanical advantage to turn prop with less added torque on motor

Aircraft Detailed Design – Propulsion

E-Flite Power 15 Brushless

Performance

Thrust: 76 oz.

Max Velocity : 60 mph

Amperage Draw: 18.8 A

Full Throttle Duration : 5+ min

APC Prop: Dia-13in Pitch-8in

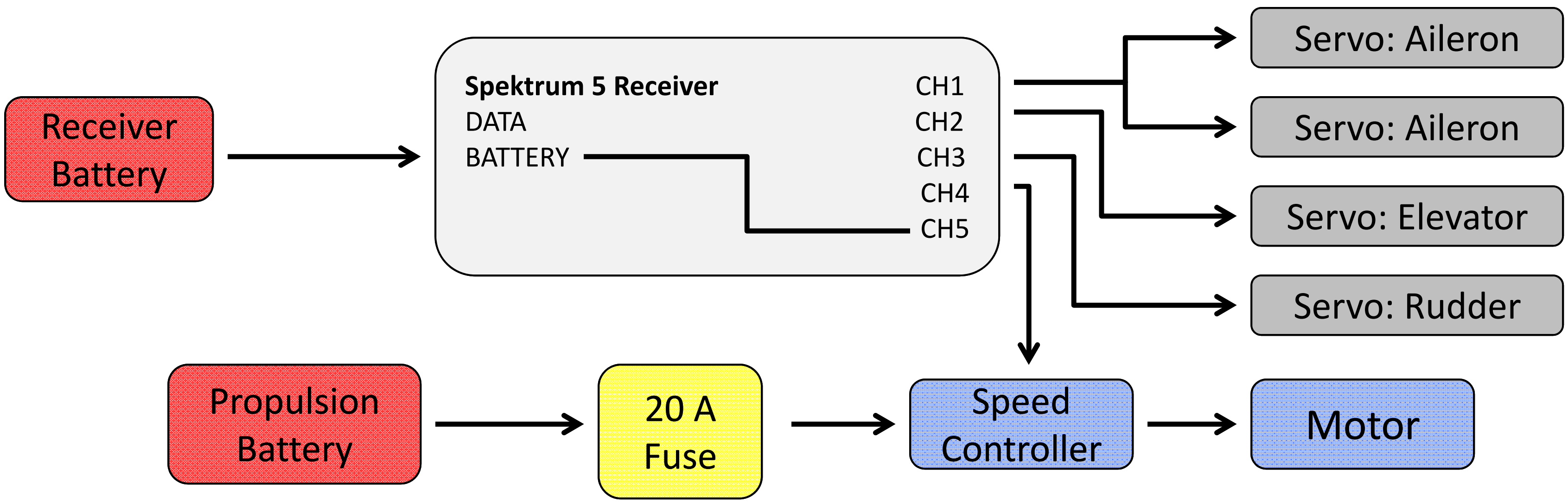
Thrust Ratio

Mission 1: 1.583

Mission 2: 1.357

Mission 3: 1.055

Aircraft Design – Control System Electronics



E-flite Electronic Speed Controller

Spektrum DX5 Transmitter

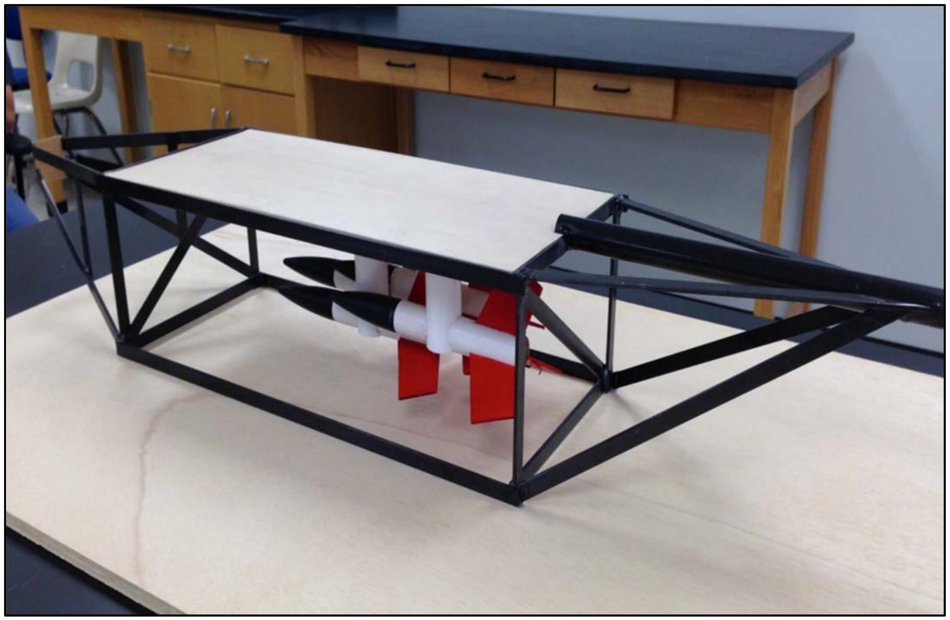
