Team 14

Poster documentary on the testing of a simple glider

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Keywords Glider, Thin Airfoil, Lifting Line, Path Tracking

Aerodynamic Modelling

A launcher, shown in figure (1), was designed to ensure that all the trials are identical; hence, the fuselage nose was modified with a hook. Moreover, the fuselage side shape was changed, as shown in figure (2), to accommodate a slot for the tail incidence variation and the fuselage material was changed to plywood for rigidity.

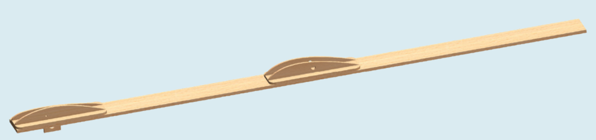


Figure (1): launcher

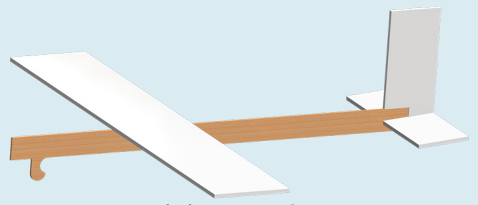


Figure (2): aircraft

The airfoil is kept as a flat plate and thin airfoil theory is used to obtain the lift curve data in table (1). As for the profile drag, experimental tests for the NACA 0003 at Re = $1{\times}10^5$ were used.

Table (1): airfoil aerodynamic parameters

C_{l_α}	$\alpha_{L=0}$	$C_{m_{C/4}}$	C_{d_0}	k1
2π	0	0	0.0073	0.353

As for the 3D effects, the lifting line theory in addition to some corrections are used. The equations are function of the wing planform parameters such as the aspect ratio, the taper ratio, and the quarter-chord sweep as well as the tail arm and incidence. A MATLAB script and a LABVIEW GUI, shown in figure (3), was constructed to vary those parameters and calculate the key performance parameters of the whole aircraft such as the trim angle and the trim speed, as well as the lift and drag coefficients.

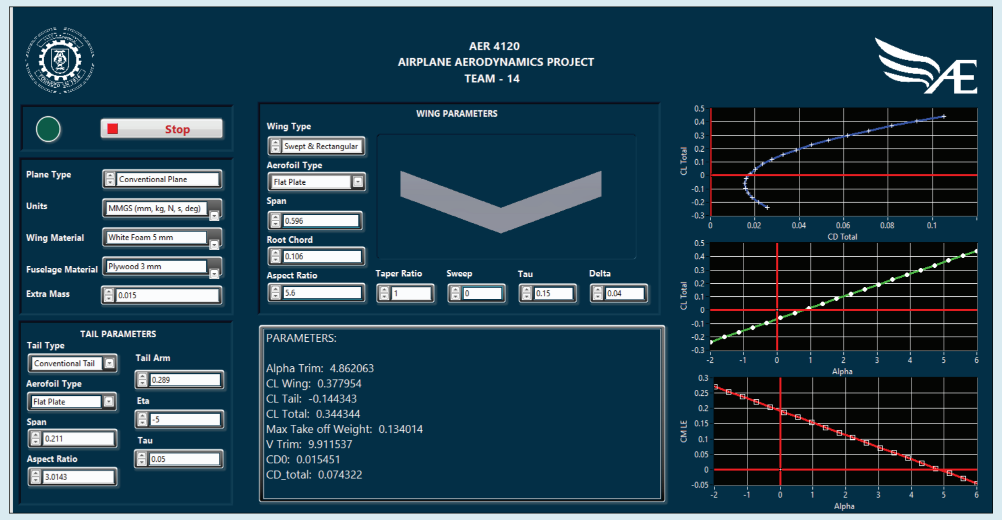


Figure (3): LABVIEW GUI for modeling

For the base configuration, the inputs and outputs are shown in table (2), and the lift, drag, and pitching moment curves are shown in figure (4).

