Unmanned Vehicle Land, Air & Water for Surveillance

Dinesh Kumar Gouda[1] Ankit Raj[2] Raghabendra Dalei[3]
[1,2,3]Parala Maharaja Engineering College, Brahmapur, Odisha, India

Abstract— The objective of this work is to develop a cost effective unmanned ground vehicle which would carry out surveillance and tracking missions in fortress area. The developed system is equipped with a high frequency GPS module and Auto pilot controller, which enabled the user to define the mission path. Live status of the system's current position, speed, battery status etc. can be viewed from the ground station. If necessary, the unmanned vehicle would be switched over from manual mode to autonomous mode. The system is equipped with a down facing optical flow sensor and forward facing SONAR sensor for obstacle avoidance. It is also equipped with a high end wireless, infrared camera for capture and transmission of video under low light conditions. The vehicle is pre-programmed to return to base in case of communication breakdown, thereby minimizing the chances of system loss. 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 vehicles (UVs) have grown in popularity and are an excellent resource that can be utilized for surveillance missions. Since this is a common capability of UV, this project will create a surveillance that is autonomous, inexpensive, lightweight, and easy to manufacture. The unmanned vehicle is designed as a tricopter that houses one camera with a wireless transmission system that provides live feed from the cameras to the ground station. It is also intended to be able to carry a payload for future developments. Though not all of the goals is fully realized by the project's conclusion due to stability and networking complications, the UV met size and cost standards, and could successfully localize its position with GPS and IMU sensors. Additionally, its controls are understood through simulation and testing.

Key words: Autonomous Vehicle, Efficient Algorithms, Obstacle Avoidance, SONAR Sensor, Surveillance, Auto-Balance in Air Mode, Enhanced Suspension System

I. INTRODUCTION

Unmanned Vehicles (UV) has tremendous potential in military and civilian applications, specifically in areas like reconnaissance, surveillance, target acquisition and monitoring etc. Usually, the vehicle will have a set of sensors to perceive the environment, and will either autonomously make decisions about its behavior or pass the information to a human operator at a different location who will control the vehicle through tele-operation. An autonomous robot has the competence to:

- Acquire information about the milieu
- Work for aprotracted period without human mediation
- Move either all or part of itself throughout its operating milieu
- Avoid circumstances that are damaging to people, property, or itself.

An autonomous robot may also undergo a process called machine learning for accomplishing its tasks or adapting to changing surroundings. During the recent years, the researchers have been striving to achieve higher degree of autonomous mode in ground vehicle to enhance operational performance by infusing microcontroller and software approach. However, significant technology advances will be necessary before even the simplest and most crucial applications can be practically addressed. These advances will only be gained by implementing autonomous vehicle test beds and gaining experience with the developing technology.

II. MATERIALS SELECTION

A. General Assumptions

Material selection is one of the key factors that has a direct effect on mass and other physical properties of the vehicle. A good selection will lead to a weather resistant, lightweight, and strong product. Five primary factors were considered when choosing the materials: deflection, strength, weight, water resistance, and cost. Based on these criteria several materials were considered and compared.
The materials which we are using for making this project are as follows-

B. Fibre Glass

Why Choose Fiberglass over other materials:

1) Strong & Long-Lasting

Pound for Pound fiberglass is stronger than sheet metal. Fiberglass has a high resistance to corrosion, it will not rust. Perfect for products used outside, in states near the ocean, with the high salt content in the air. Fire-retardant resins can make your products stand up against fire and will only char not burn up. Perfect when products will be around corrosive chemicals.

2) Design Freedom

There are very few restrictions with molding fiberglass, giving the engineer unlimited possibilities. Get away from the old boxy looking products and design visually appealing ones that are still as structurally strong and durable. Can take a multi-piece part and convert it into just one.

3) Appearance

Using fiberglass for product covers and enclosures definitely improves its esthetics. Achieve any look and feel desired. Finishes give fiberglass components a high tech appearance.

4) Cost Effectiveness

With steel being dependant on China's steel prices, you will have stable prices with fiberglass. Lower costs for maintenance and warranty work. A lighter and stronger product results in lower costs for shipping and storage.

5) Special Characteristics

Fiberglass is non-conductive and radio frequency transparent. Perfect for housing electronics without disturbing their performance and protect employees from hazards inside.

