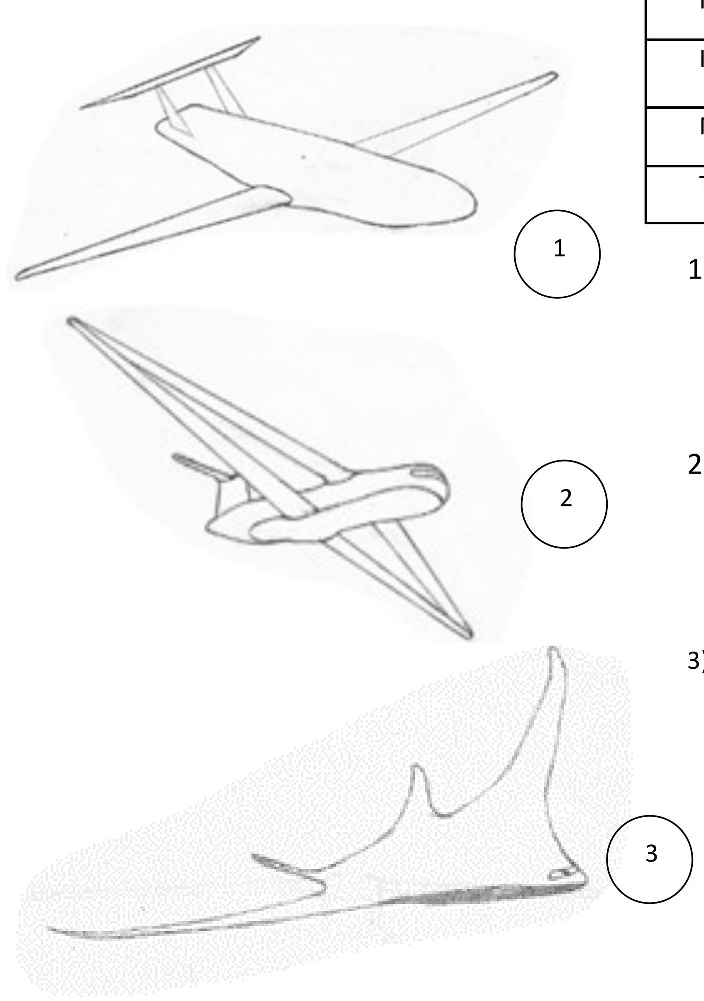
ME1332: Design Project 2 – Glider

Joana Fernandes 1839126, Juan Paredes 1708321, Entsy Mathew 1804571, Connor Mcleod 1839683, Bhuvan Pasyavula 1840179

Brunel University London

Team A5 Development



Technical specification

It must have a maximum wingspan of less than 400mm	It must have a maximum length of less than 400mm
It must be lightweight	It must have maximum lift with minimum drag
It must be strong enough to withstand forces from hitting the ground on landing	It must carry a hook
Must be an innovative design	Must glide for 12m
Total cost must be under £20	Must not contain electronics

1) Concept 1 is easy for manufacturing, the body of the plane also generates a lift, a moment is generated from the centre of lift being in front of the centre of gravity, to combat this a horizontal stabiliser was used. Stronger supports would be needed for the horizontal stabiliser, hence a twin tail design was finalised being supported by 2 vertical stabilisers.

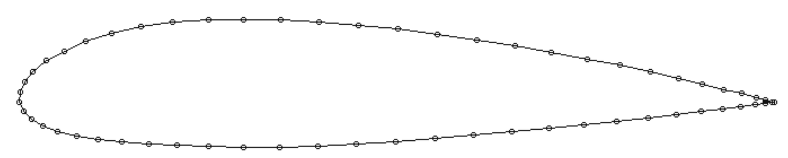
2) Concept 2 features a duel wing design, merging to form a single large wing, the wings at the bottom of the glider forms a dihedral wing, which corrects any deviation in its flight path. A single large wing means the loads are spread at 2 points, which allows the wings to be made of thinner and slightly weaker materials, but manufacturing proves a challenge.

3) Concept 3 was designed to maximise the lift, which features a blended wing design, which includes the fuselage in the design of the wing itself, the rear stabilisers also produce lift as well, meaning the aircraft can fly without vertical stabiliser, which hence reduces the drag on the aircraft, but manufacturing of concept 3 would be impossible with basic manufacturing methods.

How the design works?

In our design, we are using NACA 2217 aerofoil and an aerofoil shaped fuselage. A NACA aerofoil was used due to high lift characteristics and low volume which helps shed weight. The aerofoil will have a positive dihedral angle, 5 degrees to the horizontal, enabling the glider to sustain stability during flight and even when banking. To achieve the dihedral aerofoil design, an insertion (at 5° angle) will be made in the fuselage and the aerofoils will be placed into the fuselage via glue.

The fuselage will be made out of blue Styrofoam and the wings will be made out of balsa wood. Both of these materials have very low density and most importantly, provides ease in manufacturing the aerofoil shaped fuselage and NACA 2217 aerofoil. The fuselage can be shaped by being filed down manually.



NACA 2216

The predicted cycle time for this glider in manufacturing and designing will be around 20 hours.

