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# Modeling of Unmanned Surveillance Aircraft

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**Abstract:** Surveillance is critical for military, law enforcement, and search and rescue operations. In the past, stealth aircraft and helicopters were used for these types of missions. Recently however, unmanned aerial vehicles (UAVs) have grown in popularity and are an excellent resource that can be utilized for surveillance missions. Since this is a common capability of drones, this project sought to create surveillance UAV that was autonomous, inexpensive, lightweight, and easy to manufacture. The drone was designed as a quadrotor that houses two cameras with a wireless transmission system that provides live feed from the cameras to the ground station. It was also intended to be able to carry a payload for future developments. Though not all of the goals were fully realized by the project's conclusion due to stability and networking complications, the drone met size and cost standards, and could successfully localize its position with GPS and IMU sensors. Additionally, its controls were understood through simulation and testing.

**Keywords:** Aerofoil, Styrofoam, brushless motor, Propeller, ESC, Servo motor.

## I. Introduction

The development of unmanned aerial vehicles unmanned surveillance aircraft has been growing significantly over the last decade. UAVs have been expanding from military applications into civilian purposes like aerial photography, field surveillance, and disaster relief. However, most are often found to be expensive and difficult to deploy. To address these issues, this project sought to implement a lightweight drone capable of performing surveillance while communicating in real time to the user. Before the team could establish project specifications, they conducted extensive background research to gain a deeper understanding of the current technological advancements within the drone industry. Though modern-day technology is quickly advancing and improving UAVs and drones, developments in this field began decades ago, even before the first manned airplane flight occurred in 1903.

The first and most primitive designs centered on balloons. The first attempts began in France in 1782 by the Montgolfier brothers. The explosives were attached to a timing mechanism, and upon the timer going off, the explosives dropped out and a fuse was ignited. However, due to the unpredictability of air currents and weather patterns then, Perley's aerial bomber was never successfully deployed and experimentation into other designs was expanded. In the last two decades, UAV research and development has continued to focus on military surveillance and attack applications. However, recently UAVs have become more popular in the civilian sector as well. The applications of these drones have been broad. These include disaster relief, crop dusting, and mapping new geographic areas. These UAVs have also functioned as toys controlled by smart phones.

## II. Project Ideation

This project will address the need for a low cost UAV that can be easily deployed by military personnel for near-field surveillance purposes. It is also used for surveillance in the agriculture for spying. With the recent advances in aircraft technologies, software, sensors, and communications, Unmanned Aerial Vehicles (UAVs) can offer a wide range of Applications. UAVs can play important roles in applications, such as search and Rescue, situation awareness in natural disasters, environmental monitoring, and perimeter surveillance. Developing UAV applications involves integrating hardware, software, sensors, and communication components with the UAV's base system. UAV applications development projects are complex because of the various development stages and the integration complexity of high component. This research addresses the business and technical challenges encountered by UAV applications development and Project Management (PM). It identifies the risks associated with UAV applications development and compares various risk mitigation and Management techniques that can be used.

## III. Problem Statement

The quick growth of UAV applications creates a demand for these systems. Hence, many challenges appear to be technical and managerial. Those challenges include resource allocation and Project Management

(PM), as is the case for UAV civil applications and services. The process for developing civil applications and those of a military nature is extremely different Differences arise because of the standards, to which each type of application is held, the architecture of the applications systems, and other factors One of the issues that affect the development of UAV applications is system complexity and lack of standards in the civil context of these applications. In addition, sensitive applications require well-integrated components in the UAV platform. Furthermore, UAV development consists of mixed industry backgrounds, which can vary from the aerospace industry and complex systems, to robotics and the IT industry. Therefore, the risks associated with such technology need to be addressed, and the sharing of knowledge within this industry needs to be identified. Identifying those two elements can help future developments in reducing cost and time, and delivering the final products on time and with expected standards and requirements.

## IV. Components and Description

### 4.1 DESIGN OF AEROFOIL

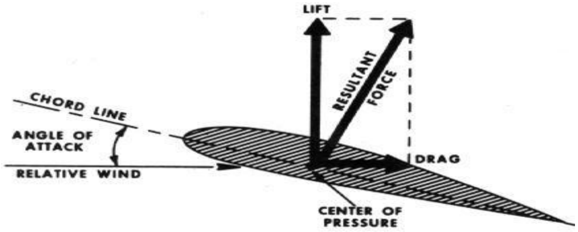
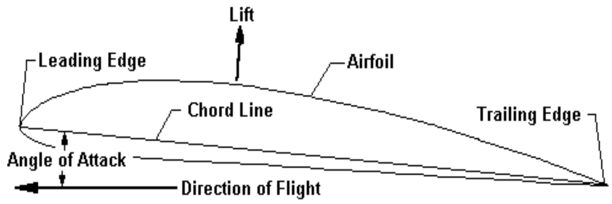



