BMFA

2015/16

TEAM 3

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Members

Tom Walker

Adam Wozencroft

Anthony Gillard

Elizabeth Matthews

Fahima Saiyed

Kieron Redmond

Ryan Beecroft

Tseno Tsenov

Roles and Responsibilities

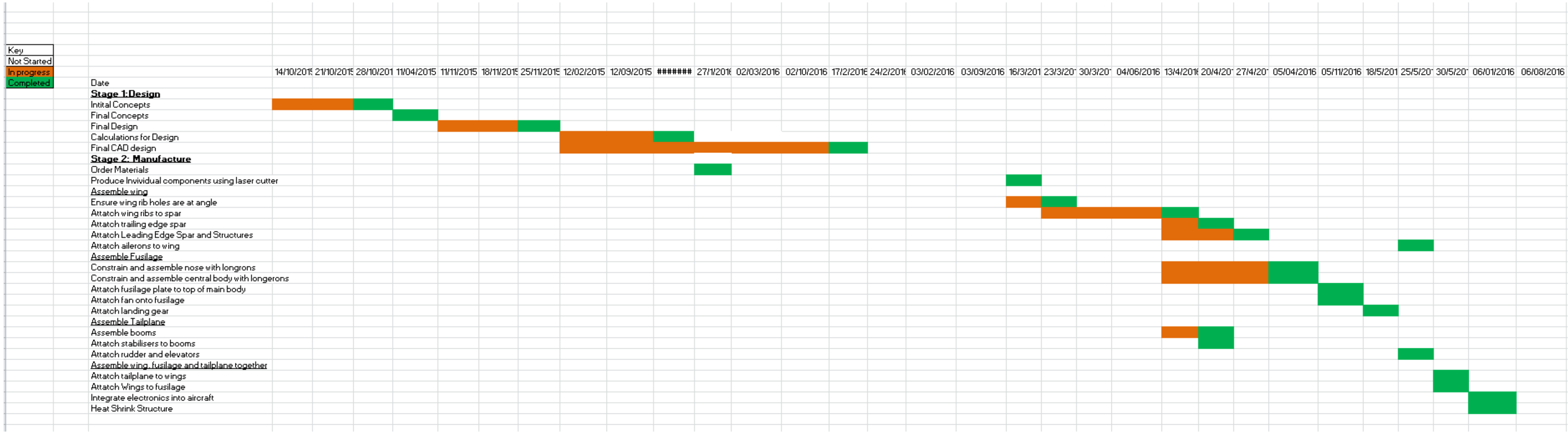
Member	Responsibility
Fahima Saiyed	Responsible for the design of the wing and the tail plane. Also responsible for the storage of the payload in the fuselage.
Anthony Gillard	Is also responsible for the design and analysis of the wing and tail plane configuration.
Tseno Tsenov	Has the responsibility for designing the landing gear and mechanism.
Ryan Beecroft	Is responsible for
Kieran Redmond	Responsible for the designing of the fuselage for the given criteria.
Elizabeth Matthews	Also responsible for the design of the fuselage and the ducted fan.

Schedule

Week Commencing	Task
19/10/2015	Drafting ideas for the requirements of the challenge.
26/10/2015	Choose and sketch a few initial concepts
2/11/2015	Review sketches and decide on final design
9/11/2016	Run some tests on xflr for the wing aerofoil
16/11/2015	General Arrangement drawings of final design
23/11/2015	Do calculations for the design concept
30/11/2015	Look at landing gear concepts
7/12/2015	Decide on landing gear concept
14/12/2015	Make any adjustments to the final design
21/12/2015	Start to decide on the material we will be using for the plane
28/12/2015	Initiate 3D drawings of the final design
4/01/2016	Continue with the 3D modelling
11/01/2016	3D Modelling
18/01/2016	Think about the materials and manufacturing process
25/01/2016	List of materials for the plane
1/02/2016	CAD Design completed

8/02/2016	Order the materials needed for the plane
15/02/2016	If materials arrive, initiate the building process.
22/02/2016	Laser cut the ribs and the frame for the fuselage
29/02/2016	Make any adjustments to the cut shapes
7/03/2016	Continue with the laser cutting for each section of the plane
14/03/2016	Assemble the wing, first the initial ribs and spars
21/03/2016	Continue building the wing until both sides are equal and complete
28/03/2016	Assemble the fuselage frames and longerons running through it
4/04/2016	Start on the building on the tail plane
11/04/2016	Continue with the building of the tail plane.
18/04/2016	Finish any structural parts that are incomplete
25/04/2016	Finish any structural parts that are incomplete
2/05/2016	Finish any structural parts that are incomplete
9/05/2016	Work on attaching the heat shrink material on the skin
16/05/2016	Continue working on assembling the plane together
23/05/2016	Carry out some tests on the plane
30/05/2016	Continue with tests and any changes that need to be made.
6/06/2016	Final testing and any adjustments that need to be made.

<u>**Gantt chart**</u>



Requirements

- Be able to carry payload of up to 4kg
- Fit a 15cm (in diameter) ball into the plane and be able to detach it with ease

Key Design Aspects

The purpose of competing in the BMFA is to challenge ourselves and to push our engineering knowledge to new heights. In keeping with this motto we have decided to have a purposely complicated design. These complicated design aspects include a swept wing, twin booms and a ducted fan all of which will improve our understanding of aeronautical engineering and the benefits and limitations of such design features.

