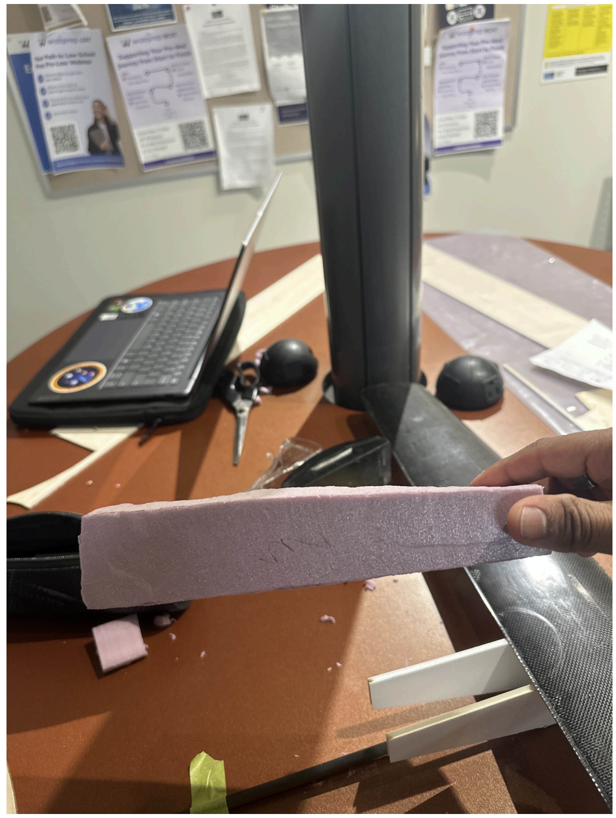
Figures 5.10 & 5.11: New foamboard and foam fuselage cutouts



Final Assembly

Once all of the individual parts are assembled, the full glider can be put together. The procedure consisted of taping the foam insert to the foamboard ‘skin’. The centre of gravity of the glider was then found, around which the wing was placed and secured with the use of rubber bands. 6 AA batteries were taped to the front of the glider to experimentally move the center of gravity based on flight performance. Over a series of 6+ tests the final orientation of batteries and wing position was determined to be optimal based on the glider's shape/setup. The adjustable nature of load (batteries) and wing allowed for last minute changes leading up to the competition. A decision matrix was made to determine which components should and should not be adjustable, which influenced the manufacturing methods used.

Figures 5.12, 5.13 & 5.14: Finished glider from front / top angles, CAD Assembly for Glider

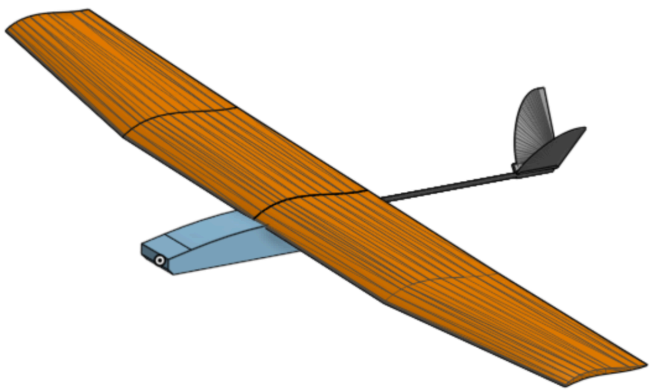


Table 5.2: Decision making matrix determining load application

Selection Criteria	Weight (100%)	Taping Batteries in Place	Glueing Batteries in Place	Taping Coins in Place	Glueing Coins in Place
Adjustability	50%	5	0	5	0
Sturdiness	30%	3	5	3	5

CG impact	20%	3	3	1	1
Total	100%	4	2.1	3.6	1.7

6: Discussion

Maximising the payload to weight ratio was an important design goal for this project. With the payload fixed at 200 grams along with the weight of the wing in the load profile, maximising this ratio meant minimizing the weight of the wing to as little as possible while maintaining its ability to not fail under the bending load.

The balance between the lightweight design and the material and manufacturing cost was another aspect to consider for the project. Multiple calculations, design concepts and iterations were done for the surface area, volume and density of the fuselage and tail fins to find the best possible design for the glider. The selected design was then applied to various different materials to find the best match in terms of metrics like cost per piece or cost per any arbitrary unit of measurement (kg, cm, etc). After going through all the calculations, the best material was then selected as per its manufacturing and labor costs along with an acceptable weight and strength. After a design has been proposed and its cost factor has been determined, further adjustments are then taken into consideration while maintaining the design and budget constraints to make sure the best possible version of the design is built.

In theory, it is possible to calculate the lift force required to make it equal to the weight of the payload. For example, if applied in a wind tunnel experiment, we can determine airfoil values such as lift and drag at various angles of attack at preset conditions. The drawback of this method is that a wind tunnel only assumes a certain fixed velocity which does not completely translate to real life conditions thereby meaning the lift force calculated is not fully accurate. Other analysis methods include using CFD software like ANSYS or a specific airfoil analysis software like XFOIL through which we can analyse different designs of the airfoil to calculate required values. With these softwares, performing the necessary calculations becomes much easier as the program essentially does it after the constraints are set. Depending on the preset values given to the software, determining the lift force for the payload can easily be done. However, just like before, designing wings through these softwares is also mainly theoretical and as such, has some discrepancies with real-life scenarios. Other factors such as human errors also come into play along with material and tool defects which also negatively affect the designing of the wing.

While the test runs for our glider were mostly effective, some notable drawbacks during the competition throws occurred mainly related to stalling of the glider, possibly due to misalignment of the wing when compared to the centre of mass from the rest of the body. Adding extra weights to the glider also proved ineffective as it increased the weight by a lot, leading to the flight distance being drastically reduced as compared to other gliders. This was further highlighted when comparing our glider to other ones as ours was one of the heaviest gliders in the competition, which when compounded with the reduced flight distance also led to a lower flight score compared to other gliders.

Opting for a V-tail was also a design choice that could have contributed to some minor inconveniences during the flight of the glider. Although it reduced drag and weighed lesser comparatively to a standard configuration, it was not as stable and as such, could have resulted in a lesser controlled flight due to needing greater care in handling and throwing which may not have been practised enough before the competition.

7: Conclusion

Overall, while the glider had some issues during manufacturing and its flight performance, the project served as an effective lesson combining both manufacturing and aerodynamic performance. Different manufacturing processes could affect the performance of the glider by changing the weight and center of mass, making it fly shorter distances or become unstable during flight. In the case of our glider, the extra counterweights used to push the center of mass forward added a lot of weight, shortening the flight distance when compared to other designs as was seen in the second throw. Furthermore, the wing would sometimes be aligned too far forward from the center of mass rather than directly over it which would cause it to drastically pitch up during flight as was seen in the first and third throw. For each attempt, the glider did survive landing with no fatal breaks or structural issues which meant that the glider was well suited to survive rough landings or impacts. Despite the flaws in the glider affecting its performance, a lot was learned regarding the design and manufacturing practices which would allow us to improve upon and refine further designs of not just this glider, but other aircraft we may design in the future.

8: Citations

[1] "Carbon Fiber Properties," Gernitex, https://gernitex.com/resources/carbon-fiber-properties/ (accessed Nov. 29, 2025).

[2] "Properties: E-glass fibre," AZoM, https://www.azom.com/properties.aspx?ArticleID=764 (accessed Nov. 29, 2025).

[3] "EP," Designerdata, https://designerdata.nl/materials/plastics/thermo-sets/epoxy-resin#google_vignette (accessed Nov. 29, 2025).

[4] "How much does carbon fiber cost per kg?," Exotic Carbon Fiber, https://exoticcarbonfiber.com/how-much-does-carbon-fiber-cost-per-kg/?srsltid=AfmBOooRQjNf5TAz1x3tjbIvq_UoElb-ghzjtN1__1rtXzk8i51QmDsb (accessed Dec. 1, 2025).

[5] "Fiber reinforcements," Addcomposites, https://www.addcomposites.com/post/fiber-reinforcements (accessed Dec. 1, 2025).

9: Appendix

Wing Analysis Sample Calculations

Sample calculations pertain to carbon fibre and top surface where applicable (such as for finding V, E, fractions, etc) due to the similarity of many of the calculations.

- Carbon fibre and fibreglass cloth volume [cm^3]: $\frac{21.1}{1.8+2.5} = 4.907$
- Epoxy volume (individual surface) [g/cm^3]: $\frac{23.64}{1.15} = 20.557$
- Cloth fraction (individual surface): $\frac{4.907}{4.907 + 20.557} = 0.1927$
- Epoxy fraction (individual surface): $1 - 0.1927 = 0.8073$
- Modulus of elasticity (individual surface) [Gpa]: $294(0.1927) + 3.1(0.8073) = 59.16$
- α: $\frac{(3.1)(0.8073)}{(294)(0.1927)} = 0.0441$
- Tensile Strength (individual surface) [Gpa]: $(1 + 0.0441) * (5.507 * 0.1927) = 1.088$
- Carbon and fibreglass cloth fractions (combined materials): $\frac{4.907}{4.907+4.907+\frac{36.4}{1.15}} = 0.111$
- Epoxy fraction (combined materials): $1 - 0.111 = 0.777$
- Modulus of elasticity (combined materials) [Gpa]: $(297)(0.111) + (80)(0.111) + (3.1)(0.777) = 43.92$
- Tensile Strength (combined materials) [Gpa]: $(5.507)(0.111) + (2)(0.111) + (0.072)(0.777) = 0.8892$
- Wing cross section area [m^2]: $0.6 * 0.1016^2 * 0.063 = 0.0003902$
- Wing moment of inertia [m^4]: $0.032 * 0.1016^4 * 0.063(0.063^2 + 0.063^2) = 1.9033e - 9$
- Bending deflection (uniform material) [m]: $\frac{2.826*0.3747^4}{8*(59.16e9)*(1.9033e-9)} = 6.184e - 5$
- Bending deflection (combined material) [m]: $\frac{2.826*0.3747^4}{8*(43.92e9)*(1.9033e-9)} = 8.330e - 5$
- Bending stress [pa]: $\frac{0.0293*\frac{0.3747}{2}*\frac{0.0064}{2}}{1.9033e-9} = 9229.2$