Fiberglass absorbs sound waves more than bounces off, thus giving it extremely good acoustics, for lowering machinery volumes and achieving acceptable and/or required sound levels. Unlike metal, plastic, and wood; fiberglass has the least expansion and contraction with heat, cold and/or stress.

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C. Carbon Fibre

Carbon fiber's distinct lightness and strength make it a viable, versatile, and useful commercial product for a wide variety of markets. Along with strength and lightweight properties, the benefits of carbon fiber and its composites include.

- A unique and distinct appearance that's nearly impossible to replicate.
- Excellent strength to weight ratio, compared to other materials.
- Works well with other materials (fibre, plastics, and metals, wood, concrete).
- Suitable for complex contours and designs.
- Superior fatigue properties.
- High Stiffness.
- High heat tolerances and resistance.
- Flexible thermal and electrical properties.
- Corrosion-resistance (with proper resins).
- Varying classifications (tensile modulus) of strength.
- The strongest carbon fiber is 10x stronger and 5x lighter than steel.

The strongest carbon fiber is 8x stronger and 1.5x lighter than aluminum.

D. Aluminum

1) Light Weight

Aluminium is a very light metal with a specific weight of 2.7 g/cm^3, about a third that of steel.

For example, the use of aluminium in vehicles reduces dead-weight and energy consumption while increasing load capacity. Its strength can be adapted to the application required by modifying the composition of its alloys.

2) Corrosion Resistance

Aluminium naturally generates a protective oxide coating and is highly corrosion resistant. Different types of surface treatment such as anodising, painting or lacquering can further improve this property. It is particularly useful for applications where protection and conservation are required.

3) Electrical & Thermal Conductivity

Aluminium is an excellent heat and electricity conductor and in relation to its weight is almost twice as good a conductor as copper. This has made aluminium the most commonly used material in major power transmission lines.

E. Rubber Wheels

1) Benefit of using Rubber wheels

1) Rubber deforms to create a larger contact patch than the size of the tire, which increases traction over uneven surfaces.
2) As shock absorption, which is huge. Rubber tires act as a bouncy cushion.
3) Noise. Rubber tires are much quieter.
4) Durability. Due to their shock absorbing qualities, they isolate the vehicle from vibration and shock, which prolongs its life.
5) Lifespan. Wood warps, cracks and splinters.

III. PLATFORM

Our robotic system (see Fig. 1) consists of mobility over land, air and water which are briefly described in the following sections.

- Land mode
- Air mode
- Water mode

A. Land Mode

The drone is designed such a way that it can overcome any obstacle that comes in its way, without de-accelerating .The drone is manufactured with spring suspension to provide better drive while off-roading.



Fig. 1:

1) Individual Wheel Drive

IWD was coined to identify those electric vehicles whereby each wheel is driven by its own individual electric motor. This system essentially has inherent characteristics that would be generally attributed to four wheel drive system like the distribution of the available torque to the wheels.

2) Independent Suspension System

It allows each wheel on the same axle to move vertically (i.e. reacting to a bump in the road) independently of the others. This is contrasted with de Dion axle system in which the wheels are linked – movement on one side effects the wheel on the other side. "Independent" refers to the motion or path of movement of the wheels or suspension.

3) Axle-Less Drive

The Drive declines the use of axle for transmission and alignment. It allows each Wheel hold by arms that are suspended directly from the body.

It improves

1) Suspension System functioning.
2) Increased ground clearance.
3) Better and bigger road-view.
4) Better off-roading and hill climbing.

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Fig. 2:

B. Aerial Mode

When the drone is activated in aerial mode the power transmission is transferred to the rotors and the drone behaves as a tri copter.

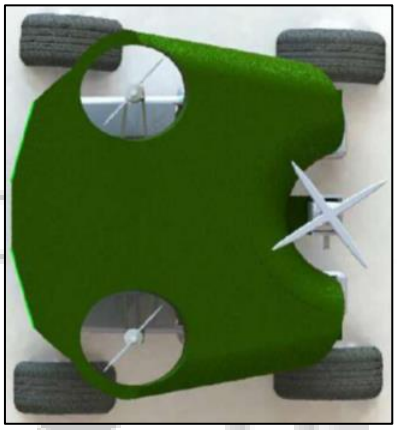


Fig. 3:

Gyroscopes are required to keep the system stable. The gyros are measuring the movement of the tri copter in three directions yaw, nick and roll. The controller compares the sensors measuring with the users commands and compensates the errors.

