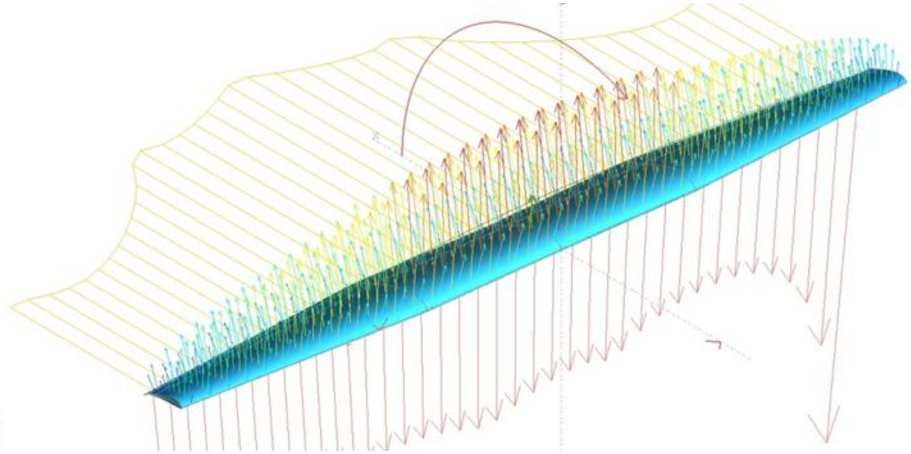
Aero Design



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Contents

Project Specifications

- **SAE Aero Design East Competition:**
  - Give students real life engineering situation
  - Design a high-lift low weight RC aircraft
  - Compete with other teams and universities

- **Aircraft Dimension Requirement**
  - Maximum combined length, width, and height is **225 inches**
- **Gross Weight Limit**
  - No more than fifty five pounds (**55 lbs.**) with payload and fuel.
- **Engine Requirements**
  - Magnum XLS-61a

Competition Description

- 1 – Design Report (50 points)
- 2 – Technical Presentation (50 points)
  - Payload loading/unloading
- 3 – Flight Round
  - Empty Weight (10% bonus)
  - Successive flight rounds
    - Flight Score = Lifted Weight x 4

- **Overall Score = Design Report Score + Oral Presentation Score + Flight Score**

- **Aircraft must make one full 360˚ loop of the field**
  - **Disqualification** if flown into "No Fly" zones x2
- Take off distance: < 61m
- Landing distance: < 122m

- **Aircraft must land within specified landing zone**
  - Multiple passes of field is allowed
  - No "touch and go" landings

Overall Layout Designs

Standard

Pros
- Highly Stable in flight
- Large area in fuselage for payload
- Reliable design throughout time