Table (2): base configuration geometry and performance parameters

Aircraft Geometry		Trim Performance	
Wing Aspect Ratio	5.6	Angle of Attack (°)	4.8621
Wing Taper Ratio	1	C_L	0.3443
Wing Sweep (°)	0	Speed (m/s)	8.2567
Tail Incidence (°)	-5	C_D	0.0743
MTOW (kg)	0.093	Glide Ratio	5

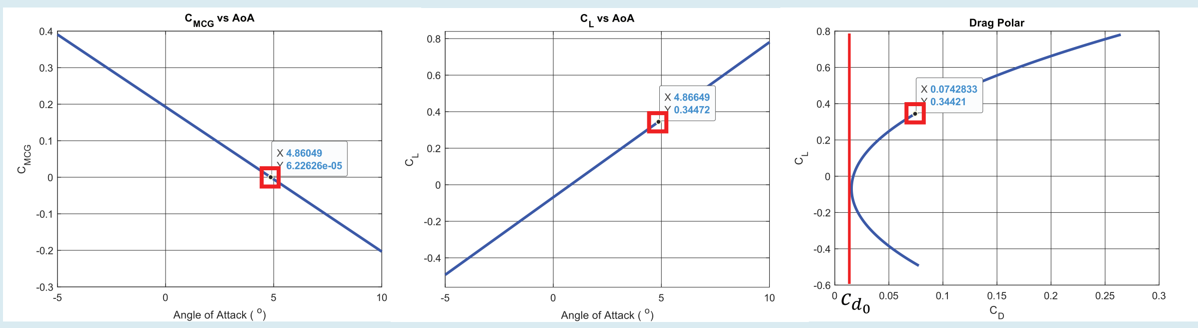


Figure (4): CL and CMCG vs AoA and drag polar for base configuration

Design of Experiments

The wing planform affects the load distribution and hence the lift and drag and the glide ratio as a result; therefore, the aspect ratio, the taper ratio, and the sweep are varied and the altitude loss over the range is recorded. Furthermore, the tail incidence directly affects the trim angle of attack which affects the lift and hence the trim velocity; so, the tail incidence angle is varied, and the trim velocity is recorded. The trim angle of attack and velocity are indicated by a phase of small accelerations. Moreover, the materials used in manufacturing the wing and fuselage have the greater impact on the MTOW which also affects the trim velocity; hence, the wing and fuselage material will be varied and the impact on the trim velocity will be studied. Finally, the wing area will directly impact the lift force generated; so, the wing loading impact on the performance will be studied. Table (3) below summarizes the planned flight tests along with the intended parameter to be varied.

Table (3): flight tests and the parameters to be varied in each test

Parameter	Flight Test 1	Flight Test 2	Flight Test 3	Flight Test 4	Flight Test 5	Flight Test 6	Flight Test 7	Flight Test 8	Flight Test 9
Aspect Ratio	5.6	3	10	5.6	5.6	5.6	5.6	5.6	5.6
Taper Ratio	1	1	1	0.5	1	1	1	1	1
Sweep	0	0	0	0	30	0	0	0	0
Wing Area	0.0632	0.0632	0.0632	0.0632	0.0632	0.0948	0.0632	0.0632	0.0632
Tail Incidence	-5	-5	-5	-5	-5	-5	0	-5	-5
Wing Foam Sheet	Polystyrene	Polystyrene	Polystyrene	Polystyrene	Polystyrene	Polystyrene	Polystyrene	Polyethylene	Polystyrene
Fuselage Plywood Sheet	3mm	3mm	3mm	3mm	3mm	3mm	3mm	3mm	6mm

Flight Testing

The area behind the faculty's swimming pool was used to construct the testing setup. A tripod was fixed at about 11 meters from the airplane range. About 12 meters were left as a room for the aircraft range. The setup is shown in figure (5).

Tracker software was used to track the aircraft movement in the flight tests and the velocity, acceleration, and aircraft attitude were studied. Figure (6) shows the tracking data of some flight tests.