Spektrum 5 Receiver

HiTec Servos

Build Process – Fuselage

Fuselage

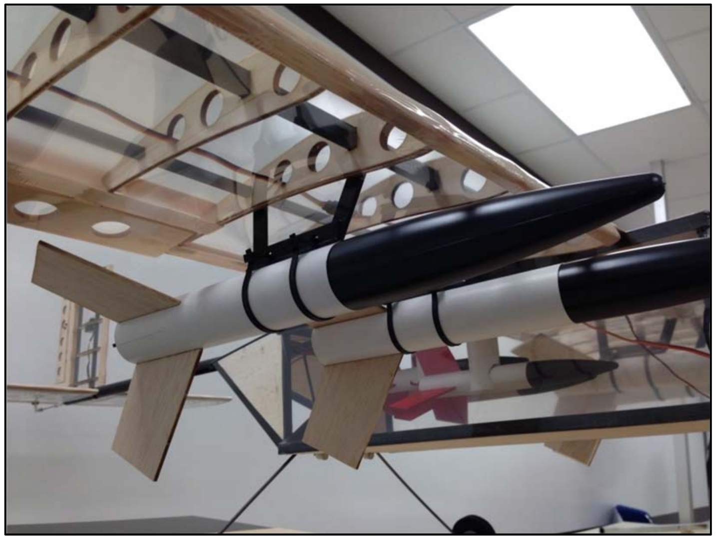
- Carbon Composite Strips
  0.5 in. x 0.125 in.
- Carbon Fiber Tube
  0.75 in. (dia) x 30.0 in. (L)
- Bass Wood Top Plate
  6.0 in. (W) x 18.0 in (L) x 0.125 in. (T)

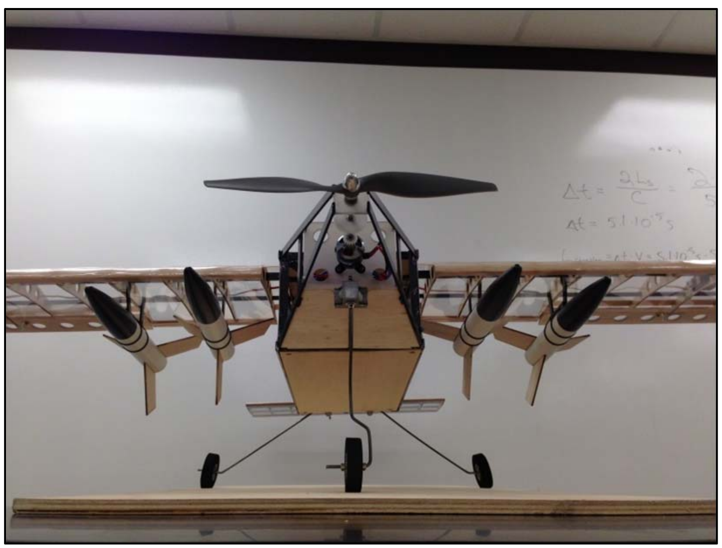


- Bass Wood Bottom Plate
  6.0 in. (W) x 18.0 in (L) x 0.125 in. (T)
- Magnetic Connection Points

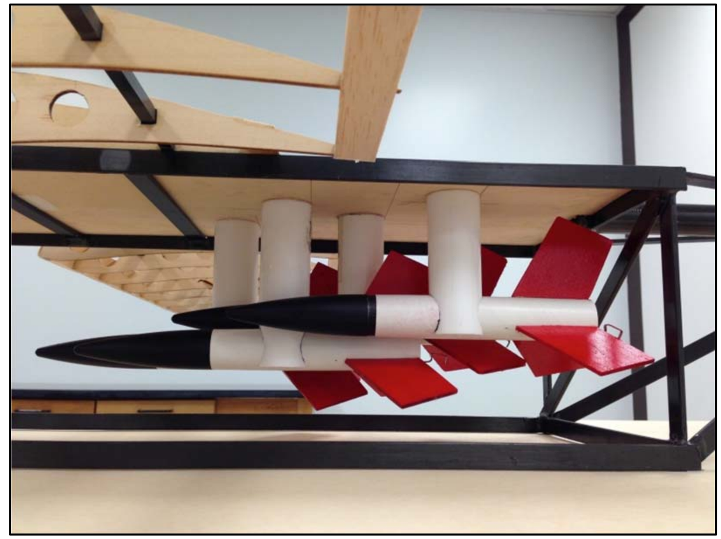
Build Process – Internal/External Assemblies

External





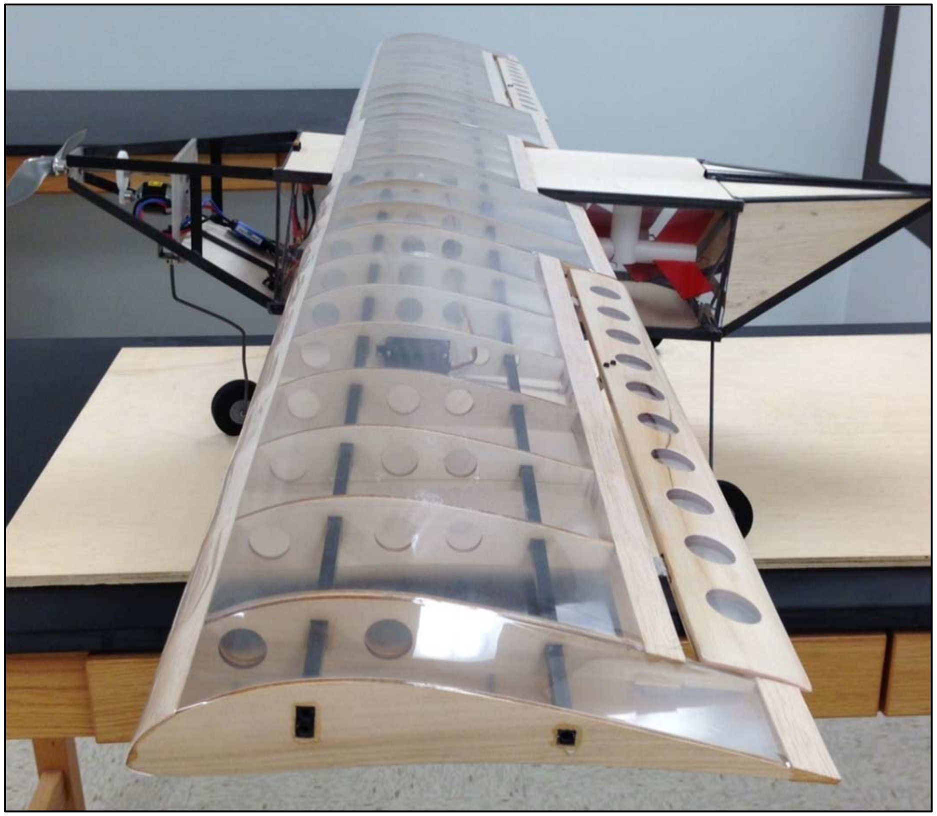
Internal

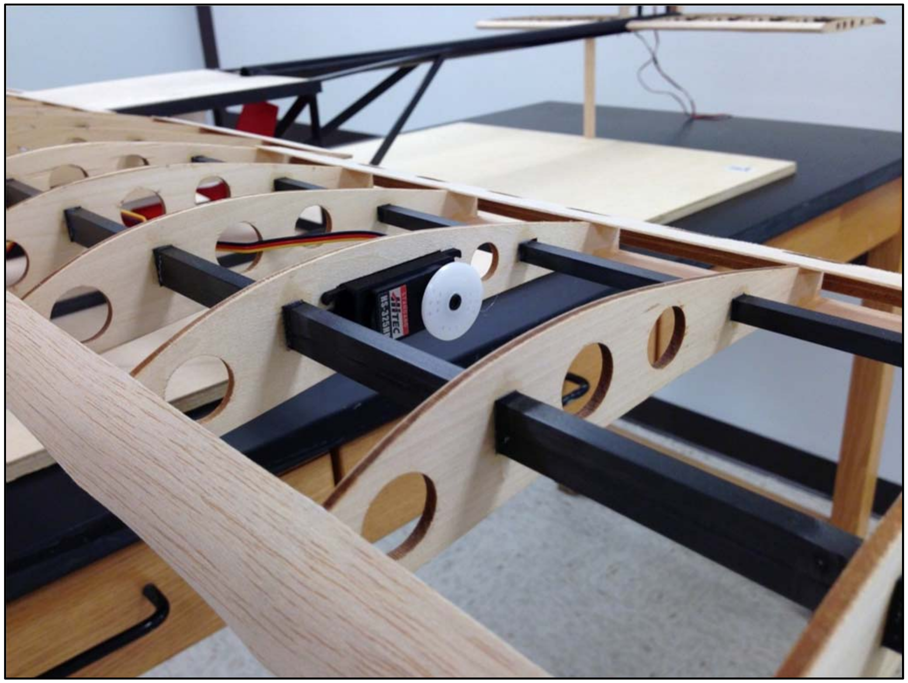


Build Process – Main Wing

Airfoil: Eppler 422

- 78 in. Wingspan
- 806 in^2

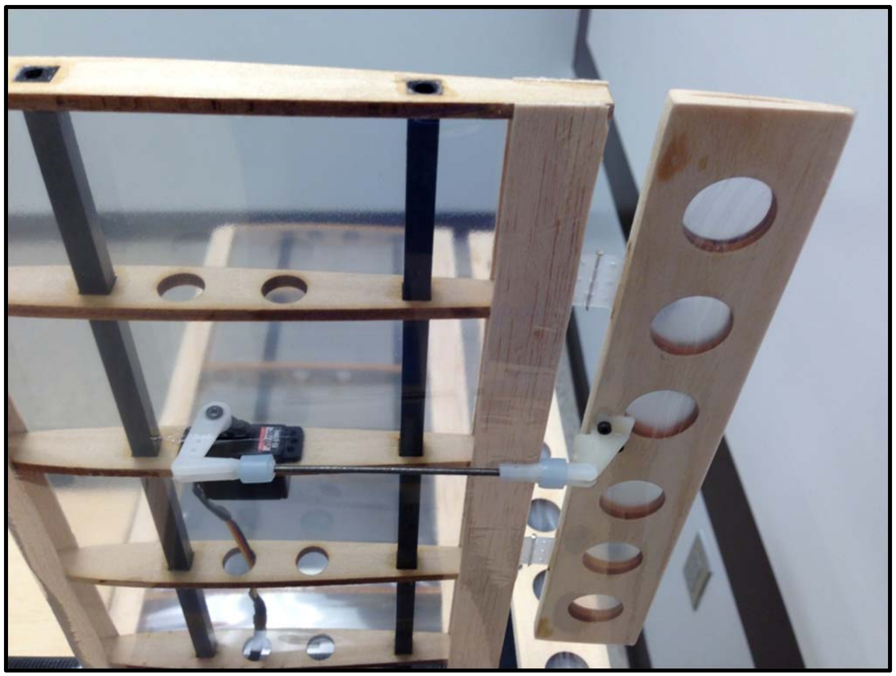


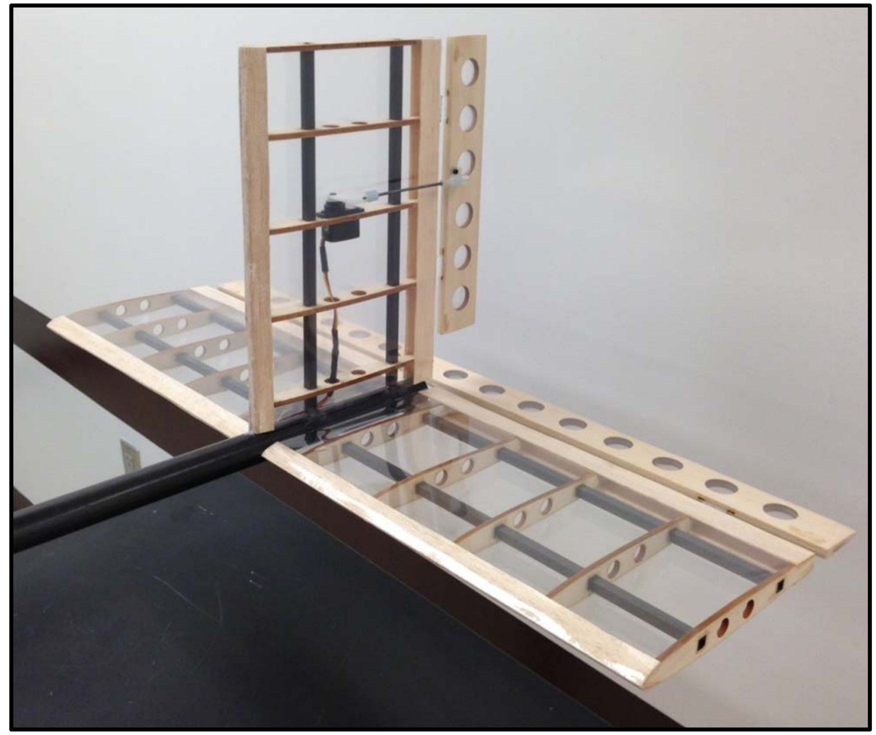


Build Process – Tail

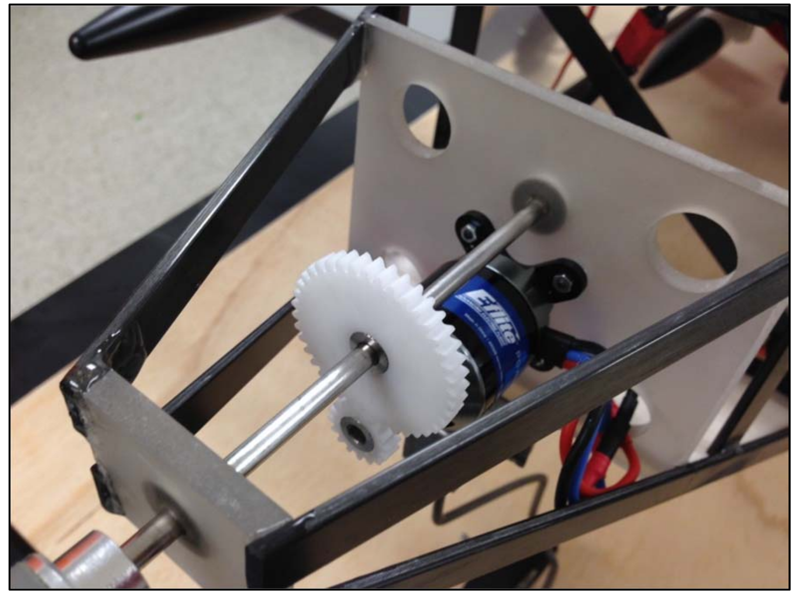
Airfoil : NACA 0008