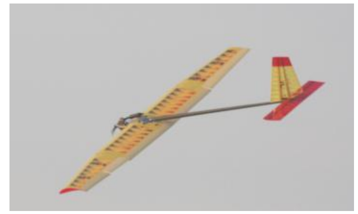
Cons
- High Drag

Flying Wing

Pros
- Most aerodynamic
- High Lift

Cons
- Unstable in flight

Minimalist



Pros
- Lightweight
- Less material
- Cheaper
- Simple design

Cons
- Unstable with high wind gusts
- Questionable structural integrity

Canard

Pros
- High lift
- High stability

Cons
- No room for error in design of wing sizes

Bi-Plane

Pros
- Highly maneuverable
- Strong structure

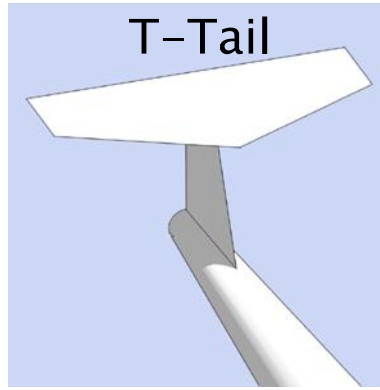
Cons
- Wings interfere with one another

Design Decision Matrix

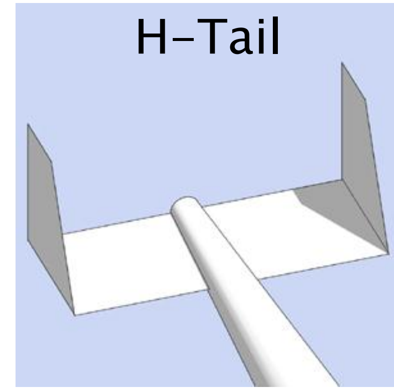
		Standard Design		"Flying Wing" Design		Minimalist Design		Canard Wing Design		Bi-Plane Design	
Selection Criteria	Weight	Rating	Weighed Score	Rating	Weighed Score	Rating	Weighed Score	Rating	Weighed Score	Rating	Weighed Score
Potential Lift	20%	7	1.4	9	1.8	8	1.6	8	1.6	7	1.4
Potential Drag	10%	4	0.4	8	0.8	9	0.9	2	0.2	3	0.3
Durability	15%	9	1.35	5	0.75	3	0.45	7	1.05	7	1.05
Cost	10%	5	0.5	5	0.5	8	0.8	3	0.3	4	0.4
Ease of Build	5%	5	0.25	6	0.3	8	0.4	4	0.2	4	0.2
Potential Flight Score	40%	8	3.2	6	2.4	7	2.8	7	2.8	7	2.8
	100%		**7.1**		6.55		6.95		6.15		6.15

Tail Designs

- Roots attached to fuselage
- High effectiveness for vertical tail
- Vertical tail height limits overall dimension constraint



- Reduced aerodynamic interference
- Horizontal tail can be lengthened for short boom designs
- Requires stronger & heavier vertical stabilizer



- Uses the vertical surfaces as endplates for the horizontal tail
- Vertical surfaces can be made less tall, adding to allowable wing length
- Complex control linkages required

Tail Design Decision Matrix

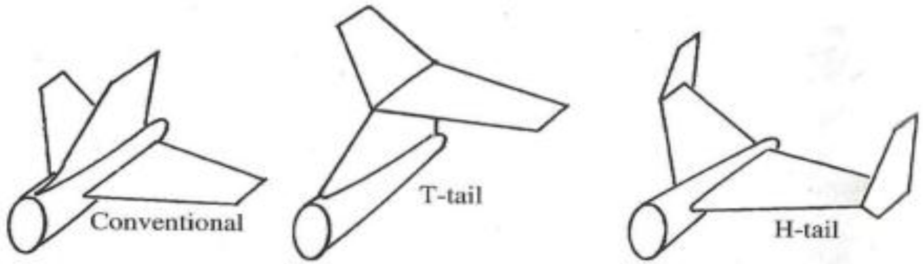


Figure of Merit	Weighting Factor	Conventional	T-tail	H-tail
Drag	0.20	3	2	1
Ease of Build	0.10	5	3	2
Maneuverability	0.15	3	4	5
Stability	0.35	4	4	5
Weight	0.20	4	4	3
Total	1.00	3.75	3.5	3.5

Tail Booms

Conventional:

- Commonly used in commercial passenger aircraft as cargo area
- Design
  - Flush with fuselage
- Strength:
  - High torsion resistance
- Weight:
  - Moderate weight in comparison

Pipe:

- Used in model aircraft and small helicopters
- Design:
  - Best done with carbon fiber
- Strength:
  - Low torsion resistance
- Weight:
  - Lightest design

Twin Boom:

- Design:
  - Greatly affects fuselage design
- Strength:
  - Great torsion resistance
  - High stability
- Weight:
  - Heaviest design

Tail Boom Decision Matrix

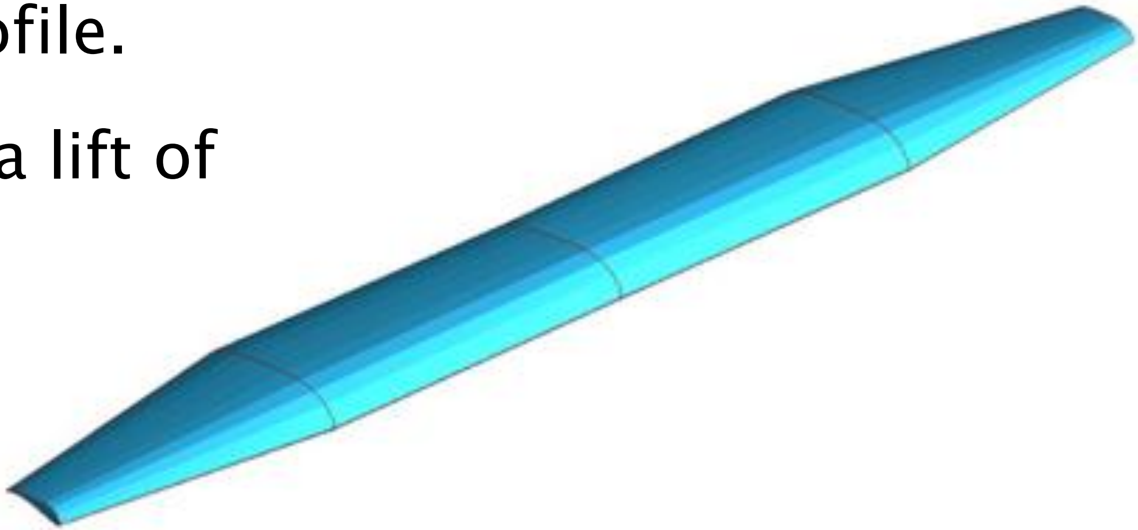
Figure of Merit	Weighting Factor	Conventional	Pipe	Twin Boom
Drag	0.20	4	3	2
Ease of Build	0.10	3	4	1
Maneuverability	0.15	5	5	5
Stability	0.35	4	1	5
Weight	0.20	3	5	1
Total	1.00	3.85	2.6	3.2

