Conceptual Design Review
ASEN 2804

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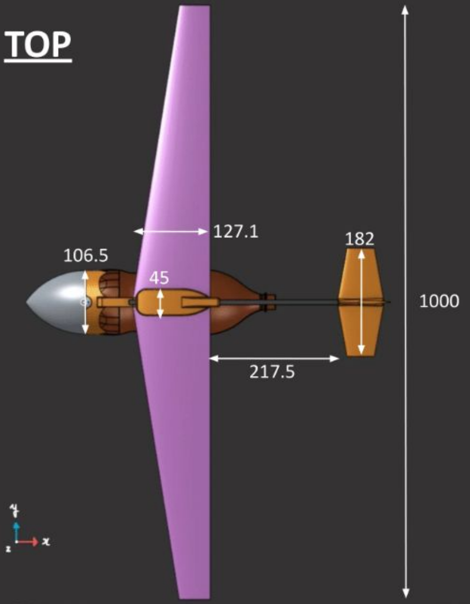
01

Original Design

Design Configuration #1: Lord of the Bingus – Wang Long Lee

TOP

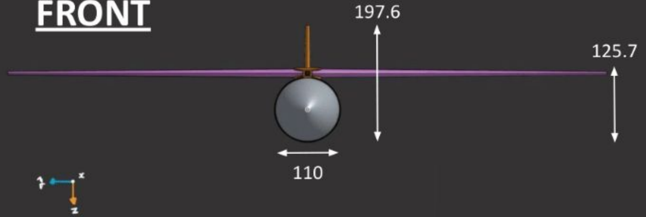


Key Configuration Parameters

Estimated Weight (N) (dry)	4.469
Wing Planform Area – S_{ref} (m^2)	0.09
Wing Loading – W/S (Pa)	50
Wing Aspect Ratio – AR	11.1
Wing Taper Ratio	0.4
Wing Leading Edge Sweep (deg)	9.85
Wing Airfoil	NACA 0011
Fuselage Fineness Ratio	4.14
Drag Polar Model Equation	$0.04884 + 0.03017C_l$^2
L/D max Estimate	15.71

SIDE

FRONT



Design Approach

- **Inertia-Activated Extendable Tail:** Deploys during launch to enhance stability, allowing a conventional glider design without a long, heavy fuselage.
- **Modular Tail Assembly:** Integrates vertical and horizontal stabilizers for easy repairs and adjustable incidence angles.
- **Swept Leading-Edge, High-Mounted Wing:** Improves lateral stability, reducing spiral divergence and enhancing aerodynamic efficiency.

Configuration Strengths

- Well proven conventional glider design
- Lightweight design, no heavy fuselage
- Easy to fabricate and modify design (mainly tail)

Configuration Weaknesses

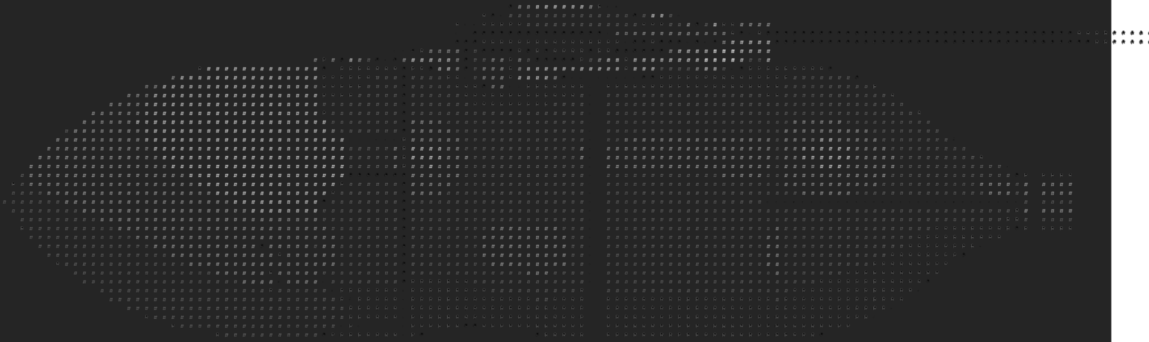
- More expensive w/ usage of carbon fiber rod
- Long printing time for parts
- Uncertainty in tail deployment (new concept)

Other Key Configuration Considerations

- Fabrication: carbon rod, pink foam, foam safe CA / hot glue
- Cost: ~ $4 per carbon rod, ~$10 pink foam, ~$5 adhesive cost
- Schedule: should be able to build with in a week

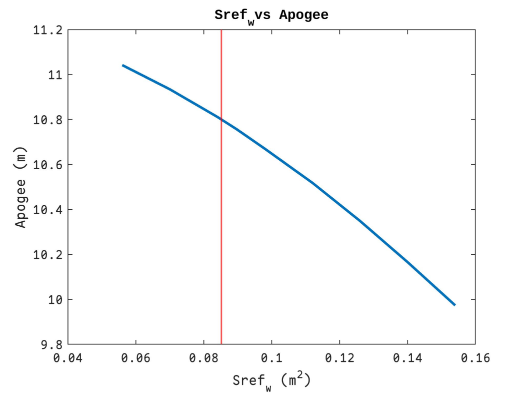
note: Dimensioned drawing are in [mm]