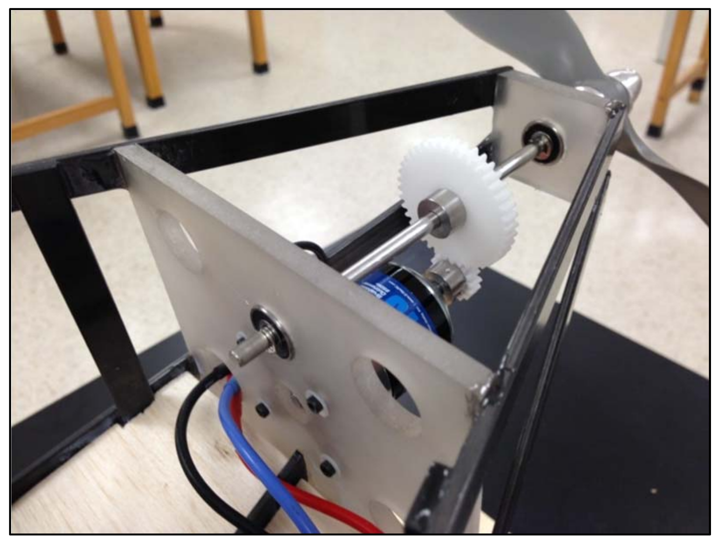
- 10.24 in. Vertical Span
- 23.76 in. Horiz. Span
- 7.90 in. Chord





Build Process – Motor Mount





2.5 : 1 Gear Ratio

- Pinion – 16 tooth (Acetal/Stainless Hub)
- Output – 40 tooth (Acetal/Stainless Hub)

Lexan Plate

- Mounts E-flite Power 15 Motor
- Houses 5mm prop shaft through press-fit bearings
- Attachment point for nose gear