Wing

The swept wing was chosen primarily due to the increase in roll stability it provides in both normal and inverted flight. We felt that if our aircraft was flyable when inverted then the probability of a crash resulting from a stall or strong gust of wind is significantly reduced. In addition to this ability the swept wing also has an aerodynamic centre much further back compared with a straight wing, this allows us to create a very compact aircraft which results in both materials and cost saving as well as surface area exposed to the air which in turn will reduce the friction drag developed by our aircraft.

However the swept wing isn't as efficient at generating lift at a given airspeed compared with a dimensionally similar straight wing. This is because the swept wing produces lift with the velocity of the air normal to the wing which is significantly less than the velocity of the aircraft.

Through detailed discussion of the benefits and limitations of a swept wing the group concluded that the overall best option was to have swept wings for our aircraft.

The main aspects of our wing it that it is high and swept. We decided to have a high wing has it improved the stability of the aircraft and since we had a limited window for flight testing the aircraft had to be as stable as possible from the outset. We also decided to have a swept wing as it would bring the centre of lift further down the fuselage which was required due to the centre of gravity being towards the rear of the fuselage. The motor and fan are mounted behind the wing and with a twin boom tail design the majority of the weight would be behind the centre of the wing thus by having a swept wing design, the centre of lift would be further back and closer to the centre of mass.

Ducted Fan

A ducted fan is a propulsion system in which a type of propeller is mounted inside a duct. The duct reduces the propeller blade tip loss meaning it is more energy efficient than a regular propeller at emitting thrust. This means that a ducted fan can have a smaller diameter than a propeller and still produce the same amount of thrust as a propeller of a larger diameter, you can therefore have less force pushing the propeller around which in turn saves energy. The ducted fan is also much safer as if the aircraft were to accidentally go near someone the duct could protect the person/object from serious injury from the fast spinning propeller.

There are a few disadvantages, for example, at very low level thrust the duct is less efficient than propellers due to the extra drag that is caused from the duct (i.e. more frictional drag as there is a larger surface area). From a design point of view the duct adds excess weight, the high angle of attack will produce higher levels of drag, and to obtain the thrust benefits the gap between the propeller and the duct has to be very small otherwise the disadvantages outweigh the benefits.

We decided that the benefits outweigh the disadvantages for the ducted fan as we will not be having low level thrust, and the extra thrust generated would overcome the extra weight added.

To prove our theory that a ducted fan produces more lift than a propeller, we conducted a simple experiment. The experiment involved mounting a propeller to a board on wheels connected to a newton meter. We would run the fan with and without the duct multiple times and take an average of each and compare to ensure reliability of the results. The results from the test supported our theory as the ducted propeller produced around half a newton more lift than the propeller on its own. This confirmed for us that the ducted fan was the best option for our particular aircraft.

Twin Booms

Another main concern of the group was to have the tail out of the wake of the propeller as this makes take offs more difficult for our pilot. To achieve this we design a plane to incorporate two booms. The benefits of such a design allowed us to position the tail in such a way as to avoid the wake from the propeller, they also made the whole tail structure stronger as this method is more efficient as transferring loads through the aircraft.

However there are some substantial disadvantages of having twin booms. One of which is the increase in surface area of the combined booms compared to the single boom. This results in an increase of friction drag which will lower the overall effectiveness of the aircraft however when this is combined with the increase in effective of the tail, in terms of producing lift, we concluded that the twin booms offered us more advantages than disadvantages.

Landing Gear Layout

For this process we started our research by studying landing gear layout currently in service around the world. We notice a considerable number of aircraft, such as the Boeing 777, had a tricycle style layout. While others such as the BAE Harrier had the landing gear attached to the wing tips.

We concluded that the tricycle style layout would best suit our aircraft for various reasons. The main one being that our aircraft needed to be able to land safety with a considerable amount of water on board. Having the landing gear directly underneath the fuselage enabled us to increase the strength of the fuselage and guarantee the impulse of force experienced induced by the water can be dissipated easily and effectively.

Structural Design

Wing

For the structure of our wing we chose a twin spar configuration as we knew the wing loading was going to be quite high thus we wanted to make sure the wing wouldn't buckle or break mid-flight. The first spar is situated just behind the leading edge of the wing and the second is about ¾ along the chord length as to make the wing rigid along the whole chord length. The spars are angled at the sweep angle as such they can run the length of the wing.

Empennage

The inverted U-tail section was built using a 10mm balsa sheet to create the desired shape. During the initial design stage we had concerns with producing a tail heavy aircraft and we took measures to avoid that from happening. The horizontal surface will be covered in solar film and this allowed us to remove material from the structure to reduce the overall mass of the tail plane. A laser cut plywood servo mount was also integrally mounted onto the horizontal stabiliser. However, lightened structure of the empennage is a quite fragile due to the reduction of strength. In addition, the empennage was relatively easy to assemble as most of the parts were slotted and glued together after being laser cut. The complete U-Tail section is attached to the tapered box-section tail booms using epoxy.

Manufacturing Process

Some images during the manufacturing process: