LAV-1 DESIGN PARAMETERS

Introduction

The design of the design of the vehicle was done using OpenVSP software. The software's analysis tools were used to perform lift, drag, and stability analysis on the design. The design parameters were informed by studies on flying wing designs and general intuitive feeling of the designers.

The following terms are used:

AoA – Angle of attack.

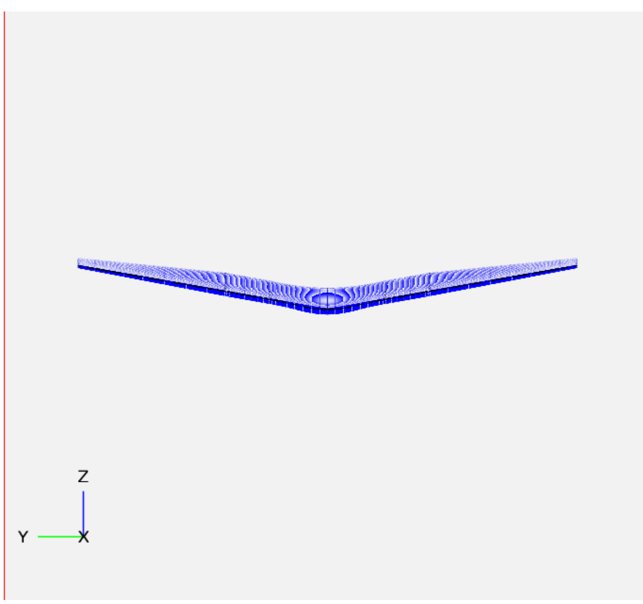
cg – center of gravity

np – neutral point

SM – static margin

1. Span

A span of 0.5 was selected as it the vehicle was an RC model and the size was relatively easy to construct.



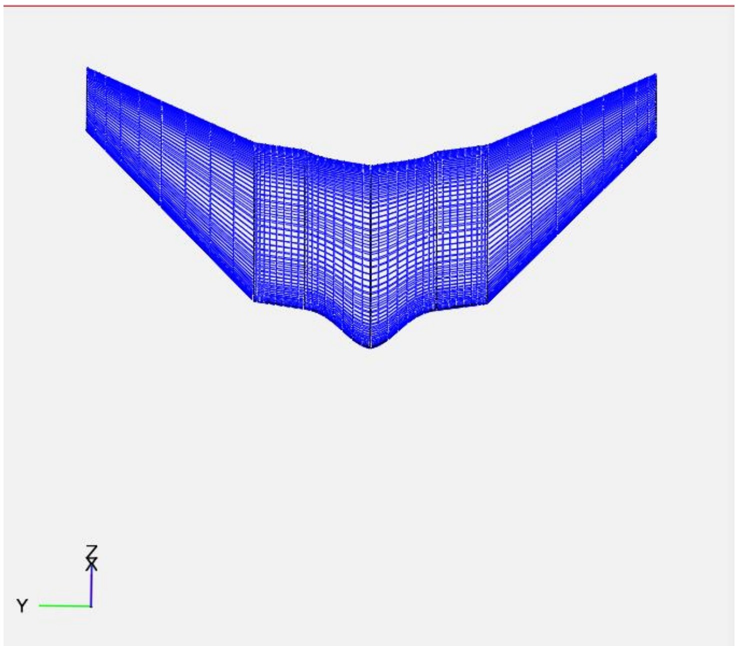
2. Cord

Based on the overall shape of the vehicle, a root cord of 0.23 and a tip cord of 0.08 were chosen. These gave the vehicle an aspect ratio of 2.88499 and taper ratio of 0.3478. It is generally preferred to keep the AR between 0.3 and 0.6 for model RC airplanes. A 0.4 TR has the least induced drag and highest lift coefficients at the tips. The impact on performance is however not much significant.

3. Sweep

The sweep of a wing provides a lot of leverage for the control surfaces and gives a large freedom space for the cog. The sweep also contributes to yaw stability of the vehicle.

A sweep of 40 deg was selected as it enabled a lot of area to be packed in a short span of .5

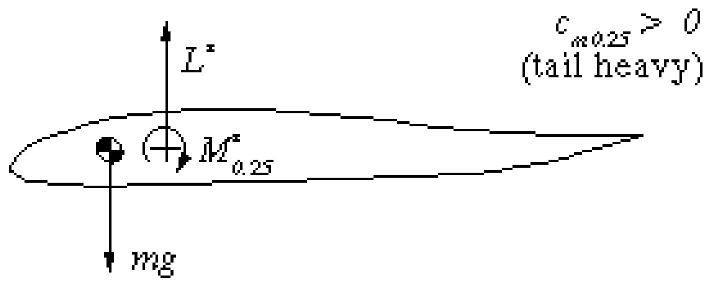


4. Dihedral

Dihedral contributes majorly to the roll stability of the airplane. A positive dihedral causes a positive stability of the aircraft. This effect was desired on the aircraft and therefore a dihedral angle of 10 deg was selected. This angle provided the optimum effect on lift and drag distributions after experimenting with different iterations.