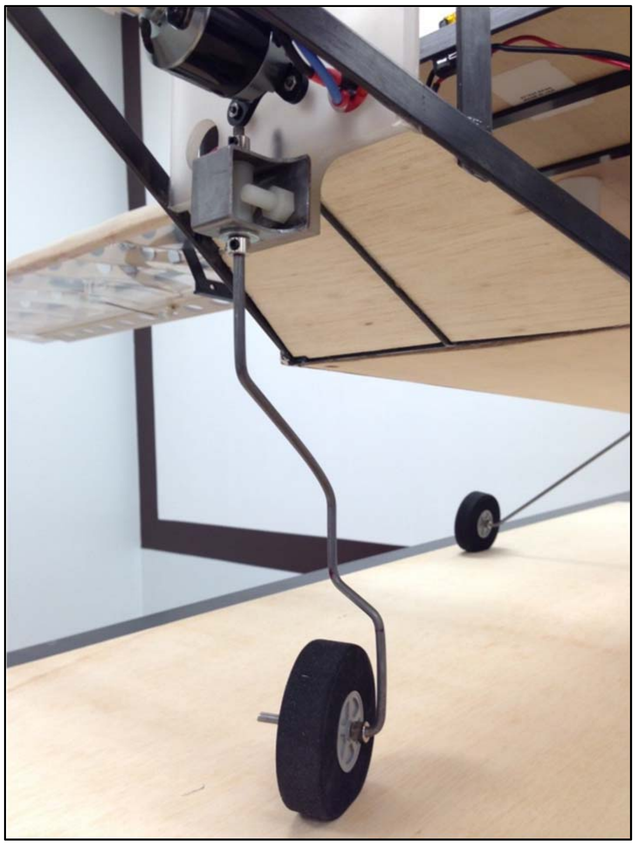
Build Process – Landing Gear

Nose Gear

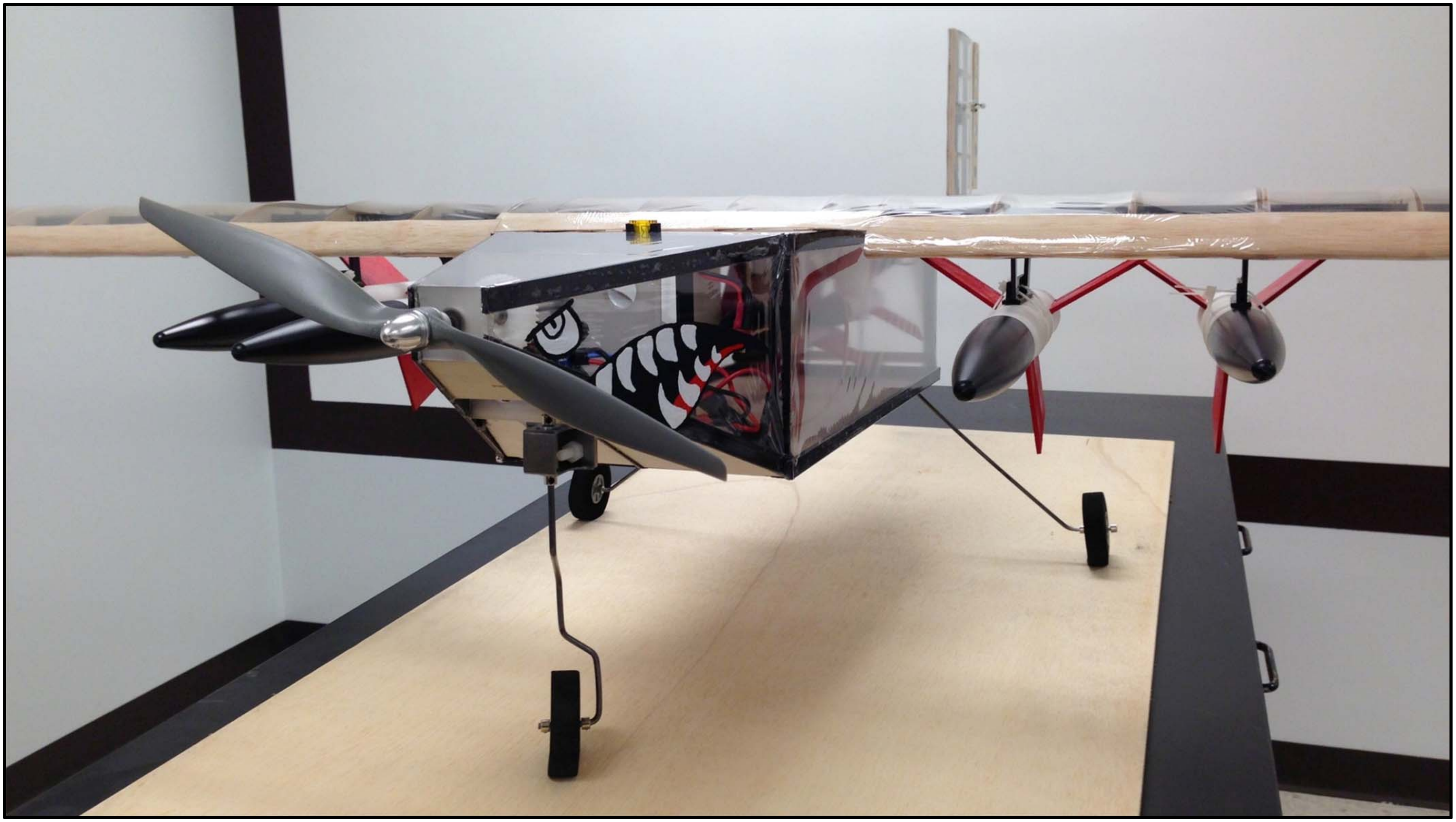
- 5/32 in. spring steel
- 1 in^2 tube machined to house rod
- 5/32 in. collars allow for swivel

