The University of Manchester

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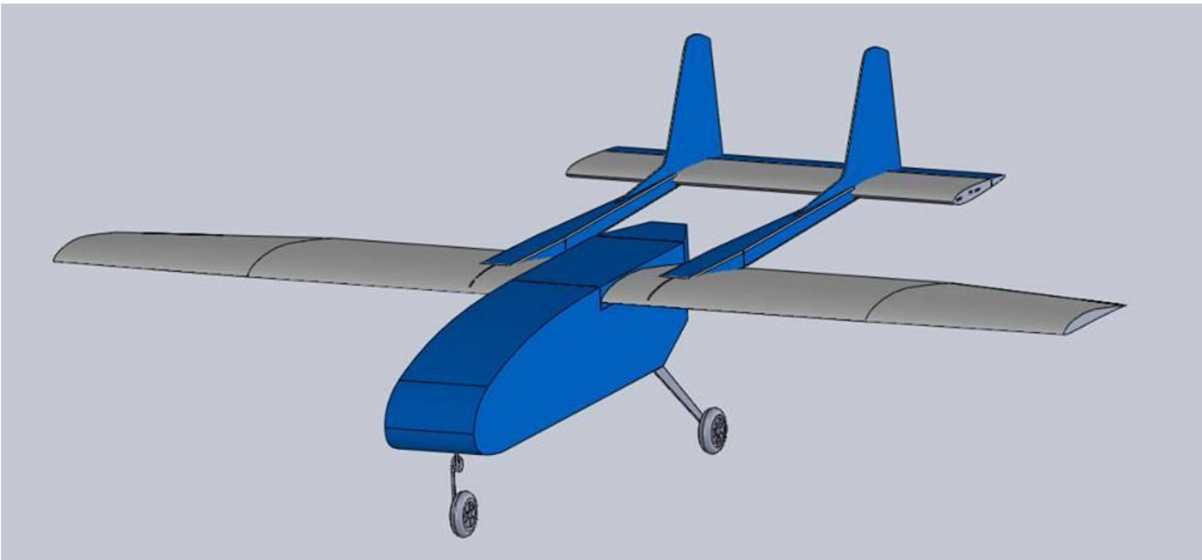
UAV Society

The Flying Saucers



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Initial Ideas for our Design

At the beginning of our design process we decided our main priority was to minimise the weight of the structure of our UAV in order to be able to carry as many tennis balls as possible. We realise that this decision means that the total weight of our UAV will be on the heavier side once filled to capacity, however our competition strategy will be to complete fewer laps of the course carrying as large a payload as possible in order to maximise the final number of tennis balls carried around the course in the allocated time.

In order to minimise the weight of our UAV when unloaded, we decided that building the entire UAV from wooden framework structures would be ideal. This means that the UAV as a whole would have a lower density and therefore would be lighter than if we were to use foam wings or solid panel of wood.

Another important consideration in designing our UAV was the position of the payload. We wanted to ensure the tennis balls naturally positioned themselves in a way that would not alter the flight dynamics. Our aim was to enable the tennis balls to remain evenly distributed during flight and to be positioned in a way to provide an ideal centre of gravity.

Constraints

Propeller efficiency	80%
Runway length (m)	25
Cl Take off	1.2
Cl Landing	1.2
Cl Cruise	1.13
L/D	40
L/D Climb	10
g	9.81
rho (SL)	1.225
Average breaking force (N)	2
MTOW (kg)	3.5
Climb gradient (%)	10
Climb gradient (rad)	0.099669
Aspect Ratio	6
Cd0	0.02
K	0.08