Wing Design

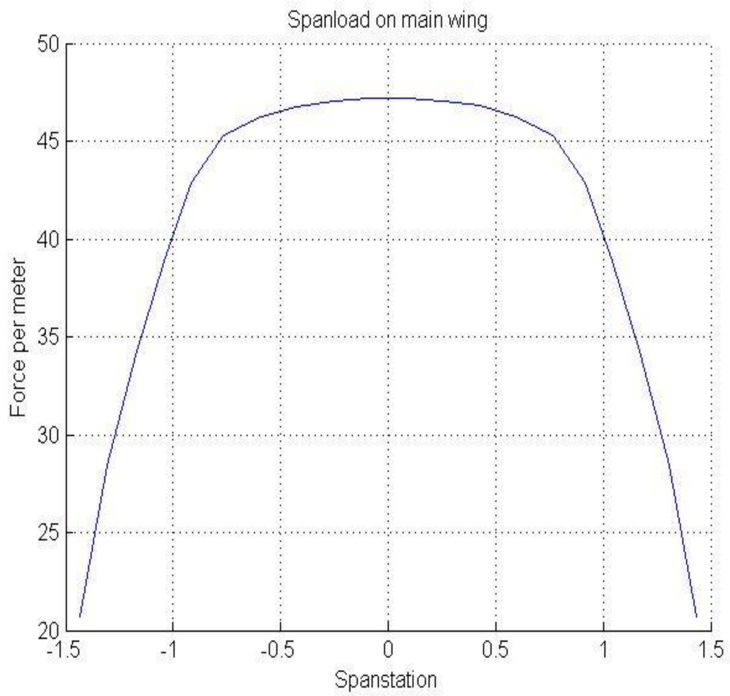
- Several wing geometries were studied using computational methods
- Custom designed wing profile
- The final wing design is a tapered wing with the same profile.
- Designed to generate a lift of 165N
  - Design Factor 1.25

Wing Characteristics

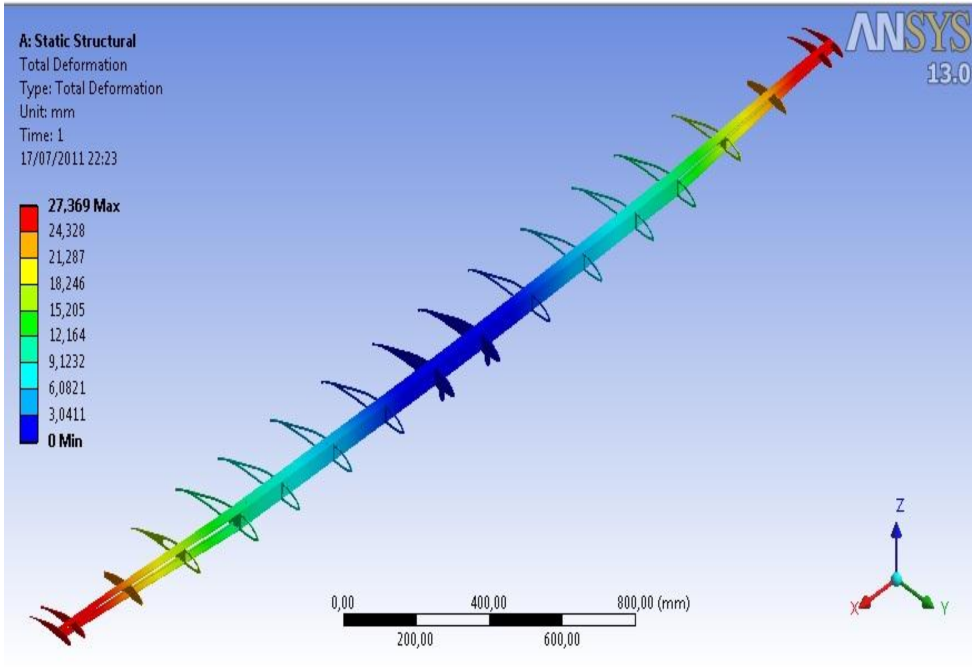
- Wing span = 2.8 m
- Root Chord = 0.32 m
- Tip Chord = 0.16 m
- M.A.C = 0.28 m
- Wing Area = 0.728 m^2
- Aspect Ratio = 10