Main Gear

- 5/32 in. spring steel
- Mounts to fuselage rear
- Slide lock into tail tube



Build Process – Completed Aircraft



Build Process – Completed Aircraft

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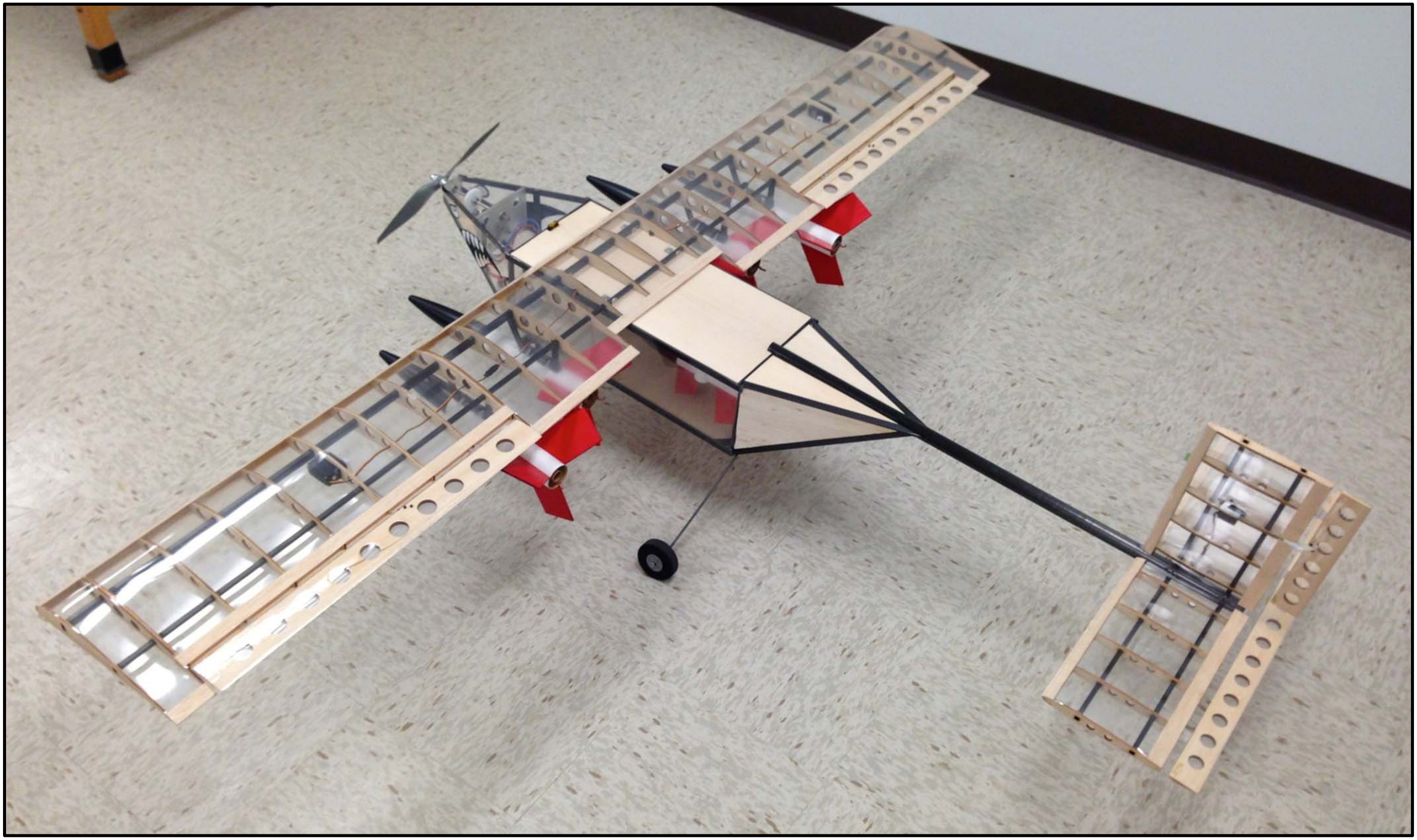