5. Airfoil selection

Longitudinal stability is a major concern for flying wings as they lack a tail wing to counter act the nose up moment of the wings. To this stability, special airfoils have been developed for use in flying wings. A major sub-category of these airfoils are the reflexed airfoils. Due to their shape, they provide a self-countering moment in the plane. A section of a reflexed airfoil is shown below.

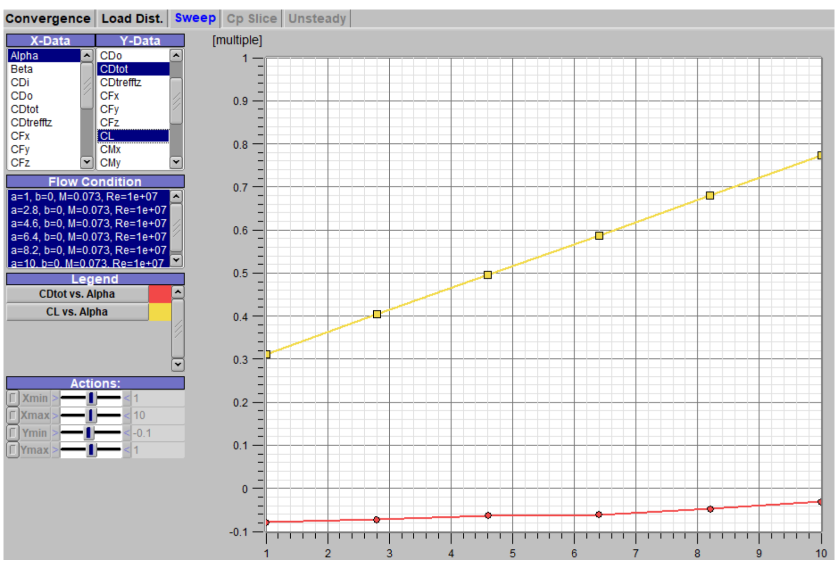


Analysis and Insights:

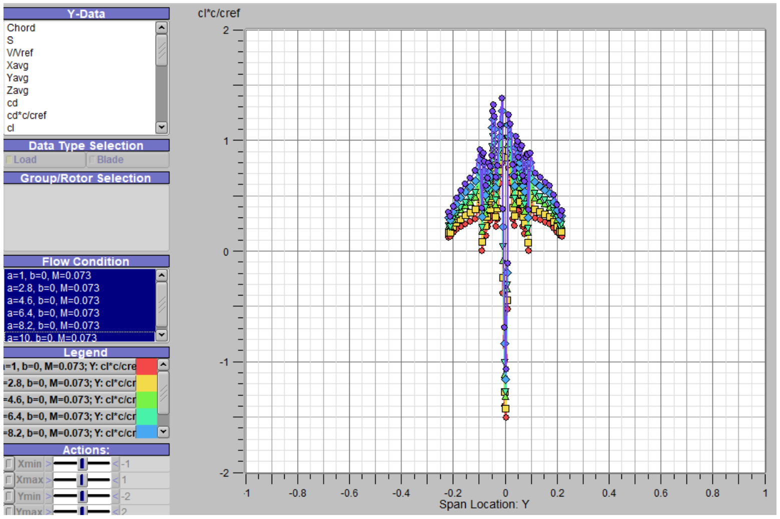
These data were taken at the following conditions:

Using the OpenVSP analysis tools, stability analysis and performance analysis was done on the model.

The **lift and drag curves** showed a descent consistent increase with increase of AoA.



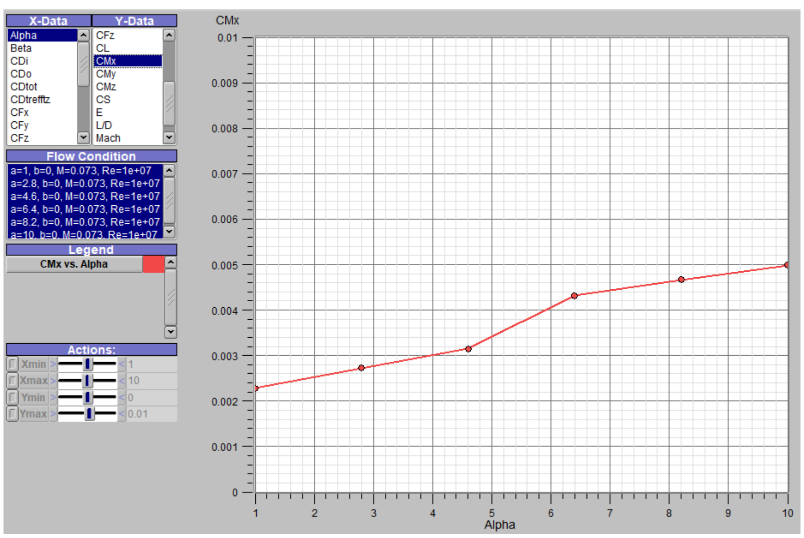
The **span-wise load distribution** was also plotted as shown below.



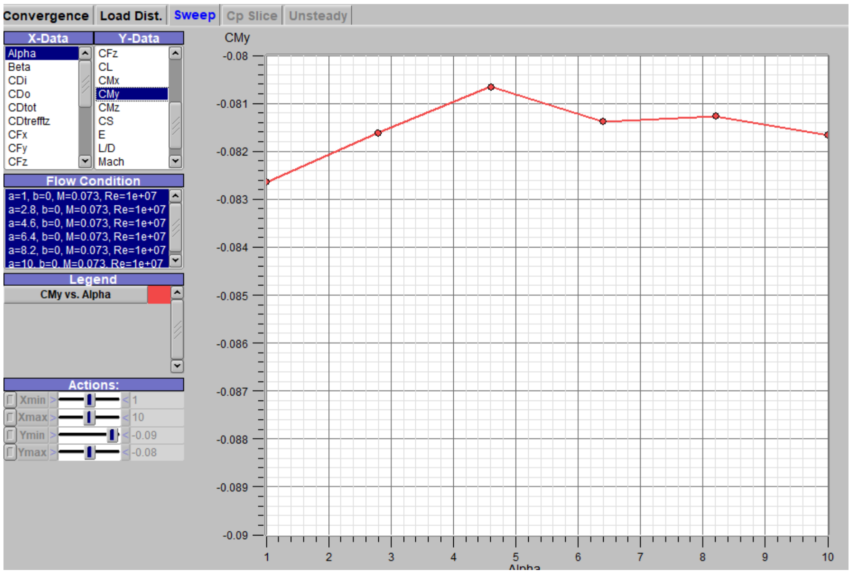
This was consistent with the expected results.

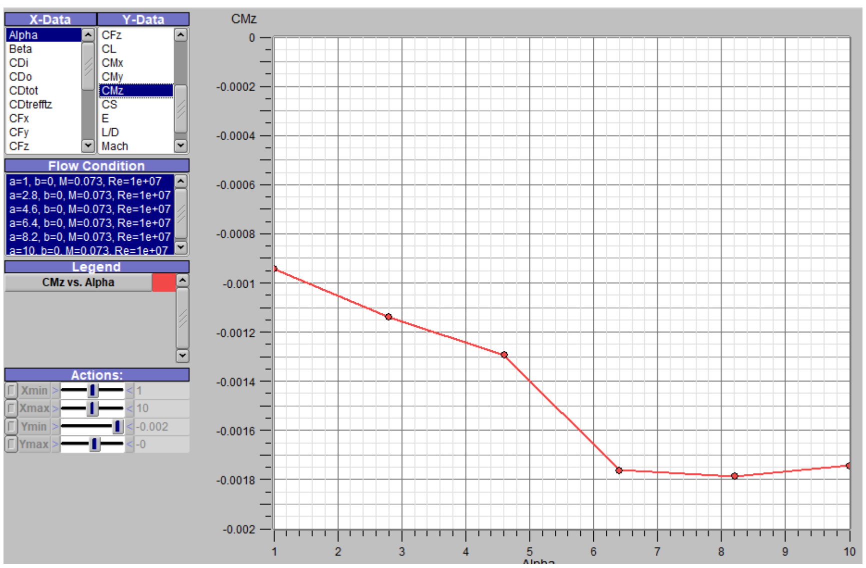
Analysis also resulted in a relatively stable plane with negligible moments along the different axes.

Longitudinal moments were generally positive. This indicates the plane would always have a tendency to nose down. However, this effect is negligible.



The y- and z- moments were generally negative, yet, also negligible. With increase in AoA, the Y-moments were relatively stable while the z-moments reduced.





Other factors which affected the design process include the **cg**, **np**, and the **SM**.

np is the position of center of gravity at which stability is neutral. The x-axis position of the np was 0.1261728.

cg = np – SM*cord

The SM is the distance between *cg* and *np*, divided by the mean chord of the wing. A desirable SM is between 2% and 5%. These constrain the cg to between 0.0122478 and 0.1169228 which is a very small window.

The target cruise altitude of the vehicle is between 2 and 5 meters. A sample calculation is done to find the lift that would be produced during cruise flight. Using the lift equation;

$$L = \frac{1}{2}\rho v^2 S C_L$$

where

- L is the lift force
- ρ is the air density
- v is the velocity or true airspeed
- S is the planform (projected) wing area
- C_L is the lift coefficient at the desired angle of attack, Mach number, and Reynolds number

A lift force of 14N is achieved at velocity of 20m/s, with CL of 0.7 and S of 0.084042. This is barely 1.4kg.

References

- https://www.researchgate.net/publication/328916819_Effects_of_Taper_Ratio_on_Aircraft_Wing_Aerodynamic_Parameters_A_Comperative_Study
- Basic Design of Flying Wing Models
- Flying Wing – Design Notes
- https://www.youtube.com/watch?v=x2Cn3vIb6gw