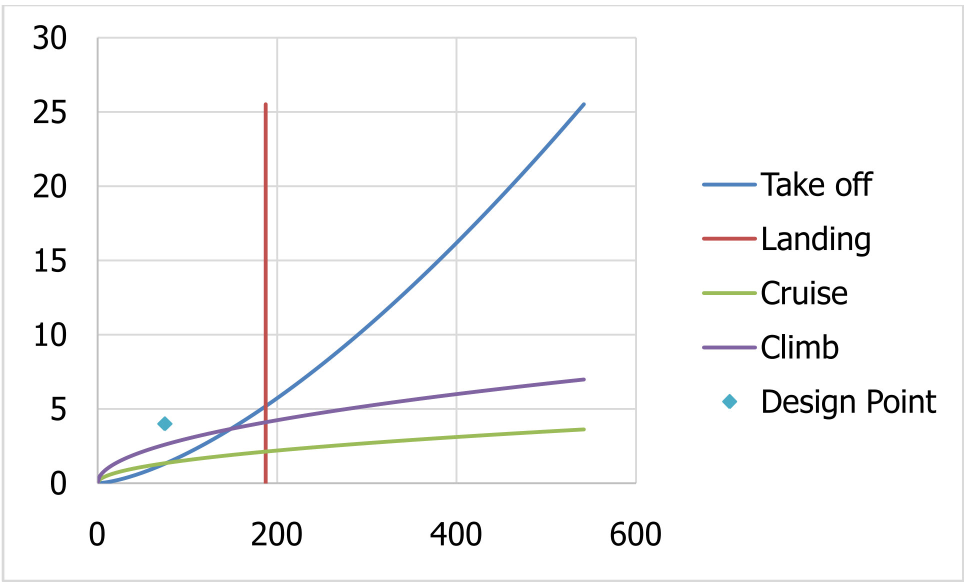
Input
Output

Design Point	
W/S	75
P/W	4

Outputs	
Wing area (m^2)	0.4578
Power (W)	137.34

Wing	
Span (m)	1.657347
Chord (m)	0.276225

Motor	
Motor Voltage (V)	11.1
Amp draw (A)	12.37297
Battery capacity (mAh)	2200
Flight time (minutes)	10.67



We used these constrains as a basis for our UAV design. Once we generated ideas we then finalised the design in such a way as to fit these constraints using them as guideline design specifications. We were able to generated a value for our wing area which would allow our loaded weight be the desired 3.5kg. The constraint analysis chart also provided us with an optimal span and chord length for our UAV.

Payload

In our initial design we decided on a payload of 40 tennis balls, however we realised such a large payload would be likely to greatly compromise our ability to fly effectively. Also a capacity of 40 tennis balls would mean that our payload would account for 65% of our desired maximum mass, for the entire loaded UAV, of 3.5kg. Creating a structure for our UAV which would be light enough, especially when also considering the weight of components such as the battery and motor, would be very difficult for this payload. We therefore decided to carry a maximum payload of 30 tennis balls which will have a mass of 1.71kg, 49% of our desired maximum mass.

We decided that the best way to position the tennis balls would be in two, one ball wide, sections separated by a vertical structure down the centre of the fuselage. This means that when the UAV turns in flight the tennis balls will have limited movement and therefore should not affect the flight dynamics.

With the aim of reducing our time on the ground, we decided that for easy access and fast loading and unloading, our UAV would have a detachable front section so that tennis balls would be able to be poured in and fall into position either side of the central internal wall.

Fuselage

The main consideration when design of our fuselage was again weight. Once again we chose to use a framework structure using balsa wood and plywood. When designing the fuselage we realised it only need to be strong enough to contain the tennis balls and electrical components and therefore weight savings could be made through minimising material usage to form the fuselage, hence the framework design instead of solid panels.

Ideally we would have liked to have primarily used balsa wood as it is lighter than plywood however it does not exhibit the omnidirectional strength that plywood does. Therefore we decided to make use of both materials, ensuring strength requirements were met whilst keeping weight to a minimum by using balsa where plywood's strength was not required.

Undercarriage

We decided that the best option would be to order an undercarriage from an online retailer. Once again focusing on minimising weight we chose a carbon fibre undercarriage as carbon fibre has a good strength to weight ratio.

The Wings

We decided to design wooden ribbed wings with plywood spars composed by 3 different layers and balsawood ribs covered in a sheet of balsawood. Although this method of building the wing may have been more difficult to design and manufacture than a foam wing design, we felt that minimising the weight of the wings was important, especially as our initial aim was to maximise our payload. With weight in consideration, we decided the wings would be constructed using plywood and balsa wood in a framework designed to use as little material as possible to provide the strength and structure required.

Through discussing aerofoils with teams that have entered the competition in previous years, we were advised to use an aerofoil from the Eppler family. Firstly we evaluated the Eppler 66 however felt this would be unsuitable due to its large under-camber, which would thought could lead to manufacturing problems and possibly effect the strength of our wing structure. We therefore decided that the Eppler 178 would be a better aerofoil for us to use as it has a much smaller under-camber whilst performing similarly to the Eppler 66.

Tail

We decided to have a twin boom tail design as we thought this would be more resistant to lateral torsion and that the booms would offer some protection to the propeller. Our tail has a symmetrical aerofoil and both the tail and the booms are made using plywood and balsa wood.

After using the constraints to find the optimal span and cord for the wings and therefore finding the desired wing area, we then used the advice of those who have entered the competition before to find the tail area. We calculated our tail area using the following equation: Vh=(St/Sw)*(It/c). Where Vh=horizontal tail volume coefficient, St=tail area, Sw=wing area, It=moment arm form cg and c=chord. We were advised that typical values for tail volume coefficient range from about 0.4-0.6.

Conclusion

The decisions we have made throughout the design process have led to the creation of a UAV which uses material very efficiently and therefore unloaded is lightweight, allowing us to have a larger payload. We have made decisions due to our own personal experiences and the experience of those who have entered the competition in previous year, but have also tried to be unique and innovative. Our UAV is constructed of wooden frameworks which we know is a risky strategy as is less durable than a solid panel and foam UAV however we feel that minimising weight is key to a good performance. As a team, we decided to use minimal material to minimise weight but designed the framework in such a way as to not compromise on the structural strength of our UAV.