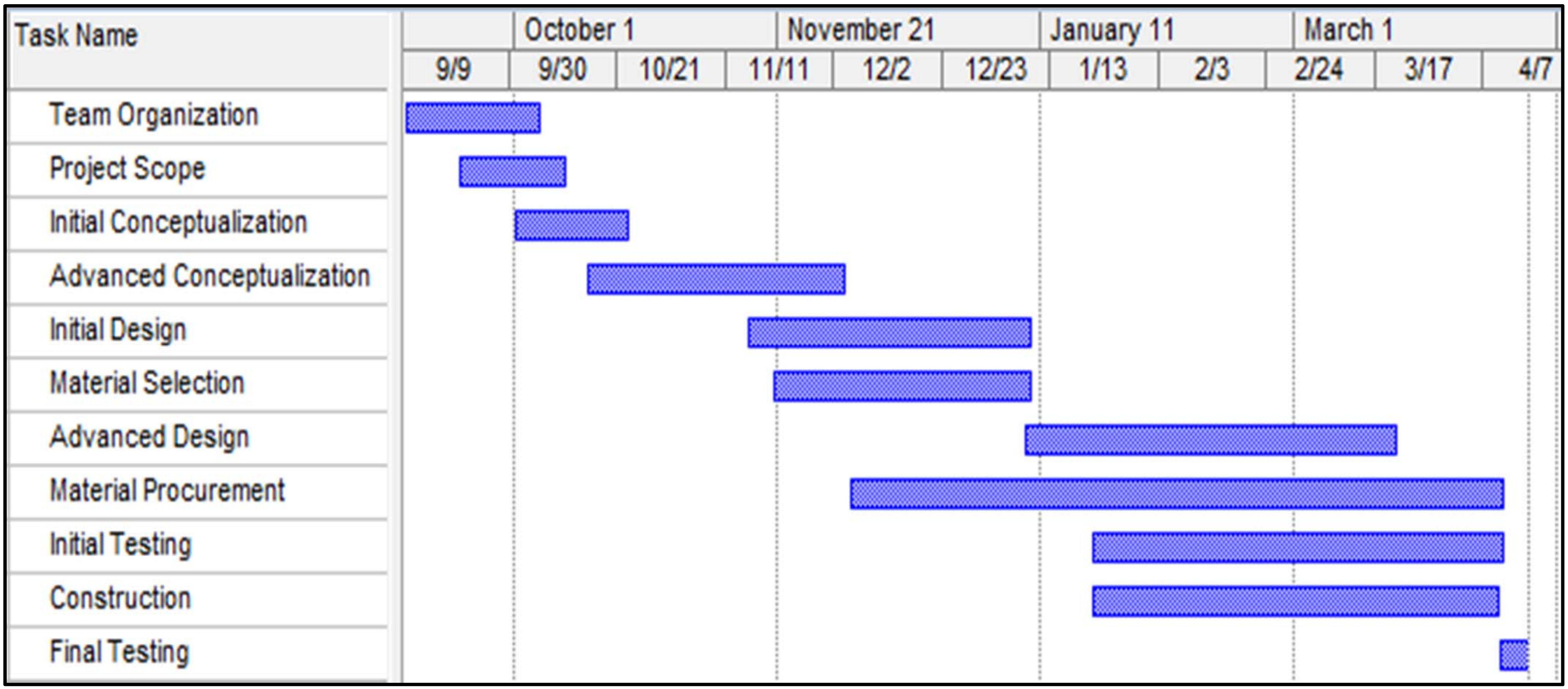
Build Process – Completed Aircraft

78 in.

Budget

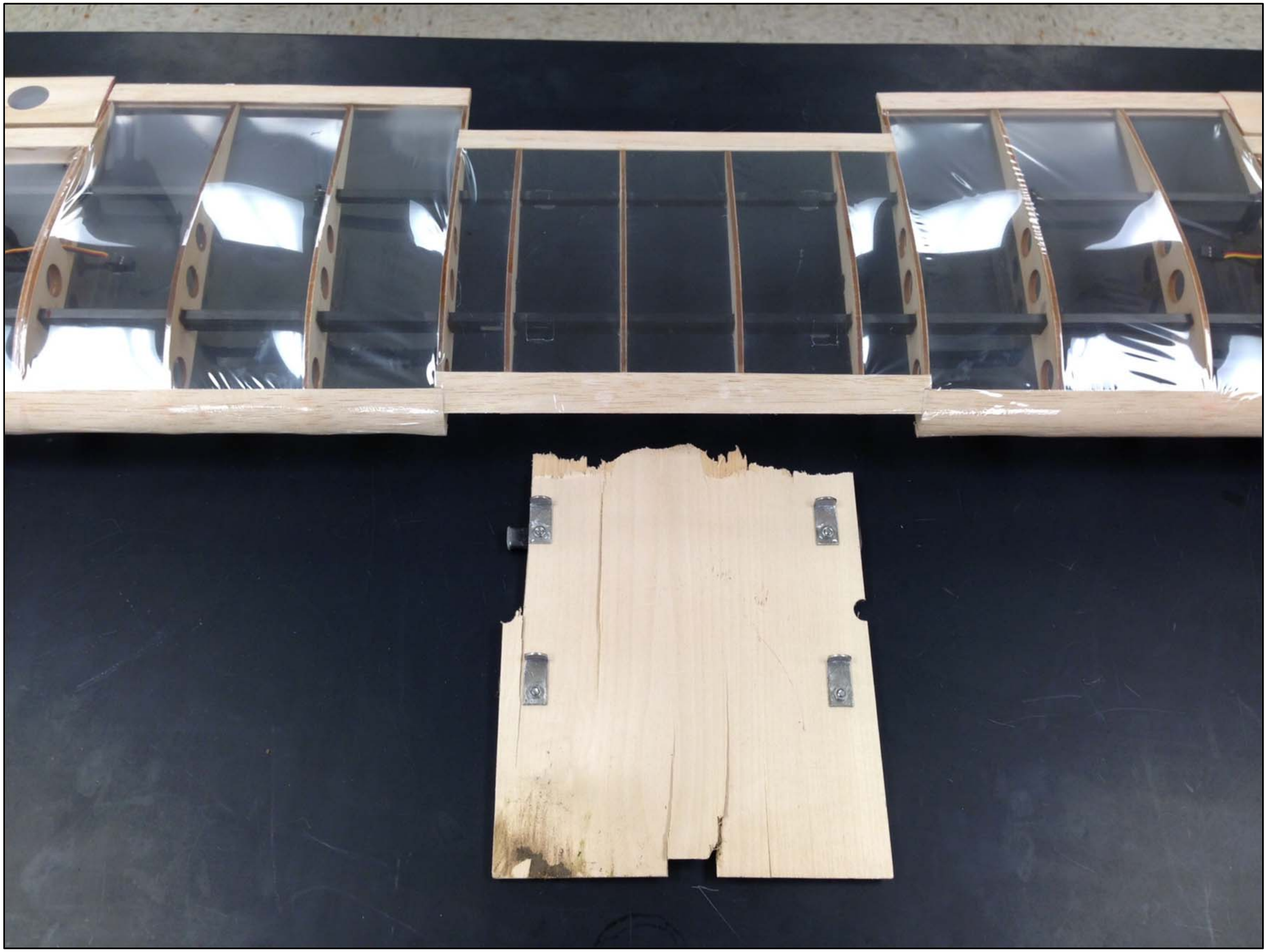
Category	Item	Cost	Total
Electronics			**$410.00**
	Motors	$110.00	
	Servos	$80.00	
	Wires	$20.00	
	Batteries	$120.00	
	ESC	$80.00	
Construction			**$445.00**
	Wood	$100.00	
	Strips	$108.00	
	Tube	$54.00	
	Monokote	$39.00	
	Spars	$96.00	
	Adhesives	$48.00	
Tools			**$77.00**
	Dremmel	$55.00	
	Heat Gun	$22.00	
Misc			**$294.00**
	Rockets	$143.00	
	Gears	$60.00	
	Shaft	$30.00	
	Hardware	$40.00	
	Landing Gear	$21.00	
	Total Funds Spent		**$1,226.00**
	Initial Budget		**$1,500.00**