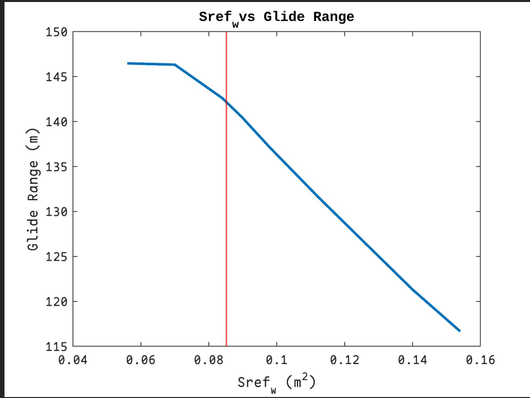
02

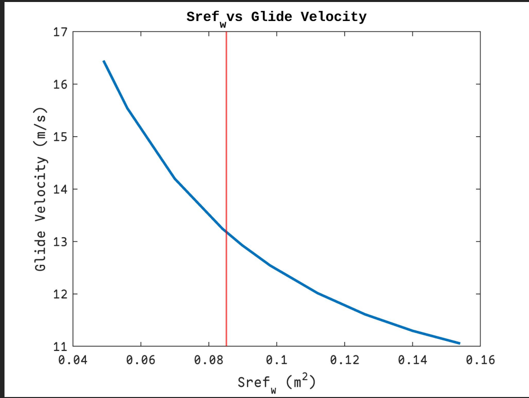


Trade Studies

Planform Wing Area (S_{ref})





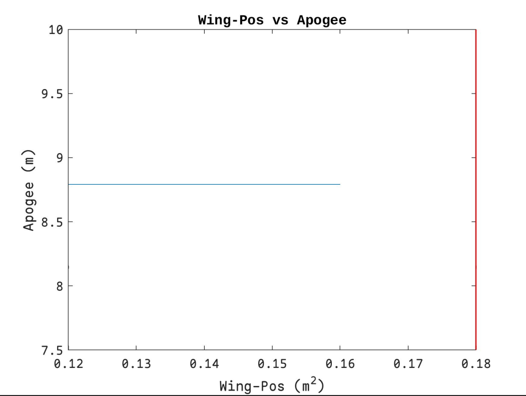


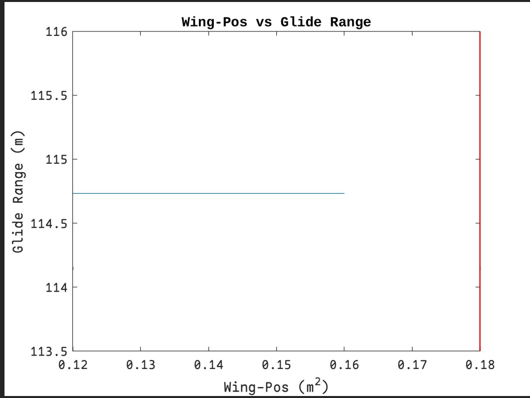
- As planform area decreases, apogee increases with a diminishing rate for smaller planform areas.

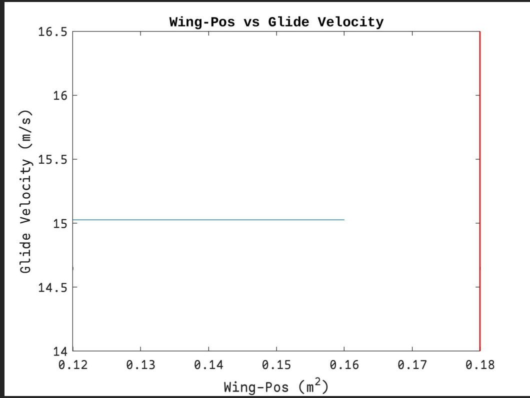
- As planform area decreases, glide range increases, plateauing at a planform area of approximately $S_{ref} \approx 0.07$ m².

- As planform area decreases, trim glide velocity increases exponentially, eventually exceeding the limit of $v_{limit} \approx 15$ m/s

Wing Position





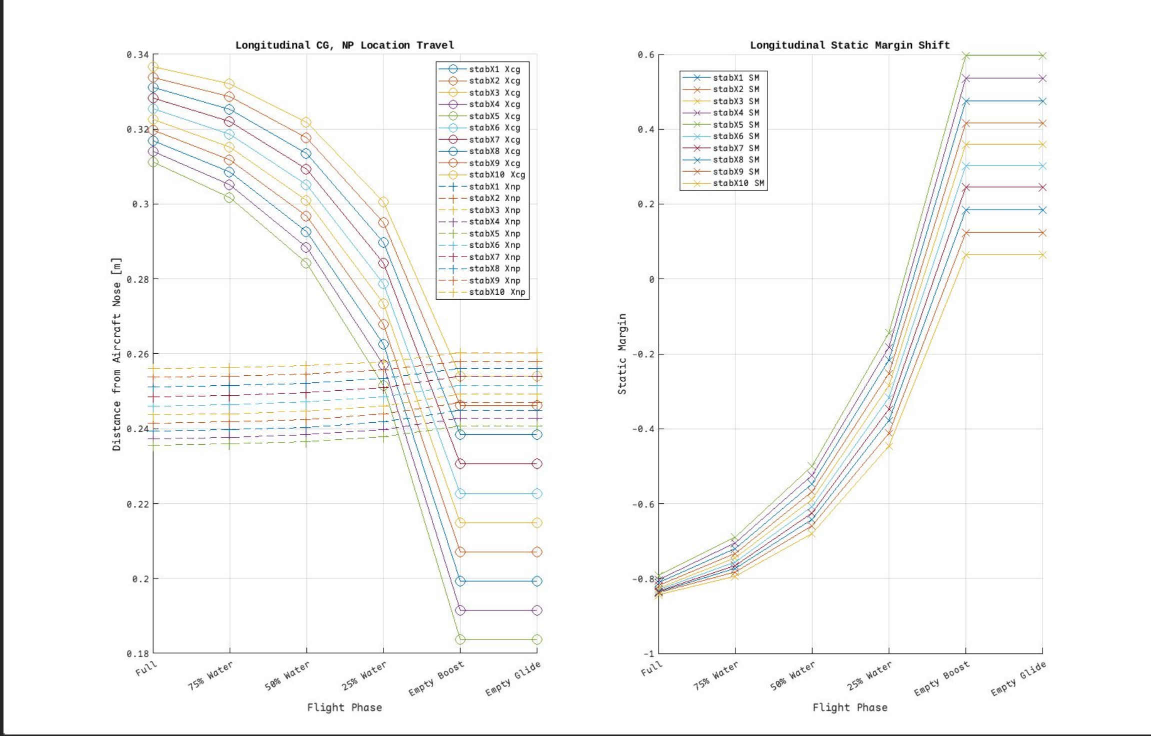


- No visible effect on apogee, range, glide velocity and other parameters.
- Only change present was location of cg hence static margin.

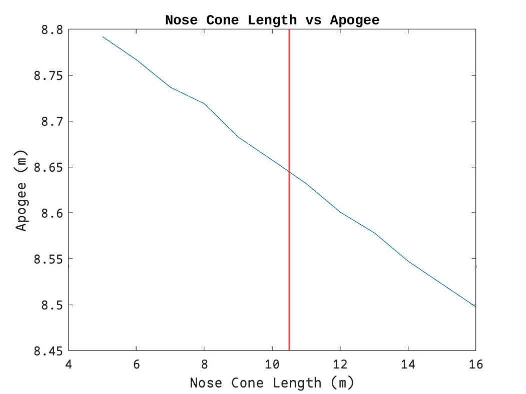
Wing Position

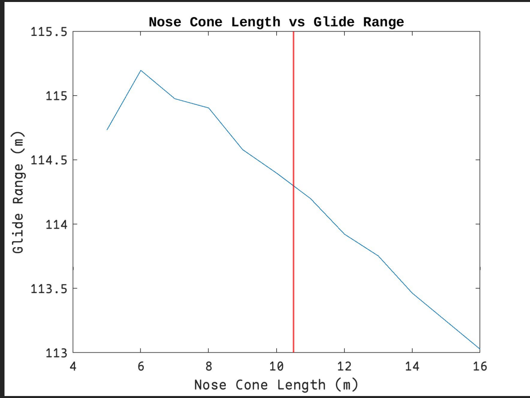
Effect on SM

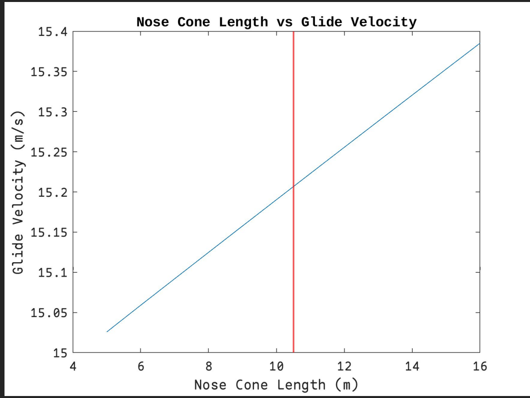
On average more than ~10% change in static margin for each cm of the position around the center of the aircraft.



Nose Cone (Payload)





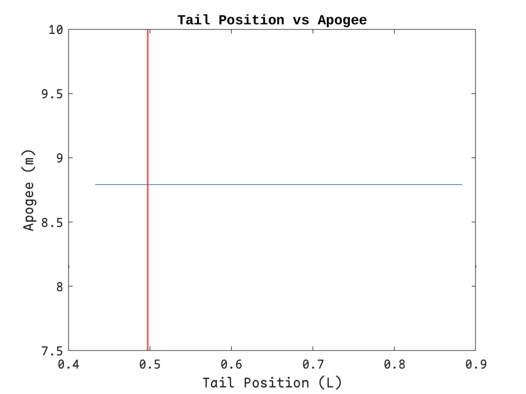


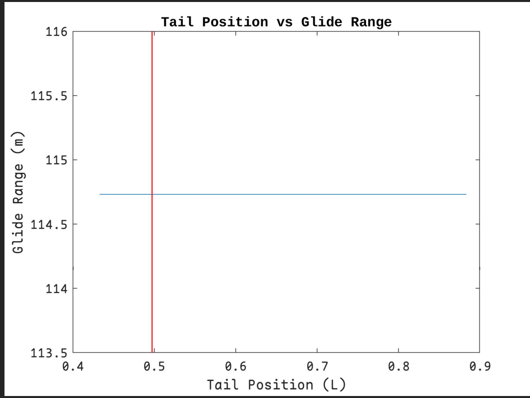
- Increased nose cone length decreases height of apogee.
- Small effect, low sensitivity parameter (total range of difference: ~ .3 [m])

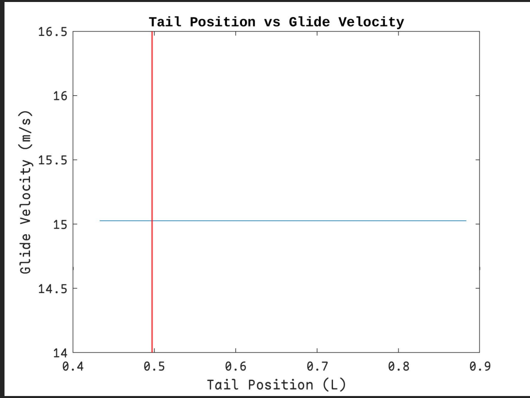
- Increased nose cone length reduces glide range
- Small effect, moderate sensitivity parameter (total range of difference: ~ 2 [m])

- Increased nose cone length increases glide velocity.
- Small effect, low sensitivity parameter (total range of difference: ~.35 [m/s])

Tail Location

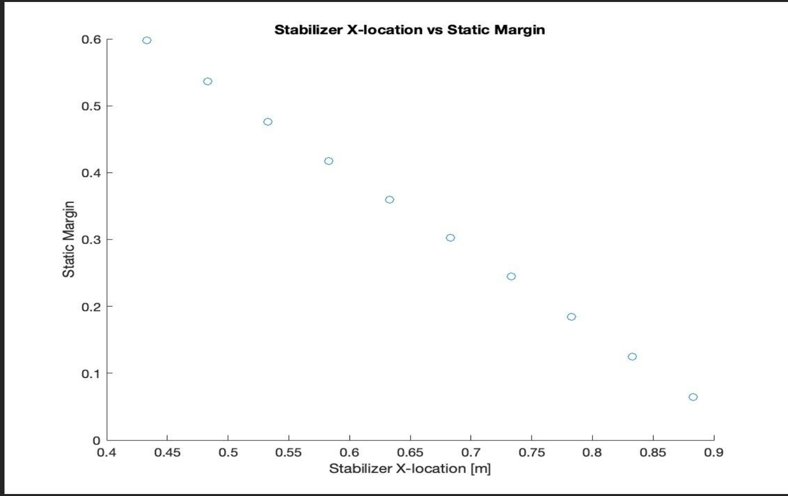


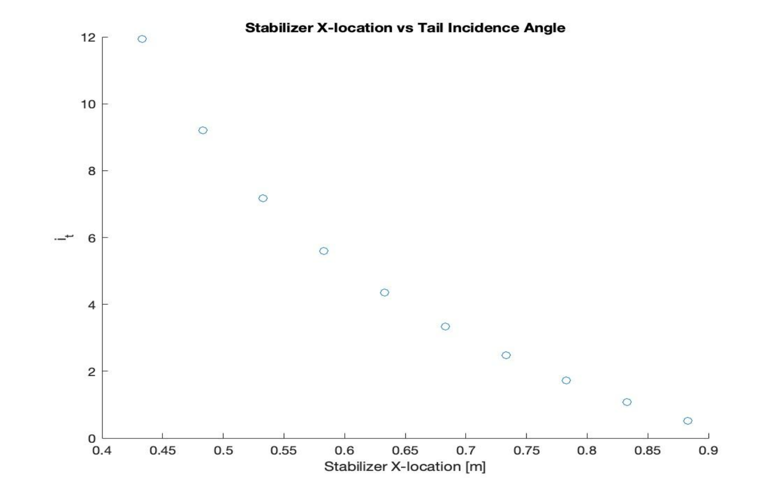




- According to our simulation, tail location has no effect on apogee, glide range, or glide velocity.
- The main effects of tail location found from our trade study were the longitudinal static margin and tail incidence angle.

Tail Location

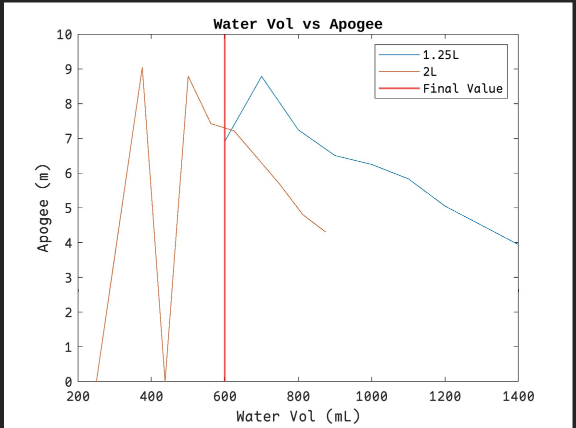


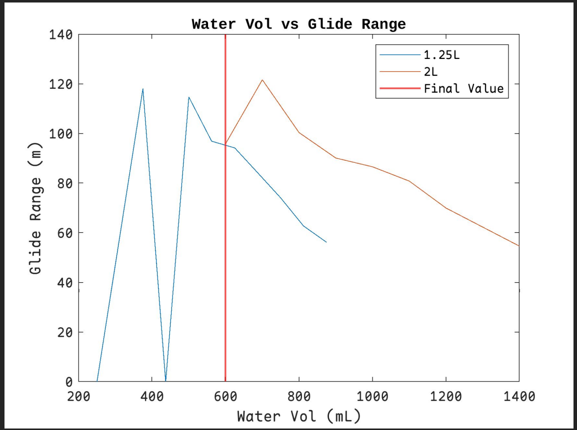


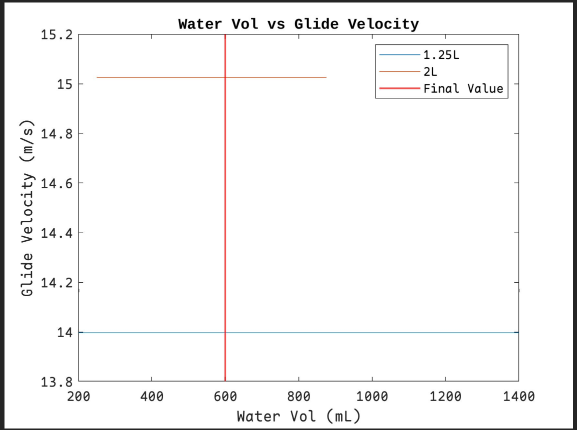
- Negative correlation with SM
- Decreases 1.2% for every cm the tail moves back

- Inverse correlation with tail incidence angle

Water Volume







- Changing the water volume had a significant effect in the model.
- Lower water volumes tended to increase boost performance.

- The effect on glide range was primarily due to the apogee reached.
- Weight is critical for the boost performance of the glider.

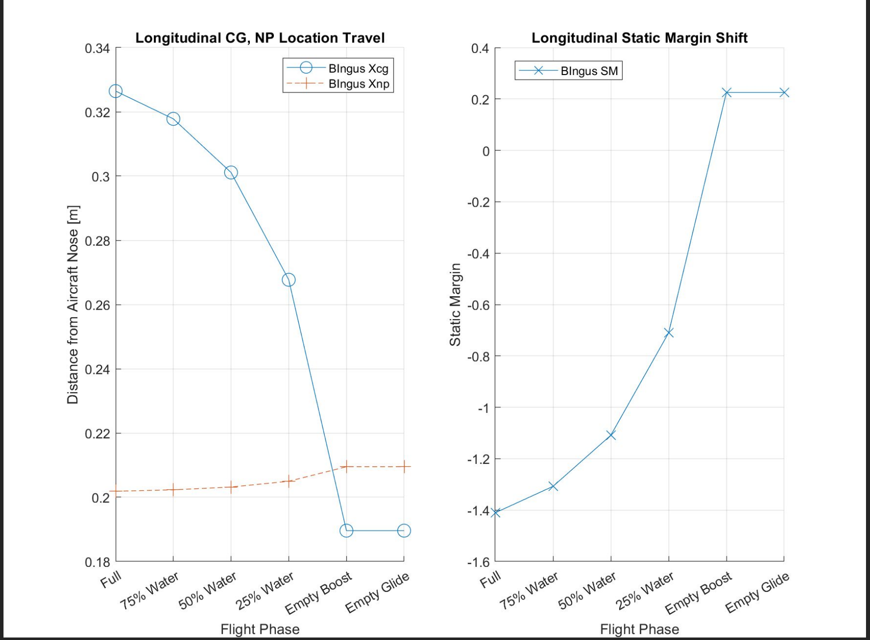
- Our final decision was 2L and 600mL of water.
- Decision made due to time constraints and code errors

02
Stability

Motion of CG, NP, & SM

Final SM: ~0.2254

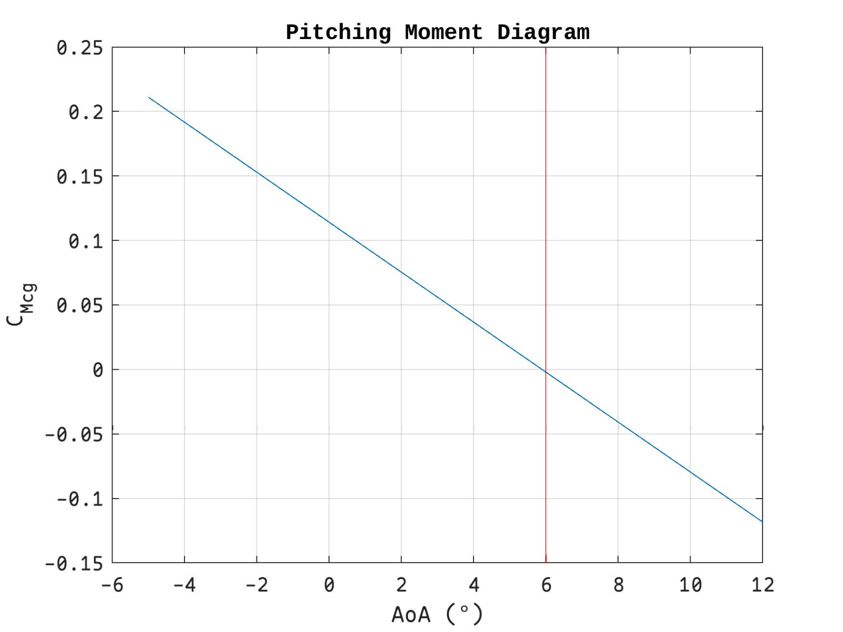
- CG moves forward
- Neutral point changes slightly due to change in CG
    - Note effects of tail deployment
- The static margin increases to a slightly positive value, indicating reasonable static longitudinal stability



Tail Incidence Angle

Trim AoA

- Equilibrium is reached with a 6 degree L/D max AoA.
- Tail incidence angle is estimated to be 4 degrees in order to trim for max glide range.



Horizontal and Vertical Stabilizers

Horizontal Stabilizer (Vh)

- Directly linked to longitudinal stability
- Target longitudinal stability of 15-20%
- Horizontal stabilizer volume coefficient of 0.4 within stability range

Vertical Stabilizer (Vv)

- Directly linked to lateral-directional stability
- Lateral-directional stability is not accounted for in our simulation
- Settled on a relatively low vertical stabilizer coefficient of 0.02
- Promotes dutch roll mode and minimizes weight

03
Final Prototype

What We Changed

Airfoil

NACA 0012 → 0018

Taper Ratio

0.4 → 0.5

Root Chord

12.8 →11.1 cm

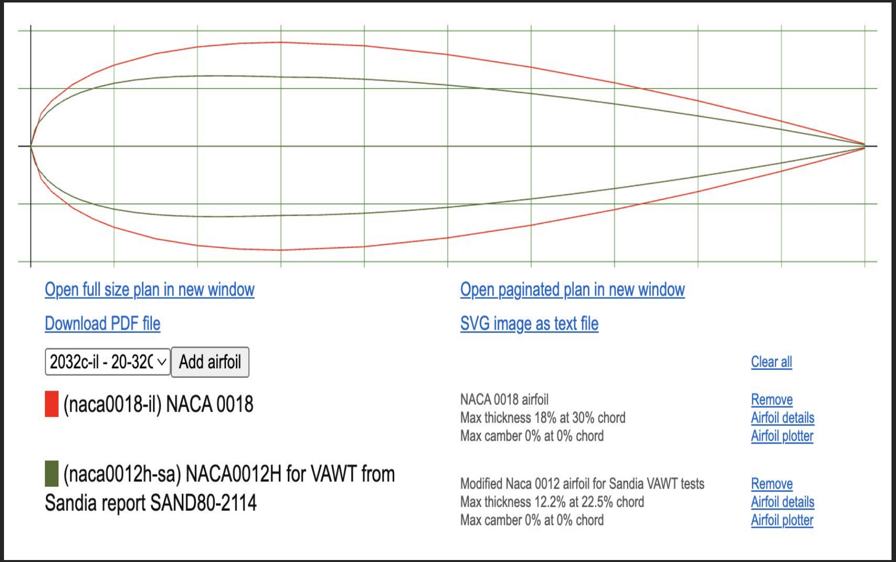
Nose Cone Length

10.5 cm

Airfoil

NACA 0012 ➔ NACA 0018

- Wanted to remain spar-free
- Worried about 0012 durability
- Airfoil change adds 6% thickness