Wing Analysis



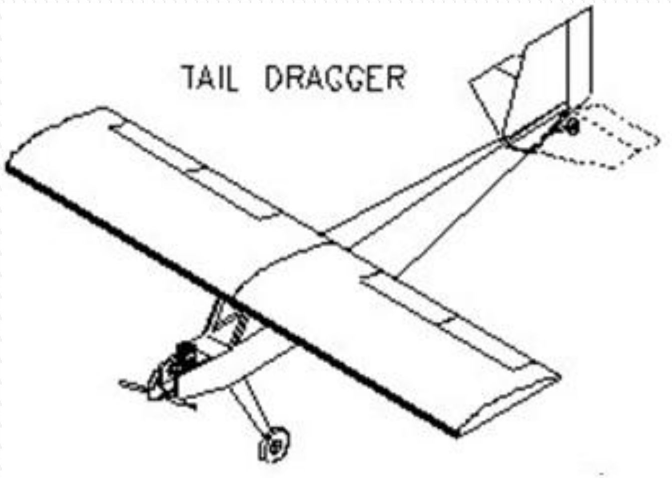
Elliptical Distribution along the wing span

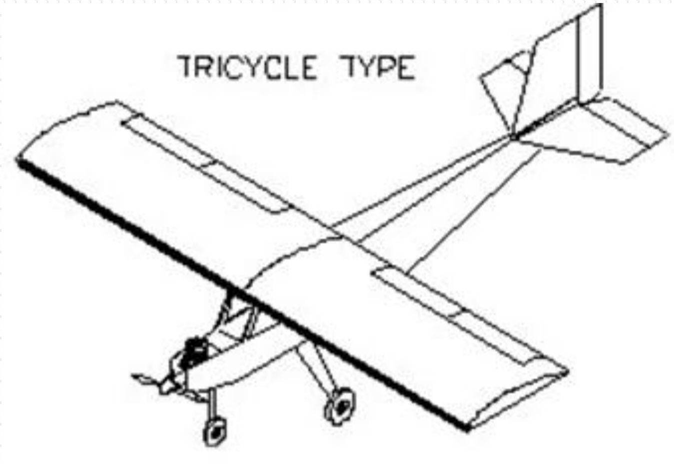


Using *ANSYS* the maximum static deflection measured at the spar tips is 27.4mm.