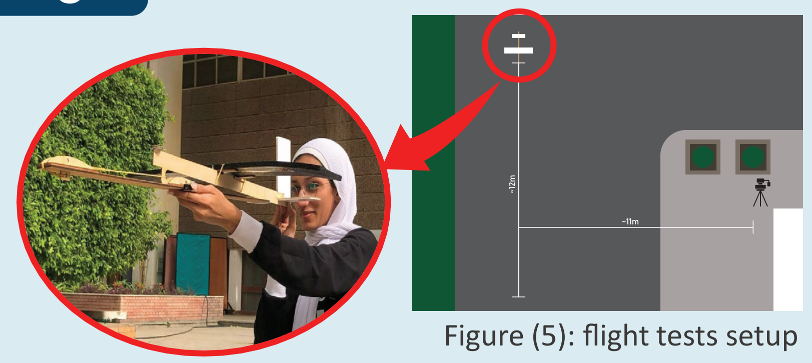
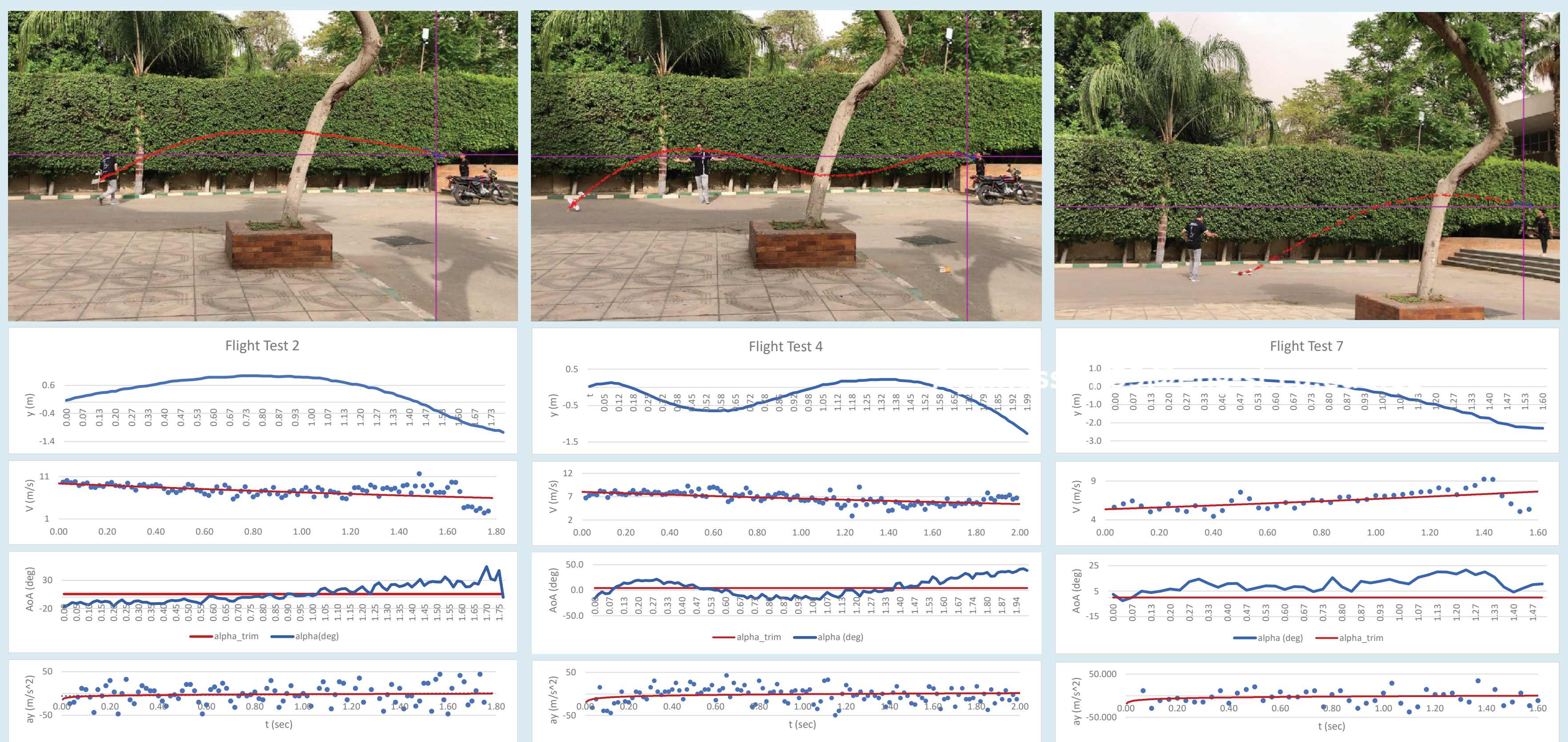