Source: http://airfoiltools.com/search/index

Taper Ratio

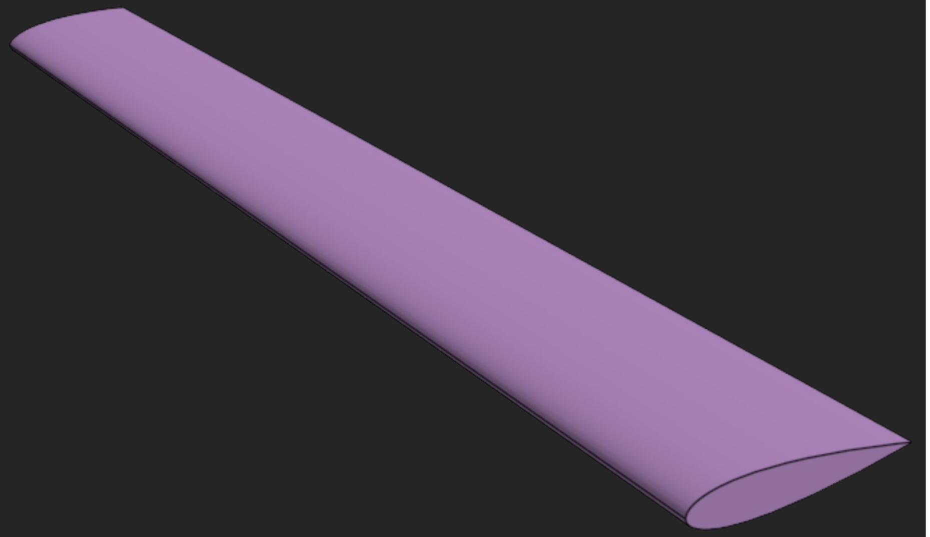
Set at 0.5 (low taper ratio)

Aerodynamic Effects:

- Shifts lift concentration towards root
- Technically lower span efficiency
- Low speed, so efficiency negligible

Structural effects:

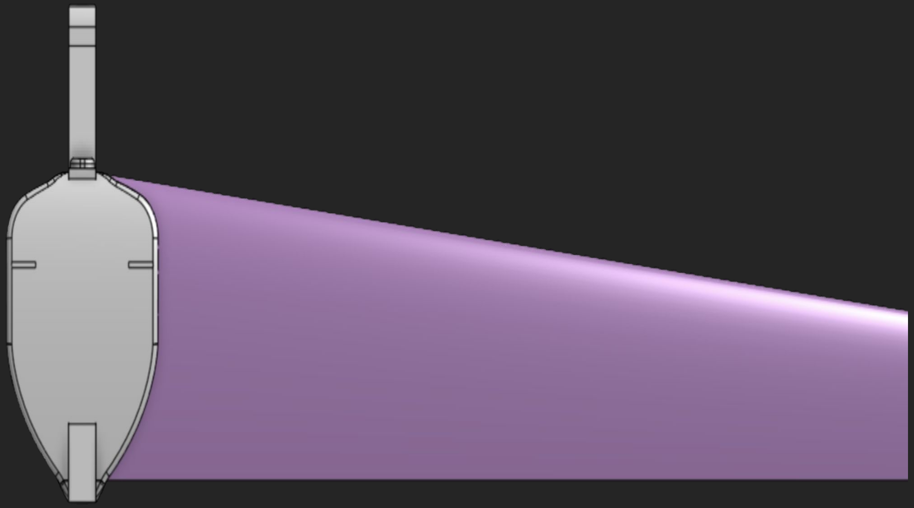
- Reduce loading on wingtip
- Higher Durability



Root Chord

128mm ➔ 111mm

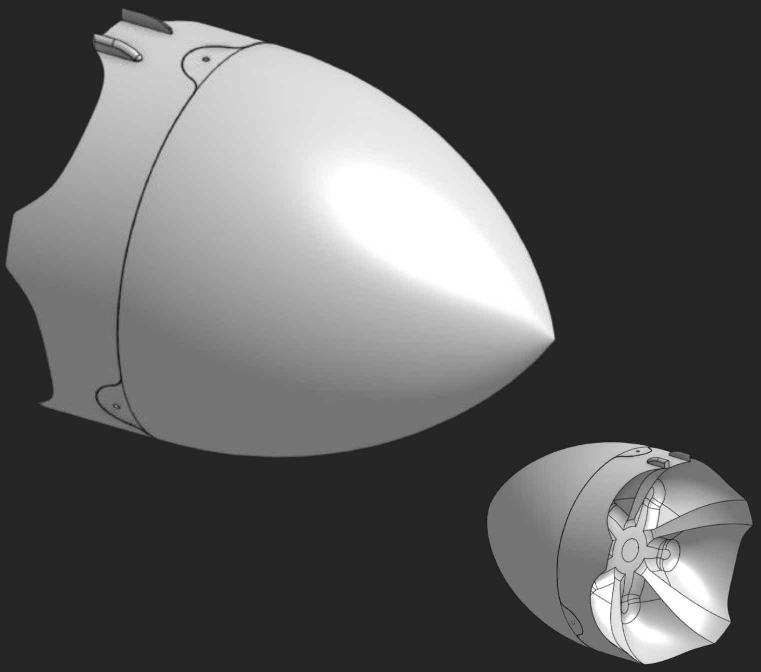
- Intended change to 120mm
- Maintain wing size after TR change
- Manufactured size 111mm due to hot-wire CNC