– Structural safety factor 1.8

Landing Gear Design and Layout





<u>Tail dragger style layout</u>

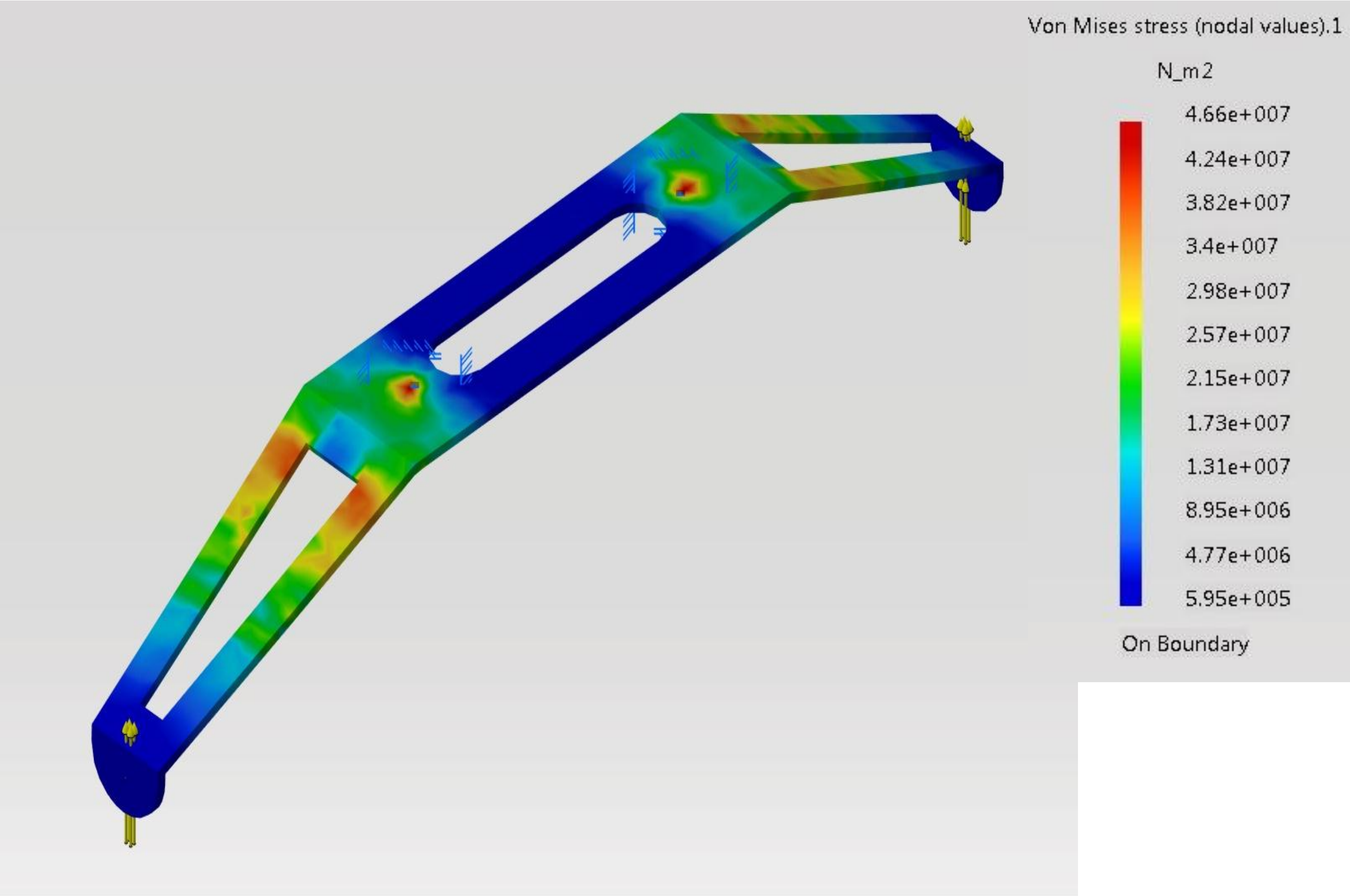
- Unstable steering
- Allows the prop to strike the ground
- Lowers aircraft's overall height

<u>Tricycle style layout</u>

- Stable steering
- Does not allow the prop to strike the ground
- Easier to land

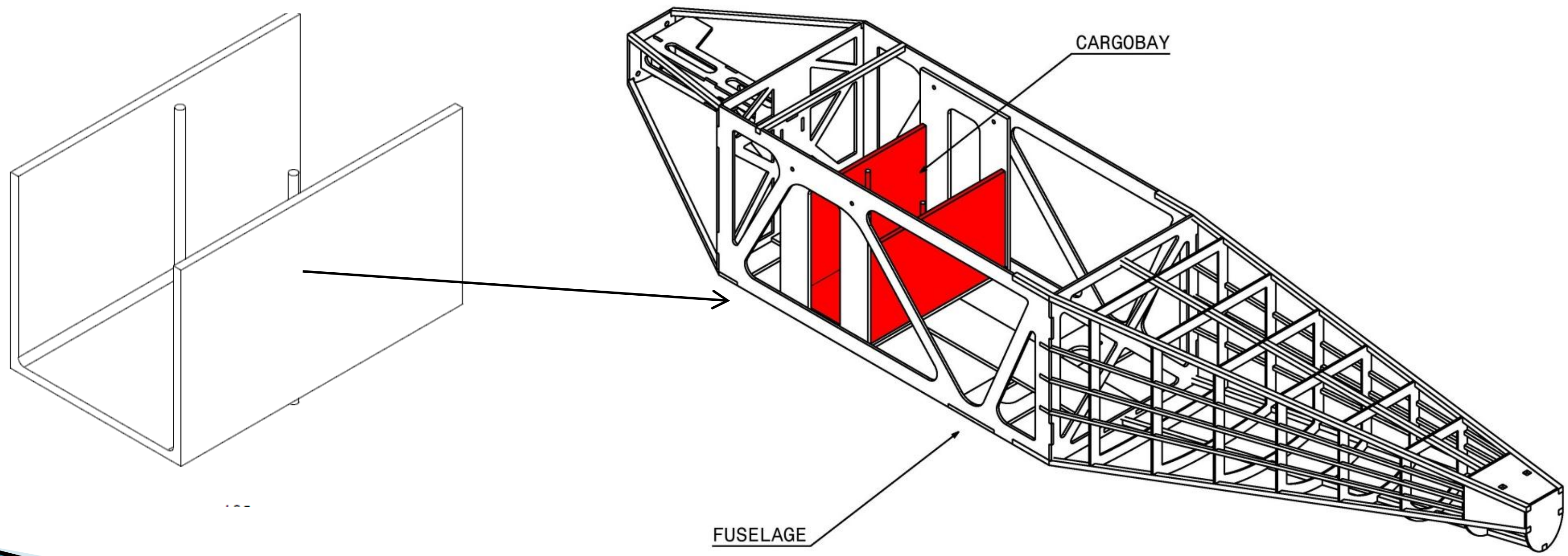
Landing Gear (ctd)

- F.E.M. used through *CATIA* software
- Made out of Aluminum 6061
- Used with nylon wheels and ball bearings

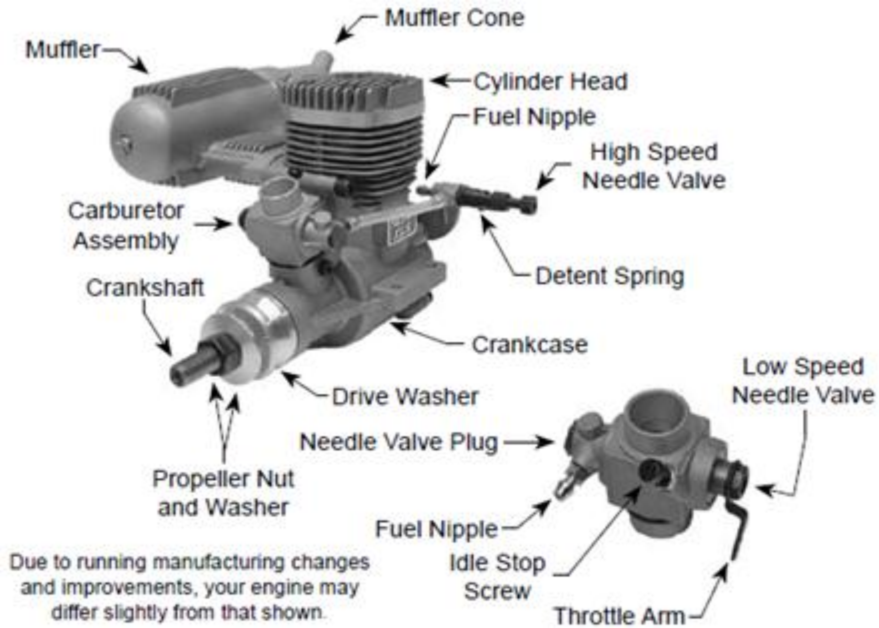


Cargo Bay & Payload

Material	Density (g/cm^3)	Cost (USD/kg)	Volume (cm^3)	Cost (USD)
Steel Alloy	7.85	0.5	2022.4	7.94
Stainless Alloy	8	2.15	1984.5	34.13
Gray Cast Iron	7.3	1.2	2174.8	19.05
Copper Alloy	8.5	3.2	1867.7	50.8