Figure 17–8 Force Vectors on an Airfoil

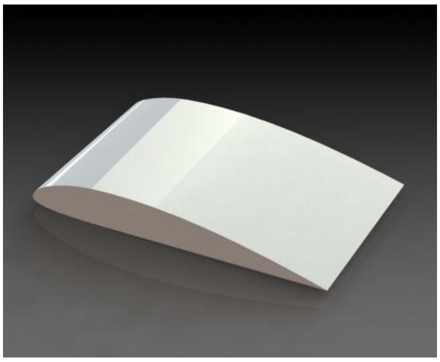



Lift Diagram

Aerofoil is a main component of a aircraft which provides lift to the aircraft it has been designed and fabricated using a Styrofoam which is a weightless material.

### 4.2 STYROFOAM

Styrofoam is a trademarked brand of closed-cell extruded polystyrene foam currently made for thermal insulation and craft applications. It is owned and manufactured by The Dow Chemical Company.



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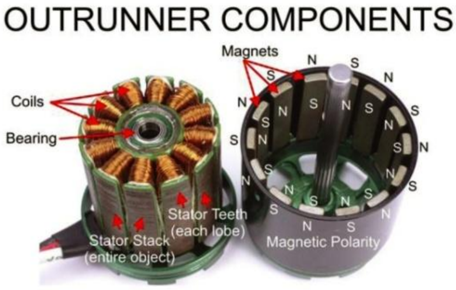
**4.3 BRUSHLESS MOTOR**

The motor is the device that converts electrical power output from the battery into mechanical power. The mechanical power then turns the propellers and generates the force needed by the robot to fly. This motor also creates a torque that rotates the robot either in a clockwise or counter clockwise direction.




**4.4 PROPELLER**

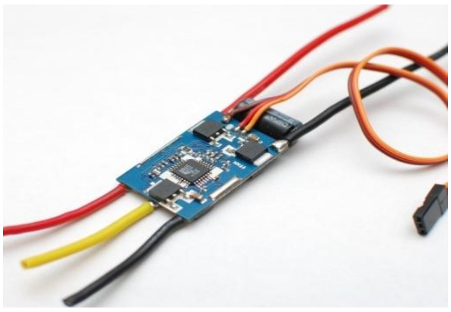
The propellers are the components of the propulsion system that provide the thrust and lift needed by the quadrotor lo leave the ground, hover, turn, and rotate. These forces are produced as the propellers rotate. The propeller hubs are attached to the motor and then a nose cap is screwed on top of the propeller to secure it to the motor.

**4.5 BATTERIES**

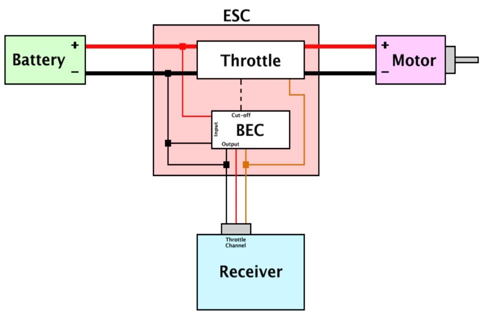
When looking for a battery to use for a quadrotor, there are a number of specifications to consider in order establishing a balance between the weight of the battery and its capacity. A battery cannot be chosen solely on its own specifications, but the other components of the drone must also be taken into Consideration. Each part has an impact on each other and therefore there are multiple combinations of components that could be used to create the ideal UAV.


**4.6 ESC (MOTOR SPEED CONTROLLER)**

In order to control the amount of current being fed into the motor, it is imperative to use a motor controller. This motor controller would prevent the motor from breaking or burning, and it would also prevent a short circuit from happening. Since the motors chosen for the project were small and did not need huge amounts of current to operate, the speed controller could actually have a low amp value. For the project the Mystery 12A Brushless Speed Controller was chosen. As its name suggests, it allows up to 12 amps of current to flow. This speed controller has some safety functions like reducing a power if the temperature goes above 120°C and reducing power or shutting off as a low current protection. This speed controller will be connected to the motors on one of their ends, and to the battery.



**4.7**



**SERVOMOTOR**

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

**4.8 RADIO CONTROL**

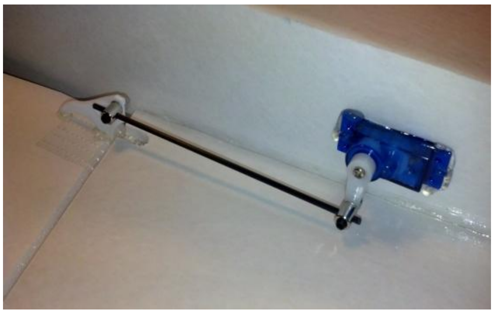
Radio control (often abbreviated to R/C or simply RC) is the use of radio signals to remotely control a device. Radio control is used for control of model vehicles from a hand-held radio transmitter. Industrial, military, and scientific research organizations make use of radio-controlled vehicles as well. The first general use of radio control systems in models started in the early 1950s with single-channel self-built equipment; commercial equipment came later. The advent of transistors greatly reduced the battery requirements, since the current requirements at low voltage were greatly reduced and the high voltage battery was eliminated.

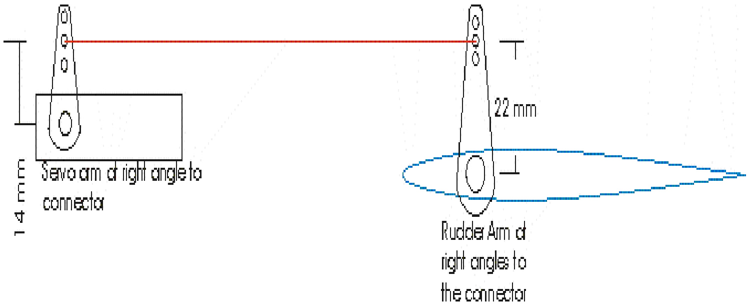
**4.9 LANDING GEARS**

Landing gear system is a major component of every aircraft. The landing gear serves a triple purpose in providing a stable support for aircraft at rest on the ground, forming a suitable shock-absorbing device and acting as a rolling chassis for taxiing during manhandling. It is the mechanical system that absorbs landing and taxi loads as well as transmits part of these loads to the airframe so that a majority of impact energy is dissipated. The main functions of the landing gear are as follows:

**4.10 SERVO LINKAGES**

Servo linkages are used to connect the servo and ailerons and rudder which are used to control the motion of flight. servo linkage system consist of a servo motor , push rods ,and control cables to provide maximum leverage to the ailerons






**4.11 RECEIVER**

Receiver system is used to receive the radio signals from the transmitter. It is a six channel receiver which has 2.4 GHz frequency.

## V. Thrust Calculation

$$T = \frac{\pi}{4} D^2 \rho v \Delta v$$

$T$=thrust [N]
$D$=propeller diameter [m]
$v$=velocity of air at the propeller [m/s]
$\Delta v$=velocity of air accelerated by propeller [m/s]
$\rho$ = density of air [1.225 kg/m$^3$]

**Dynamic Thrust Equation**

F = thrust (N), d = prop diam. (in.), RPM = prop rotations/min., pitch = prop pitch (in.), $V_0$ = propeller forward airspeed (m/s)

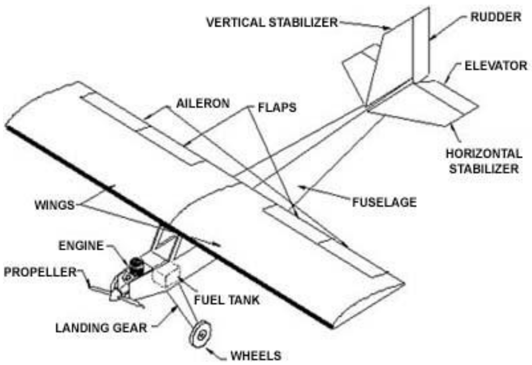
*Expanded Form:*

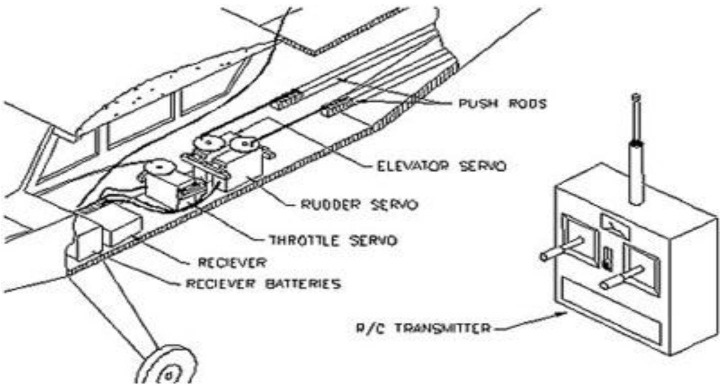
$$F = 1.225\frac{\pi(0.0254\cdot d)^2}{4}\left[\left(RPM_{prop}\cdot 0.0254\cdot pitch\cdot\frac{1min}{60sec}\right)^2 - \left(RPM_{prop}\cdot 0.0254\cdot pitch\cdot\frac{1min}{60sec}\right)V_0\right]\left(\frac{d}{3.29546\cdot pitch}\right)^{1.5}$$