Nose Cone

Ogive chosen

- Trade study supported
- Must be able to fit GPS
- Fitting in cone shape challenging
- Allows for shorter length (less SA)
- Looks cool
- Penetrates through air more efficiently for subsonic aircraft



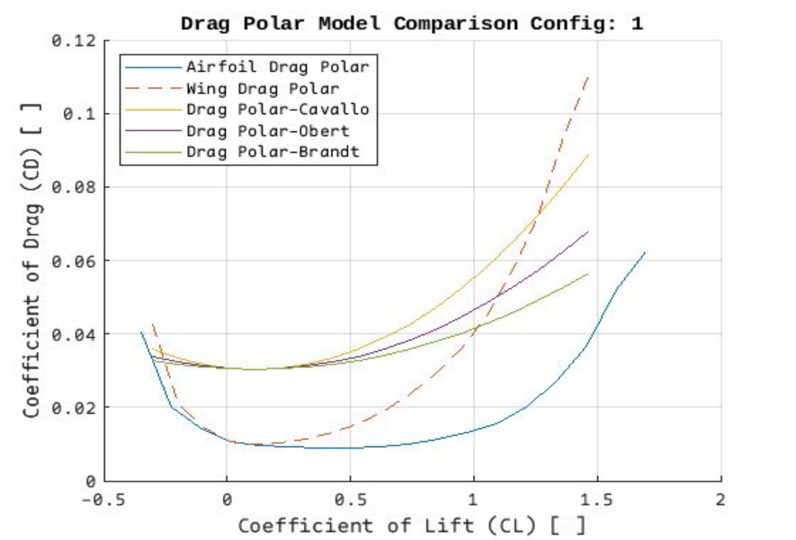
Drag Polar Comparison

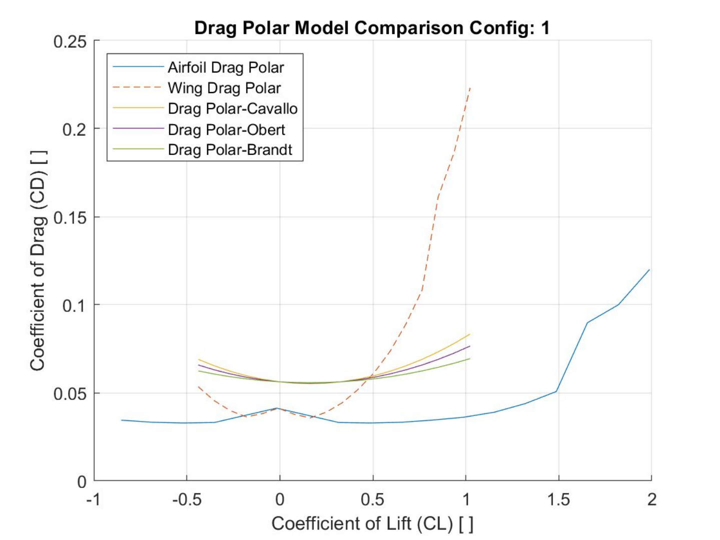
Cd0=0.0305
e0=0.601
k=0.0205

L/D Max=22
Cl_required=0.532

Cd0=0.0562
e0=0.712
k=0.0381

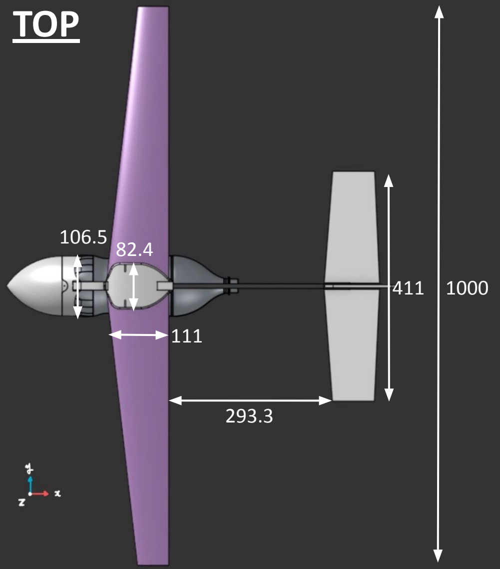
L/D Max=13.4
Cl_required=0.507



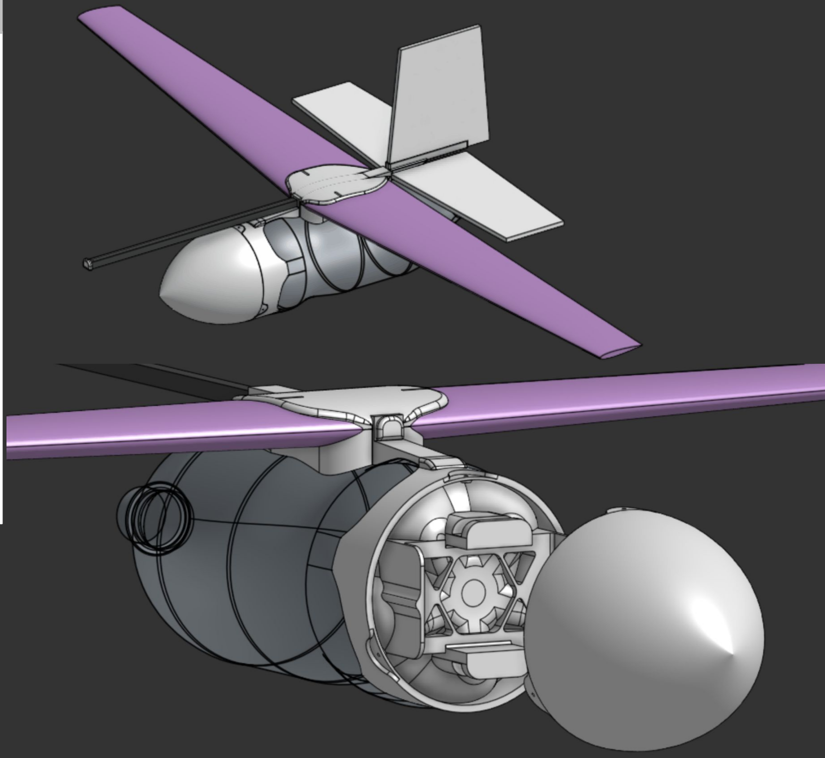


Final Design Configuration

TOP

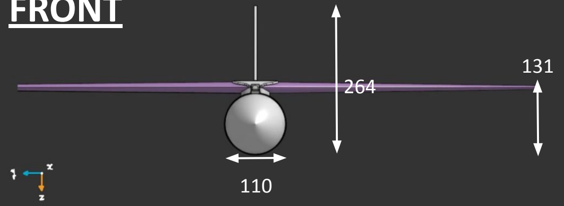


Key Configuration Parameters	
Actual Weight (N) (dry)	3.424
Wing Planform Area – S_{ref} (m^2)	0.085
Wing Loading – W/S (Pa)	50
Wing Aspect Ratio – AR	11.7
Wing Taper Ratio	0.5
Wing Leading Edge Sweep (deg)	6.45
Wing Airfoil	NACA 0018
Fuselage Fineness Ratio	4.14
Drag Polar Model Equation	$0.0488 + 0.02C_l$^2
L/D max Estimate	13



SIDE

FRONT



04
Fabrication

Fabrication

Pink foam board: Cut & sanded for aerodynamics.

PLA spine top/bottom: Split into two to clamp onto wing.

Modular PLA tail: Easier adjustments and prototyping.

Carbon fiber rod: Low mass, extendable, cornerstone of design.

Switched to white foam board for larger stabilizers

JB Weld used for strong, more permanent bonds

06 Flight Observations and Analysis

Glide Flight 1:

Observations:

- Glide stalled in first few seconds of flight
- Rolled to the right
- Nose Dive
- Glide Range limited due to crash

Corrections:

- Increased the size of the horizontal stabilizers around 3 times and 2 times for vertical stabilizer from the initial size.
- Increased tail incidence angle from 10 to 15 degrees in an attempt to increase lift (it did not)

Glide Flight 2:

Observations:

- Glider pitched downward after losing initial momentum
- Glider then rolled to the right
- Hit the ground Nose down

Corrections:

- The incident angle of the horizontal stabilizer was reduced from 15 degrees to 7.5 to attempt to prevent stalling
- Sanded off the unevenness in the wings.

Glide Flight 3:

Observations:

- Hit the ground Nose down
- No longer Spiraled
- Rolled left (previously rolled right)

Glider Analysis

Roll Stability

- Over the 3 flights the glider rolled both left and right. This indicates that our problem was with roll stability rather than wind effects or fabrication errors.
- Asymmetries and natural anhedral present could be a potential reason for roll stability.