So if you want the tri copter to be hover and the roll gyro detects rolling to the left, the controller powers up the left motor a little while braking the right motor to compensate the unwanted movement.

This is happening all the time, just watch a Video of a hovering tri copter to see the ever-changing speed of each rotor. It is like trying to balance a plate on a stick.

The same principle is used for the nick function.

The yawing of a tri copter is a special case. If you are using a rotor, it produces torque that tries to spin your flying object into the opposite direction of the rotor. A helicopter is using his tail rotor to compensate this direction. A quadcopter, hexacopter, octocopter an all copters with an even amount of rotors are using the fact that two rotors in the same plane that are turning in opposite directions with the same speed are neutralizing their torque.

A tri copter has two rotors that are spinning in opposite directions but there is a rotor left who produces torque that tries to spin the tri copter. Because of this, tri copters are usually using a rear servo to tilt the rear rotor to compensate this torque in the same manner a helicopter tail rotor does. The advantage of this solution is more yawing agility in comparison to multi copters with even amounts of rotors.

C. Advantages of a Tri Copter

1) Three points in space define a plane: The tri copter is very agile
2) Yaw Servo makes yawing faster
3) Three motors/esc are cheaper
4) Easy to bring cause of collapsing arms
5) Power consumption

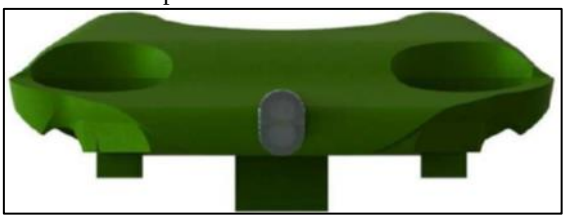


Fig. 4: Front View Cad Design of Aerial Mode

Basic Flight Physics

Similar to other flying objects, a tricoptor has a group of forces and torques acting on it while it flies. There are four main forces acting on the drone: drag, lift, weight, and thrust. In order for the drone to fly, these different forces need to be balanced. This can be seen by utilizing Newton's Second Law.

Newton's Second Law: $F=ma$ (1)

For constant velocity acceleration is zero (a=0). Thus the sum of the forces is equal to zero. So for steady, constant velocity flight, completing a force balance in the horizontal direction on the diagram obtains:

$$F_{thrust} - F_{drag} = 0 \quad (2)$$

$$F_{thrust} = F_{drag} \quad (3)$$

Since this is for a constant velocity, the aircraft is either moving or at rest. An analysis in the vertical direction will produce similar results.

$$F_{lift} - F_{weight} = 0 \quad (4)$$

$$F_{lift} = F_{weight} \quad (5)$$

Thus, for steady level flight the thrust must equal the drag and the lift must equal the weight. In order to gain altitude, the force of lift must be greater than the force due to gravity. Similarly, in order to accelerate the vehicle the force of thrust must be greater than the force of drag.
For the tricopter to perform different types of movements, the sum of the forces and torques have to follow a certain pattern.

D. Naval Mode

The Drone can also be converted into naval mode, that is the drone can float on water and sail like a miniature ship.

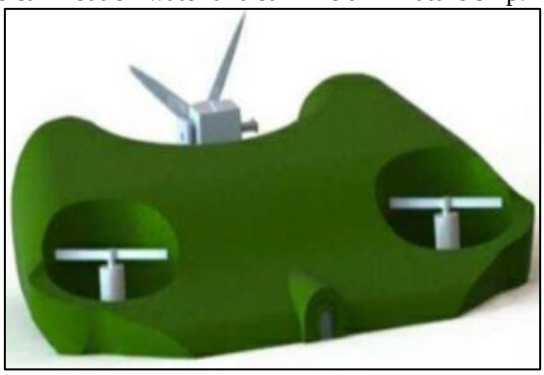


Fig. 5:

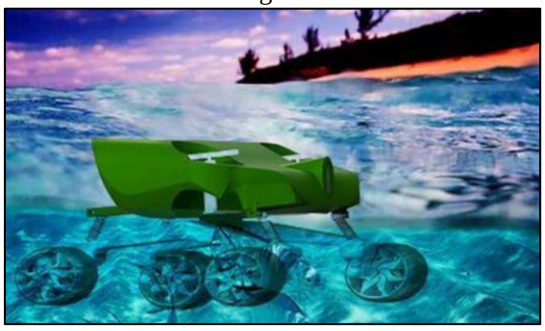


Fig. 6:

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The whole drone is such manufactured that the whole body remains hollow and air tight. Since the air is lighter than water, buoyancy force on the body will be enough to keep the body on water.

Further for sailing, the system is designed such as the rear rotor of tricopter rotates 900 on X- axis and starts behaving as Propelling blade. The blades of total length 8cm produce a torque of 920KV.

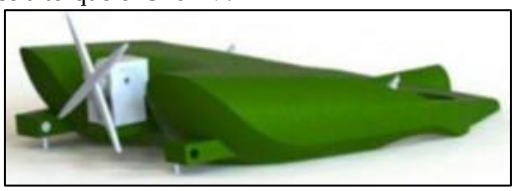


Fig. 7:

3.3 DESCRIPTION:

S.NO	COMPONENTS	SPECIFICATION
1.	BLDC MOTOR	DJI 2212/920KV MOTOR Dimension(mm) :28*24 Shaft :800mm Weight :56gm Standard current :15-25A
2.	ESC	SIMONK 30A FOR DJI 2212/920KV Dimension(mm) :52*26*7 Weight :28gm Burst current :40A
3.	SERVO MOTOR	S3003 SERVO MOTOR Dimension :40.4*19.8*36 Weight :32.2gm Torque :3.2Kgcm
4.	POWER DISTRIBUTION BOARD	RACETEK MATEK PDB-XT60 I/p voltage:9-18v DC (3S-4S Lipo) O/p voltage:5v Current :2A Continuous Burst current :2.5A/12V
5.	DC GEAR MOTOR	Supply voltage: 6v-12v RPM: 150RPM No load current :80mA(AT 6v) No load Torque :400g-cm(AT 6v) Stall Torque :3500g-cm(At 6v) Stall current :1650mA(AT 6v) Reduction ratio :1:298

Table 1:

IV. SOFTWARE DESCRIPTION

A. GPS

A Global Positioning System (GPS) device is a helpful and commonly used sensor for a UV. As most people know, a GPS device can be used to help determine its own altitude, longitude, and latitude positions. A GPS device typically receives a signal from a satellite to calculate these positions. Depending on the GPS device chosen, some devices give the internal clock and standard deviations of its positions.

B. Microcontrollers

Microcontrollers are practically the motherboards of most UVs. A microcontroller is essentially a small computer with a processor, memory, and programmable inputs and outputs. Microcontrollers are usually where batteries are plugged into and all of the sensors and actuators are split off of. For current UVs, some microcontrollers are built from scratch just to reduce the cost of the product. Famous microcontrollers include Arduino, Raspberry Pi, and Vex. Depending on the brand and version, a microcontroller can consist of different peripherals and battery voltages. As stated above, the system power and system sensors are important and both are limited by which microcontroller is chosen.

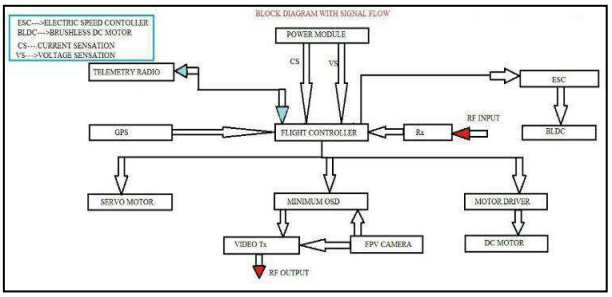


Fig. 8: Block Diagram of on Board Computer with Sensors

C. IMU

An Inertial Measurement Unit (IMU) is extremely important for any autonomous aerial vehicle/drone. The IMU can be used for stability control, velocity estimation, and position estimation. An IMU normally consists of an accelerometer, gyroscope, and sometimes a magnetometer. An accelerometer is a sensor that measures acceleration in the x, y, and z axis. Depending on how the IMU is mounted, these directions will change. The gyroscope is a sensor that measures the roll, pitch, and yaw of the aerial vehicle.

