# Design, Manufacturing and Analysis of Unmanned Aerial Vehicle (UAV)

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*Abstract*— To design the efficient aircraft capable of accurately lifting and dropping a humanitarian aid package from a certain height. Accurately predicting the lifting capacity of the aircraft is the essential part of the project. The wing, tail, fuselage and control systems have been designed by us. We have designed a mono plane aircraft of approximately 2kg in weight which can lift an object of 1 to 2kg. Thus the total weight of aircraft and object will be approximately 4kg. It is controlled by a remote device of frequency 2.4 GHz.

***Key words:*** UAV, Unmanned Aerial Vehicle, WING

## I. Introduction

An unmanned aerial vehicle (UAV), commonly known as a drone and also referred to as an unpiloted aerial vehicle and a remotely piloted aircraft (RPA) by the International Civil Aviation Organization (ICAO), is an aircraft without a human pilot aboard. ICAO classify unmanned aircraft into two types:

I) Autonomous aircraft and
II) Remotely controlled aircraft.

The typical launch and recovery method of an unmanned aircraft is by the function of an automatic system or an external operator on the ground. Historically, UAVs were simple remotely piloted aircraft, but autonomous control is increasingly being employed.

Fig. 1: Final UAV Model

They are usually deployed for military and special operation applications, but also used in a growing number of civil applications, such as policing and firefighting, and non-military security work, such as inspection of power or pipelines. UAVs are often preferred for missions that are too "dull, dirty or dangerous" for manned aircraft.

### A. Problem Statement:

In situation such as floods, epidemics, curfews, relief camp and other casualties where there is a danger to human life we can use this type of UAV. By adding camera it can also be used for surveying or examine the condition in situations where there is a danger to human life.

### B. Objectives:

According to the problem statement defined above, we chalked out the requirements, which are as follows:

1) To design an aircraft that can perform well at low Reynolds Number.
2) Plane capable of lifting capable of lifting particular payload and also capable of dropping a humanitarian package from a certain height to a précised location.
3) The constraint on empty weight required a high lift, under cambered aerofoil, to reduce the wing area and thus reduce aircraft weight.
4) The criteria for good trade studies require that the aircraft should be manufactured with minimum cost and with ease of manufacturing.
5) To design an aircraft with minimum drag.

### C. Applications:

1) Aerial surveillance
2) For dropping humanitarian aid package
3) Reconnaissance
4) Traffic control
5) Mineral exploration
6) Urban mapping
7) Agriculture (detecting the health of crops)
8) Defense.

### D. Plane Specifications:

1) Wing Span – 1.6 meters.
2) Total Wing Area – 0.44 sq.m.
3) Speed – 44 km/hr.
4) Aspect Ratio – 6.
5) Root Chord – 0.272 meters.
6) Configuration – Mono Plane.
7) Wing Plan Form – High Wing.
8) Motor – emax 850 kV.
9) Propeller - 12X6 Tractor Configuration.
10) Servos – emax 16 grams.
11) ESC – 60 A.
12) Battery – Lithium Polymer 3000 mAh (4 Cell).
13) Material – Medium Density Fiber Board, Extruded Polystyrene, Fiber Glass Kevlar and Balsa Wood.

### E. Design Specifications:

1) Wing Airfoil – Selig 2091
2) Tail Airfoil – NACA 0009
3) Thrust – 2.3 kg @12000rpm
4) Aileron – 20% of Chord Length of the Wing
5) Elevator – 30% of Chord Length of the Tail
6) Rudder – 30% of Chord Length of the Tail

## II. Past Researches

UAVs has been developed and adopted by many countries. Drones (UAV of bigger capacity) have also been used by animal rights-NGOs, advocates to determine if illegal hunting is taking place, even on private property. Beyond the military applications of UAVs with which drones

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became most associated, numerous civil aviation uses have been developed, including aerial surveying of crops and spraying anti-insecticides for crops, acrobatic aerial footage in filmmaking, search and rescue operations, inspecting power lines and pipelines, delivering medical supplies.

## III. AIRCRAFT COMPONENTS

An UAV comprise of several major components. It mainly includes wings, horizontal tail, Vertical tail, fuselage, propulsion system, landing gear and control surfaces. In order to make a decision about the configuration of each aircraft component, the designer must be fully aware of each component. Each aircraft component has inter relationship with other components and interfere with other components.

### *A. WING:*

The main function of wing is to generate the aerodynamic force of lift to keep the aircraft airborne. The wing tends to generate two other unwanted aerodynamic productions- an aerodynamic drag force plus an aerodynamic pitching moment. Furthermore, the wing is an essential component is providing the aircraft lateral stability which is fundamentally significant to the flight safety. In almost aircraft the "Ailerons" is arranged to be at the trailing edge of the outboard section.

### *B. Fuselage:*

The primary function of fuselage is to accommodate the pay load which includes the passengers, cargo, luggage and other useful loads. The fuselage is often a home for pilots and crew members and most of the time fuel tanks and engine.

### *C. Horizontal Tail:*

Its primary function is to generate aerodynamic force to longitudinally trim the aircraft. In major cases the elevator is a movable part of the horizontal tail, so longitudinal control is applied through horizontal tail.

### *D. Vertical Tail:*

Its primary function is to generate an aerodynamic force to directionally trim the aircraft. The vertical is an essential component in providing the aircraft directional stability which is a fundamental requirement for the flight safety.

### *E. Motor:*

A DC Brushless motor is used to run the propeller.

### *F. Battery:*

A lithium polymer (LiPo) Battery is used to run the control systems of UAV.

### *G. Landing Gear:*

Its Primary function is to facilitate the take-off and landing. During the take-off and landing operations, fuselage, wing, tail, and other components are kept away from the ground through landing gear. Rolling wheels as part of landing gear allows the aircraft to accelerate without spending a considerable amount of thrust to overcome the friction.

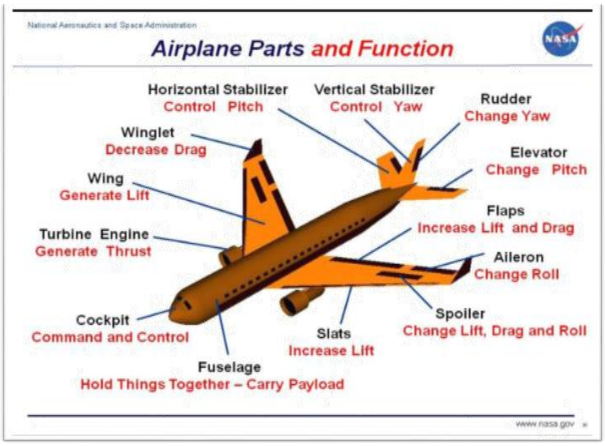


Fig. 2: Airplane parts and functions

## IV. CONCEPTUAL DETAILS

It is a separate discipline of aeronautical engineering wherein designer should be well versed with aerodynamics, structures, stability controls and propulsion. It is a process in which basic question of size, weight performance & configuration arrangement is answered. New ideas & problems emerge as a design is investigated in ever increasing demand.

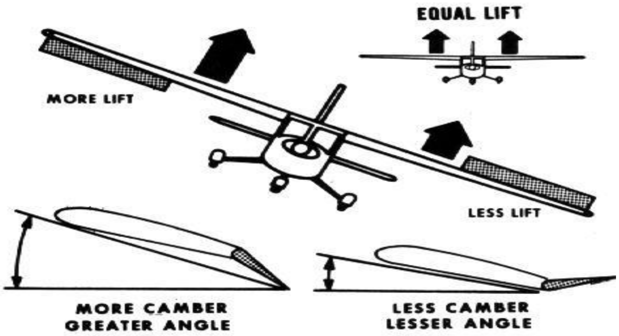


Fig. 3: Forces exerted by the Aelerons

## V. RESEARCH METHODOLOGY

This research falls under the general research field of Aeronautics and Astronautics (Aero- Astro). This research field is concerned with studying the conception, design, implementation, and operation of aerospace products and systems. Since the final goal of this research is to develop a method to design human-computer interfaces for controlling systems, this research relates specifically to the systems engineering aspects of Aero- Astro.