*Simplified Form:*

$$F = 4.392399x10^{-8}\cdot RPM\frac{d^{3.5}}{\sqrt{pitch}}(4.23333x10^{-4}\cdot RPM\cdot pitch - V_0)$$

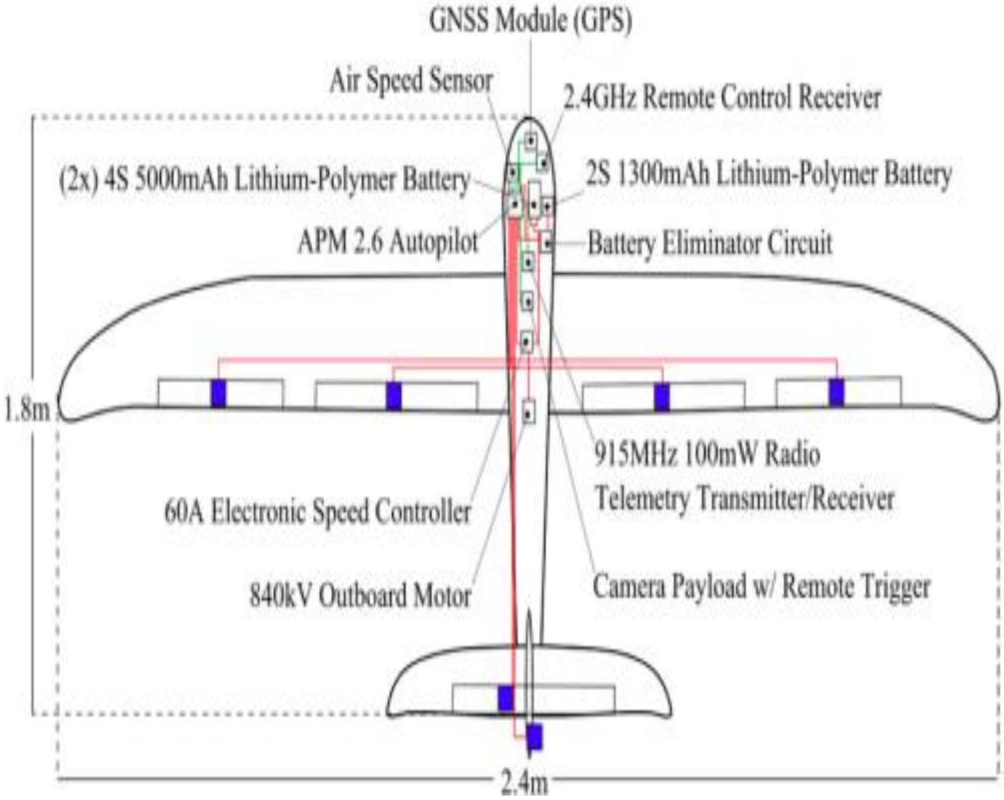
## VI. Model and Drawing




## VII. Working of UAV

The design of the unmanned surveillance aircraft consists of the quad rotor with four propelling wings. Out of the four motors, the left and right induce pull action, while the front and back induce push action. The brain of the robot is a microcontroller board that has been designed for auto-piloting drones. The microcontroller is combined with an inertial measurement unit. This unit consists of a 3 axis gyro, 3 axis accelerometer and a barometric pressure gauge. An RC transmitter is used to navigate the robot. Functionalities of the robot can be enhanced further by fitting a GPS chip for gauging latitude and longitude and a SONAR system for gauging the altitude.




## VIII. Conclusions

The final results showed that not all of the specifications and goals set at the beginning of the project were met. Although fully autonomous flight was not achieved, the team made significant development towards creating a low-cost, lightweight unmanned aerial vehicle capable of surveillance with its implementation of a camera system. Several design iterations were completed to create a quadrotor best suited for the project goals and the final prototype demonstrated potential for success with the project goals. As described earlier in Section 6, there were several tests performed to ensure the designed prototype would successfully fly. If more time was available, the team would have been able to design a more robust controls system that would ensure stable flight. Furthermore, the team's work on a user-friendly and intuitive GUI would promote the surveillance aspect of the quadrotor. Overall, an unmanned aerial vehicle was fully realized in this project. The quadrotor demonstrated it had the power to fly to a high altitude, but lacked the stability. Further iterations of this project would ensure its future success.

## IX. Final Model







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