Power Plant



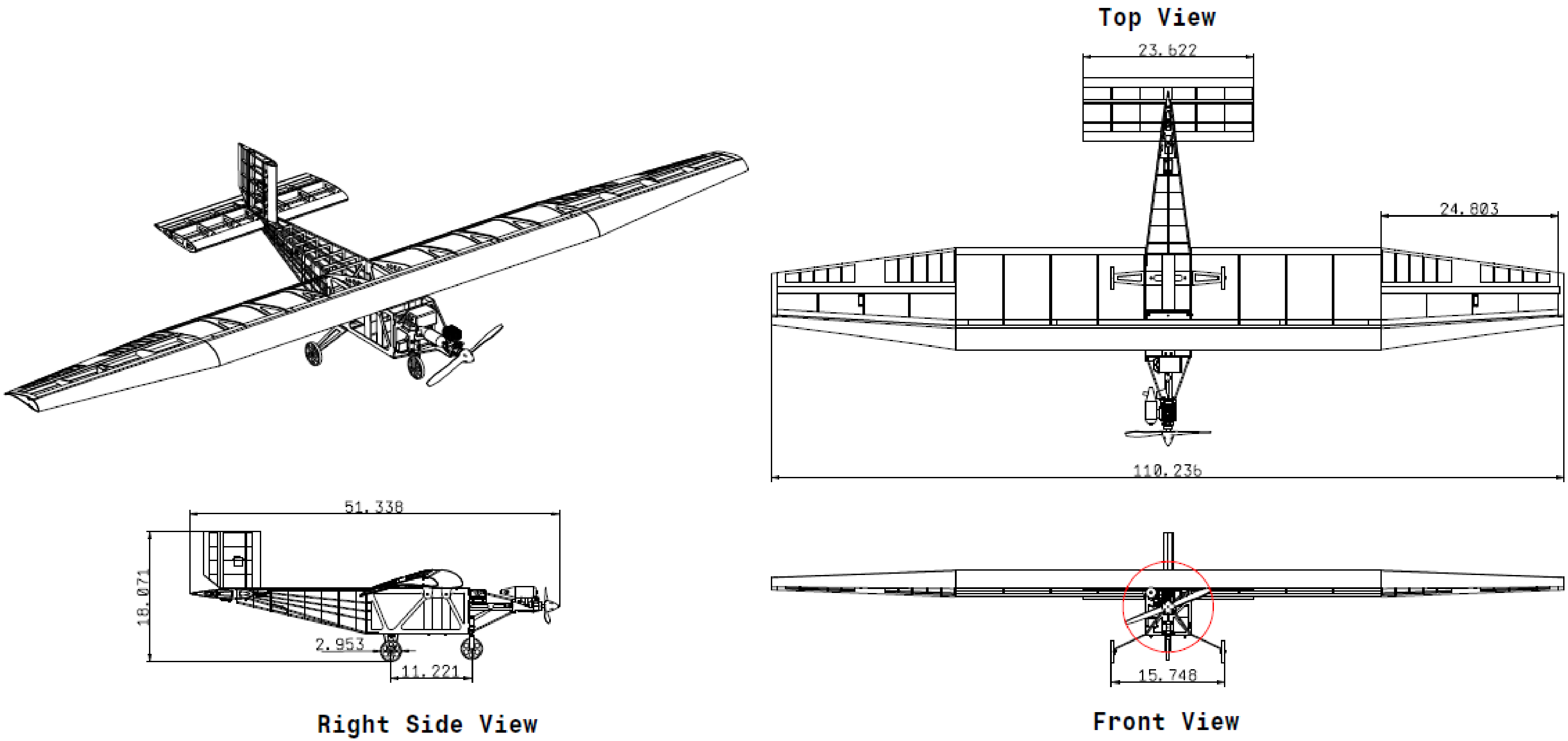
SPECIFICATIONS AND FEATURES

- Displacement 9.94cc (0.607ci)
- Bore 24mm
- Stroke 22mm
- Practical RPM .... 2,000 - 16,000rpm
- Weight w/Muffler 22.5oz

- ABC Piston and Sleeve
- Dual Ball Bearing-Supported Crankshaft
- Dual Bushing-Supported Connecting Rod
- Lightweight, High Power Output
- Rear Needle Valve Assembly for Safe Tuning