Drag Effects

- The NACA 0018 Airfoil may only be feasible for flights at higher speeds. For a brief moment after the initial throw the glider seems to behave as predicted, but once it slows down the pitch rapidly decreases.
- Glider tended to nosedive which could be caused by the fuselage being just the water bottle. The turbulent flow generated by the bottle could decrease the performance of the stabilizers.

Boost Phase

Observations

Launch One:

- Tail detached under force of initial launch.
- Sufficient apogee at 45 degrees launch angle.
- Spun rapidly on descent.

Launch Two:

- 60 degree launch angle.
- Minimal horizontal glide distance.
- Landed directly on launch site.

Analysis

Launch One:

- Ballistic path indicates the wings had a minimal effect on flight performance.
- The tail falling of makes this flight difficult to analyze.

Launch Two:

- Glider pitched up after launch indicating that the wings were generating sufficient lift at the initial high velocity.

Performance Summary Table

	Boost Apogee	Glide Range	Glide Velocity
Estimated	10 m	134 m	11.6 m/s
Actual	12.7 m	17.7 m	8.43 m/s

07
Conclusion

What We Learned

- All models are inaccurate. Instead of using those models for exact values, use them for trends.
- Drop tests should be performed on vital components early in fabrication process to ensure durability.
- Test experimentally when possible.
- Start manufacturing phase as early as possible.

Requirements Summary Table

	Required	Actual
Glide Range	100 m	17.7
Trimmed Glide Velocity	7-15 m/s	8.43 m/s
Static Margin	10%-30%	22.5%
Horizontal Tail Volume (VH)	0.4 - 0.7	1.7
Vertical Tail Volume (Vv)	0.04 - 0.07	0.072
Total Wingspan	≤ 1m	1m

Design Methodology

Design

- Requirements should be decided on prior to design. Designs should be crafted around the requirements.
- Test early and often helps determine durability and efficiency.
- Check for feasibility at every stage of design.

Team Cooperation

Positives:

Teamwork:

- Engaged, ready to participate in the group.

Work Assignment:

- Tasks were distributed evenly among most group members.

Communication:

- Maintained efficient communication via Discord™

Negatives:

Time management:

- Fabrication phase took longer than anticipated.

Design Disagreements:

- Team had difficulty coming to a consensus on the final design.

Personal Challenges:

- Faced occasional obstacles in achieving smooth and cohesive group collaboration.

Thanks!

Questions?