The design of interfaces for complex systems typically focuses on the tasks that individual users must accomplish during any kind of mission or operation. A common approach used for designing complex systems is the CTA (Cognitive Task Analysis). It is a powerful tool for improving existing technologies, but it is insufficient for futuristic environments, since it requires access to subject matter experts and existing system implementations. In particular, this research explores systems that are only partially automated, which means that human performance is strongly relevant to the appropriate system functionality.

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## VI. AEROFOIL SELECTION

In order to select airfoils needed for the aircraft the team created criterion for each aerofoil to meet. A series of airfoils were listed, the airfoils were selected for analysis based on standard Airfoils used in the competition and also based on Low Reynolds number and high lift criteria. Based on the constraint analysis and configuration selection carried out earlier, a one feet chord was assumed at cruise velocity of 40 mph. The following airfoils were analyzed in XFLR5 for a Reynolds number of 3.65e5.

The table below shows the comparison between different airfoils:

| **Criteria** | **S1223** | **Ch10** | **E423** | **Fx74-C15140** | **Fx63-137** |
|---|---|---|---|---|---|
| **(Cl/Cd)max** | 90 | 110 | 102 | 80 | 115 |
| **Cm** | -0.27 | -0.28 | -0.24 | -0.245 | -0.21 |
| **Cl-max** | 2.27 | 2.01 | 2.01 | 2.24 | 1.78 |
| **Stall angle** | 13 | 11 | 12 | 13 | 20 |
| **Stall Characteristics** | Sudden | Gentle | Gentle | Sudden | Gentle |
| **Thickness** | 12.14 % | 12.84 % | 12.52 % | 14.05 % | 13.67 % |

Table 1: AeroFoil Selection Tradeoff

Based on the above analysis CH10 was selected as it was better with respect to Cl/Cd and Cl-max as compared to other aerofoils and had gentle/gradual stall characteristics.

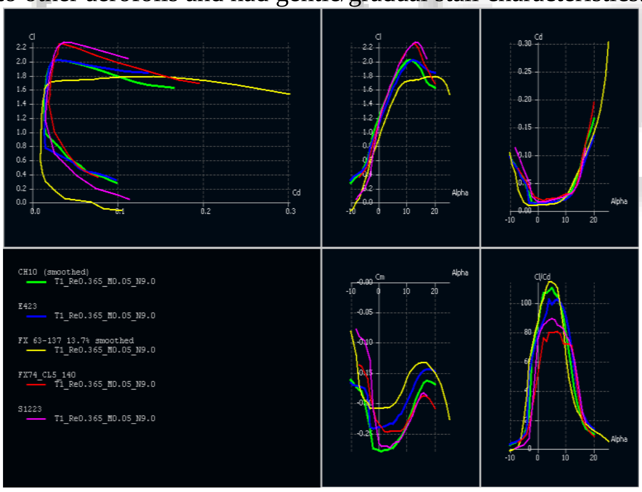

Fig. 4: 2D Xfoil Analysis

## VII. CONCLUSION

The project is an ideal representation of the kind of challenges that engineers face continuously in industry. The complexity level of the design aspects of the components is the proper performance of the aircraft, as well as a harmonized correlation of all of them, provide perfect ground for a demanding project.

Having to make a series of studies and analysis for each of determine the best result, will offer the chances to gain a hands-on experience of how decision are taken in the real world. All factors affecting the overall performance of a given part are taken into consideration, and the perfect balance between efficiency and strength are what determine the best result. Many times in the real world though, reaching that intersection point between maximum efficiency and strength come at a high prize, which in many cases fall outside the margins of a predetermined budget. It is in this case when alternative solutions have to be thought of an analysed. The alternative yielding the highest prise cost reduction with the least sacrifice for the optimal design is the most favourable solution.

This project serves a great guidelines as to what is expected of engineers when working in the industry. The importance of meeting deadline the unavoidable necessity to co-relate and work with people from different disciplines and being able to communicate and present your own ideas effectively and the importance of using your own knowledge and creativity to solve problems our all addressed in this project. That is what makes it so unique and rewarding.

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