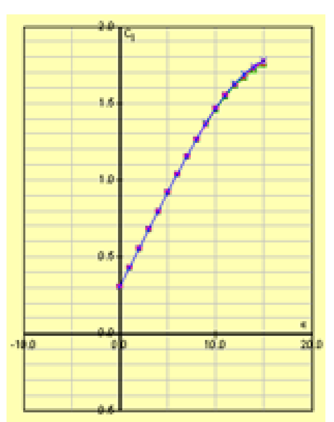
Engineering science/calculations

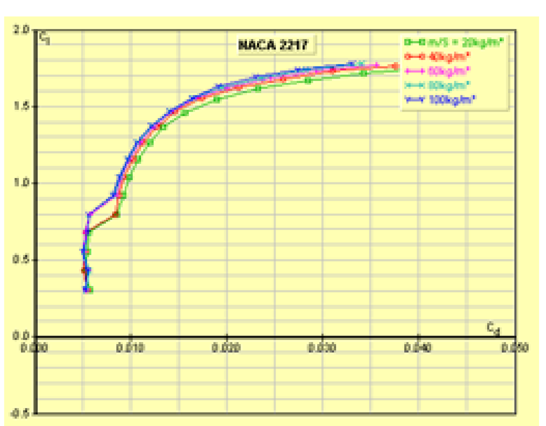
Calculating Lift-Drag Ratio $\frac{L}{D} = \frac{Lift\ Coefficient}{Drag\ Coefficient} = \frac{12}{1.1} = 10.91$

$AR\ of\ Wing = \frac{b^2}{s} = \frac{b^2}{bc} = \frac{b}{c} = \frac{17.5\times2}{10} = 3.5$

$AR\ of\ Fuselage = \frac{5}{30} = \frac{1}{6}$

The gradient a_o can be obtained from the aerofoil graph of lift coefficient against the angle of attack to calculate the lift coefficient of the wing.





Angle of attack (α) is taken as radians

$$a_0 = \frac{dy}{dx} = \frac{\Delta c_L}{\Delta\alpha} = \frac{1.35-0.3}{\frac{\pi}{20}-0} = 6.685rad^{-1}$$

Calculating Lift Coefficient: $C_L = \frac{a_0}{\left(1+\frac{a_0}{\pi(AR)e}\right)} \times \alpha$

$$C_L(total) = \left[\frac{a_0}{\left(1+\frac{a_0}{\pi(3.5)e}\right)} \times \alpha\right] + \left[\frac{a_0}{\left(1+\frac{a_0}{\pi\left(\frac{1}{6}\right)e}\right)} \times \alpha\right]$$

Calculating Drag Coefficient:

$$C_{Di} = \frac{C_l^2}{\pi(AR)e}$$

$$C_{Di}(total) = \left[\frac{C_l^2}{\pi(3.5)e}\right] + \left[\frac{C_l^2}{\pi\left(\frac{1}{6}\right)e}\right]$$

Drag Coefficient (Total Drag): $C_D = C_{DO} + C_{Di}$

Total Mass of Glider:

Volume of Styrofoam: 1.01×10^{-3} Density of Styrofoam: $45kgm^{-3}$

Volume of Balsa Wood: 1.43×10^{-5} Density of Balsa Wood: $150kgm^{-3}$

$mass = density \times volume$

Mass of Styrofoam: $45 \times (1.01 \times 10^{-3}) = 0.045kg = 45g$

Mass of Balsa Wood: $150 \times (1.43 \times 10^{-5}) = 0.002kg = 2g$

∴ Total Mass $= 45 + 2 = \mathbf{47g}$

Calculating Launch Velocity:

$$V_{md} = \left(\frac{1}{C_{d0} \times \pi \times AR \times e}\right)^{0.25} \times \left(\frac{2mg}{\rho S}\right)^{0.5}$$

For an angle of attack of 8°:

$$V_{md} = \left[\left(\frac{1}{C_{d0} \times \pi \times 3.5 \times e}\right)^{0.25} + \left(\frac{1}{C_{d0} \times \pi \times \frac{1}{6} \times e}\right)^{0.25}\right] \times \left(\frac{2mg}{\rho S}\right)^{0.5} = 3ms^{-1}$$

Calculating estimated horizontal distance: $\frac{cL}{cD} * (1.1)$

Angle of Attack (Degrees)	Angle of Attack (Radians)	Lift Coefficient ($C_L - wing$	Lift Coefficient ($C_L - fuselage$)	Total Lift Coefficient (C_L)	C_{DO}	C_{Di}	Total Drag Coefficient (C_D)	Estimate horizontal glide distance (m)
0	0	0	0	0	0.006	0	0.006	0
2	0.0349	0.1393	0.0154	0.1547	0.006	0.00246	0.00846	20.11
4	0.0698	0.2785	0.0307	0.3092	0.006	0.00984	0.01584	21.47
6	0.1047	0.4178	0.0461	0.4639	0.006	0.0221	0.0281	18.16
8	0.1396	0.5571	0.0615	0.6186	0.006	0.0394	0.0454	14.99
10	0.1745	0.6964	0.0768	0.7732	0.006	0.0615	0.0675	12.6
12	0.2094	0.8356	0.0922	0.9278	0.006	0.0886	0.0946	10.79
14	0.2443	0.9749	0.1076	1.0825	0.006	0.1206	0.1266	9.41

Bill of materials

Description	Quantity	Price (inc VAT)
Balsa sheet	1	£2.10
Balsa block	1	£3.84
Blue Styrofoam	1	£4.46

Drawing of final design