Schedule

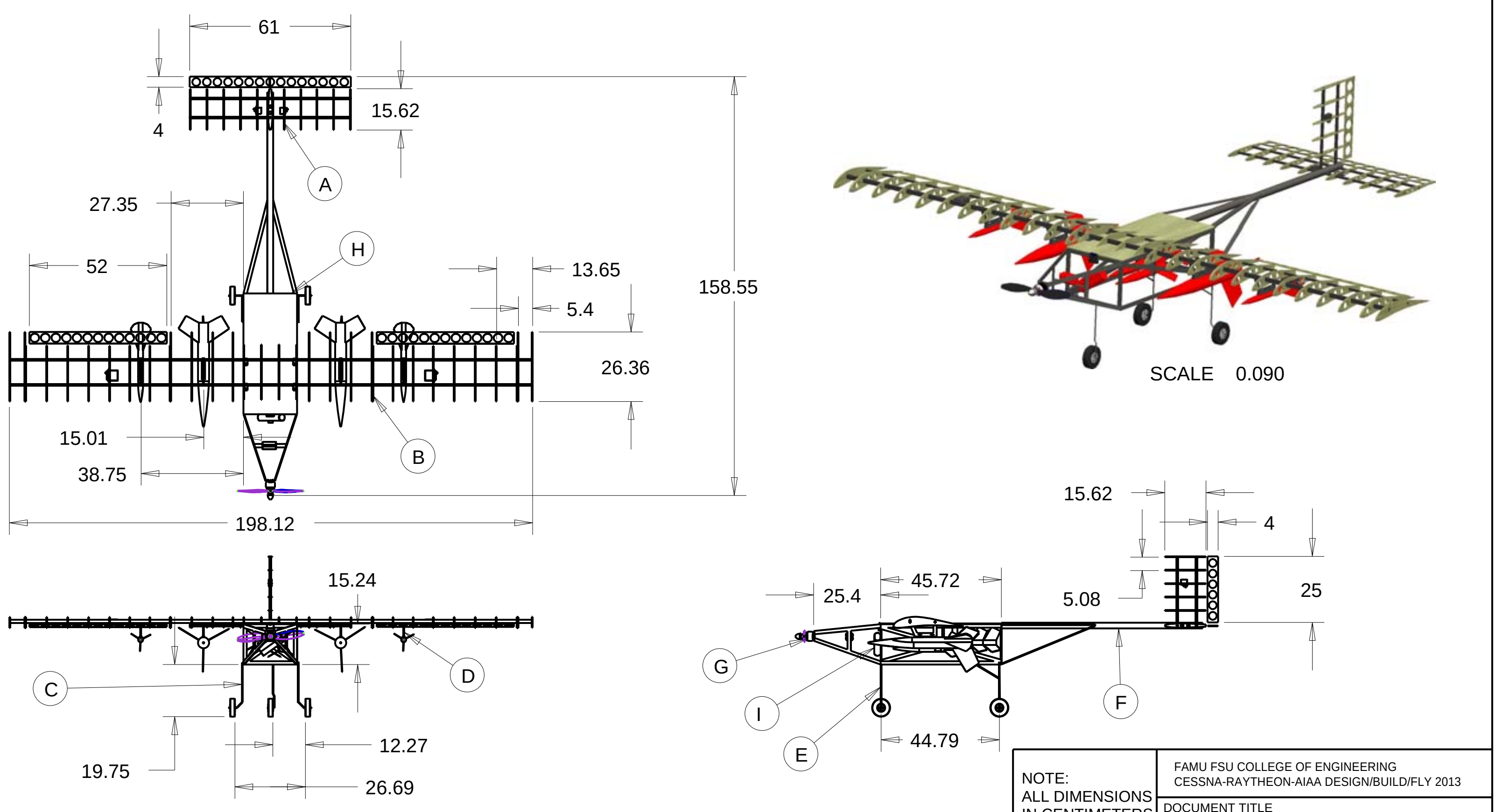

Task Name
October 1
November 21
January 11
March 1
9/9
9/30
10/21
11/11
12/2
12/23
1/13
2/3
2/24
3/17
4/7
Team Organization
Project Scope
Initial Conceptualization
Advanced Conceptualization
Initial Design
Material Selection
Advanced Design
Material Procurement
Initial Testing
Construction
Final Testing

Flight Results

Failure Analysis



Questions



Primary Componants

A	Tail Section	D	External Store Mount	G	Propulsions System
B	Main Wing	E	Nose Gear	H	Fuselage
C	Main Landing Gear	F	Fuselage/Tail Connector	I	Battery Compartment

NOTE:
ALL DIMENSIONS IN CENTIMETERS

FAMU FSU COLLEGE OF ENGINEERING CESSNA-RAYTHEON-AIAA DESIGN/BUILD/FLY 2013			
DOCUMENT TITLE: Three View			
TEAM NAME: PEGASUS	DATE APPROVED: 02/19/2013	REPORT TITLE: DRAWING PACKAGE	SIZE: B
DRAWN BY: Lee Becker	SCALE: 0.07	SHEET NUMBER: 1 of 4	