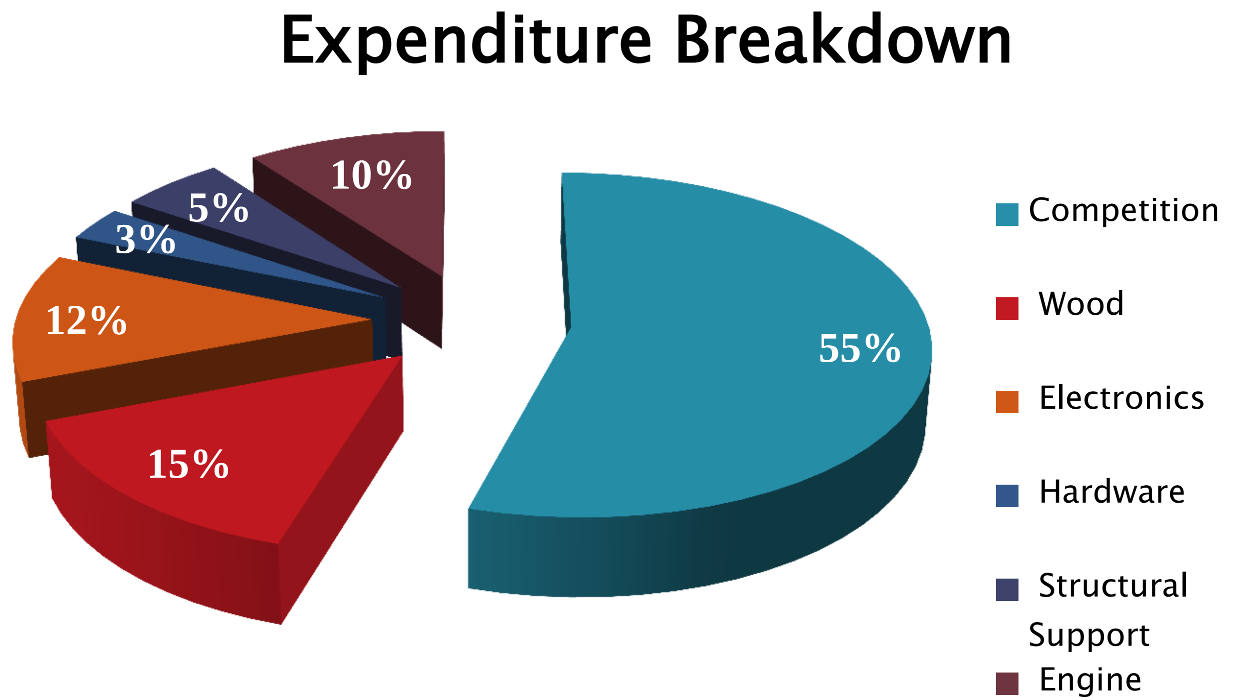
Propeller	13x6 JXF	13x6 MAS	11x6 JZ	11x7 APC
Rotations [RPM]	9210	8610	10690	12090
Mass[g]	28.7	25	26.8	50.7
Measured Thrust	26 [N]	25 [N]	30 [N]	32 [N]

System Diagram



Engineering Economics

- Budget: $3,000
- Total expenditures ~$2,014



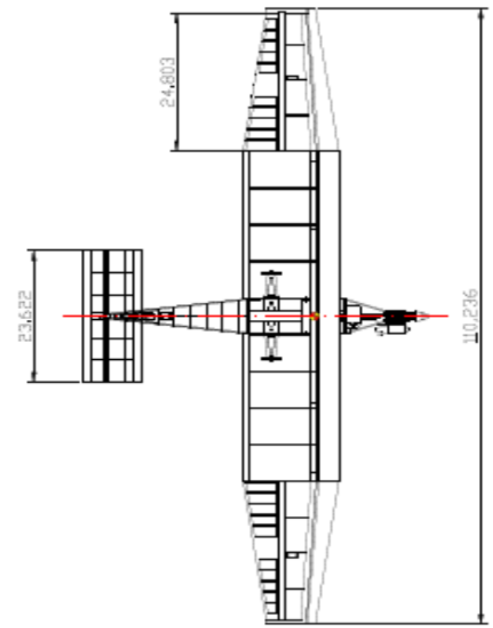
Tests

- Successful Tests
  - Servo calibration
  - Motor break-in
  - Motor full-throttle
  - Static wing loading
  - C.G. verification
  - Mechanical trim adjustments
- Future Tests
  - Test flight scheduled for 04/14/2012
    - Pilot availability
  - Timed cargo loading/unloading
    - Under 1 minute each

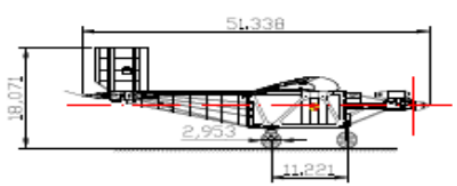
Verification of Competition Guidelines

- Actual Plane Measurements
  - Length: 51” (129.5 cm)
  - Height: 23” (58.4 cm)
  - Width: 110.25” (280 cm)

  - Overall: 184.25” (468 cm)
    - Within competition requirements



- Empty Weight: (~6.8 lbs)
  - Theoretical Max Payload: (55-6.8)



Conclusion

- Design process yielded:
  - Standard design aircraft
    - Custom designed wing profile
    - Conventional tail & tail boom
    - Tricycle landing gear design
- Within our design constraints
- Confident our design will finish in top 10 at Marietta, GA
- Experienced & overcame difficulties involved with international collaboration projects

Questions