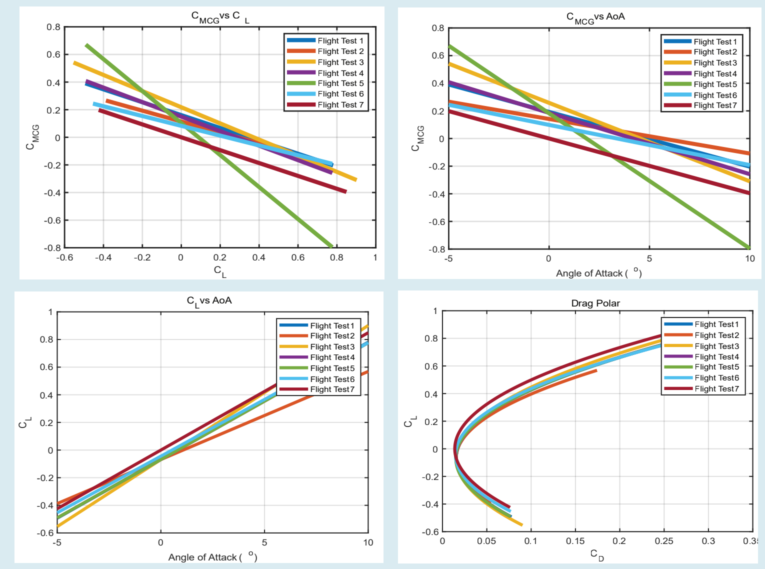
Figure (5): flight tests setup



Data Reduction and Analysis

To improve accuracy and minimize the error, each flight test was held at least three times and were averaged to obtain a single input value. Additionally, the camera and launching positions were fixed during the experiment. The results were obtained on "Tracker" software and analyzed on excel to get the required parameters. The flight characteristics shown in the table below were measured as follows: the endurance by taking the time taken for the glider to land, the range by measuring the distance covered by the glider, and the angle of attack by using the velocity components. The point at which the vertical component of acceleration approaches zero is the point at which V trim and alpha trim are measured. The flight oscillated around its AoA in most of the flights which makes the plane statically stable. Then,these values were compared with the theoretical values and calculated the error which was in the acceptable range of 10 to 20%.

Characteristics	Flight Test 2	Flight Test 4
Endurance (sec)	1.73	2.20
Range (m)	13.18	13.32
Glide Ratio	4.4	5.547
Trim Angle(°)	5.65	4.187
Trim Velocity (m/s)	10.16	10.626



Conclusions

- The plane oscillated around its AoA in most of the flights which makes it statically stable.
- The glider's characteristics obtained from most of the flight tests, such as the gliding ratio were found to be close to other teams.
- The experiment can be improved by adding another source of data acquisition such as sensors on the glider to measure other essential parameters.
- Put into consideration the weather as the day that we conducted the experiment in was so windy.
- The flight were the tail incidence angle was given a zero angle had a lower trimming velocity and angle compared to the other flights where the tail's incidence angle was -5.

Software Used

Contributions

#	Task	Team Members		
1	Aerodynamic Modelling	Aya Khaled		
2	MATLAB Code	Aya Khaled		
3	LabVIEW GUI	M. Hamdy		
4	Tracker	Roaa Tareq		
5	Launcher	Roaa Tareq		
6	Experiments Design	Aya Khaled	M.Hamdy	R. Tareq
7	Design & Manufacturing	Aya Khaled	M.Hamdy	R. Tareq
8	Poster	Aya Khaled	M.Hamdy	R. Tareq

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2	Roaa Tareq	1	24	5	Mohamed Saied	2	17
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