This sensor is also dependent on how it is placed on the aerial vehicle. The magnetometer is a sensor to detect the strength and direction of magnetic fields.

They can be used to help calibrate the IMU to ensure that the accelerometer and gyroscope measurements are valid.

The IMU is one of the prime sensors that allow the aerial vehicle to fly without crashing. An IMU normally doesn't take up much power but must be processed fairly fast to ensure that no data is lost. If the IMU is not processed fast enough, an aerial vehicle could easily flip upside down without correcting itself. The cost of an IMU can still be fairly expensive depending on the brand. The average price of an IMU used for hobby UAVs is around RS 200, while commercial and military systems require much more highly developed IMUs at a higher price point.

D. Motor Driver

A motor driver is a little current amplifier; the function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor. The most common values for maximum supply voltage are 36 V and 52 V. We also carry motor drivers with supply voltage up to 450 V. The number of outputs can be between 1 and 12, with the most common motor drivers having 1, 2 or 4 outputs.

E. Electronic Speed Control

An electronic speed control or ESC is an electronic circuit that controls and regulates the speed of an electric motor. It may also provide reversing of the motor and dynamic braking. Miniature electronic speed controls are used in electrically powered radio controlled models. Commonly used in Quadcopters, Electric car, etc.

F. GUI – Graphical User Interface

The design of the Graphic User Interface (GUI) had to be useful for the user and also user-friendly. In order to make it user-friendly, it was necessary to make the GUI as simple to use as possible, as well as clear and concise.

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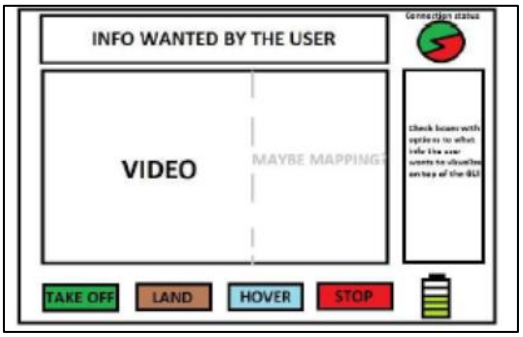


Fig. 9:

G. Analysis & Testing

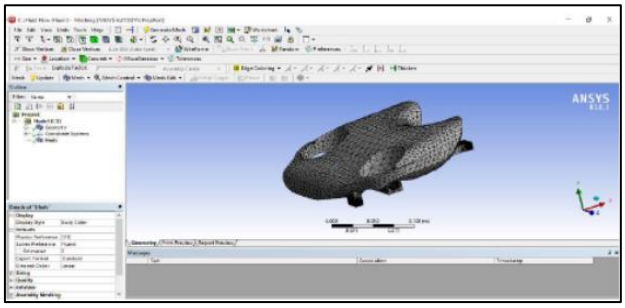


Fig. 10: Meshing (Front View)

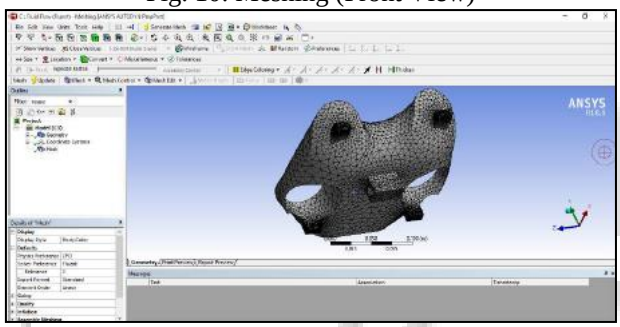


Fig. 11: Meshing (Rear View)

First we imported the geometry in the design modular and then the geometry was created. Now we meshed the object for various testing like velocity air flow, etc. ANSYS Meshing is aware of the type of solutions that will be used in the project and has the appropriate criteria to create the best suited mesh. ANSYS Meshing is automatically integrated with each solver within the ANSYS Workbench environment.

V. RESULTS

The above concept model is being analyzed and tested in ANSYS 18.1 with fluid flow (fluent), for the purpose of velocity test (aerodynamic air flow test).

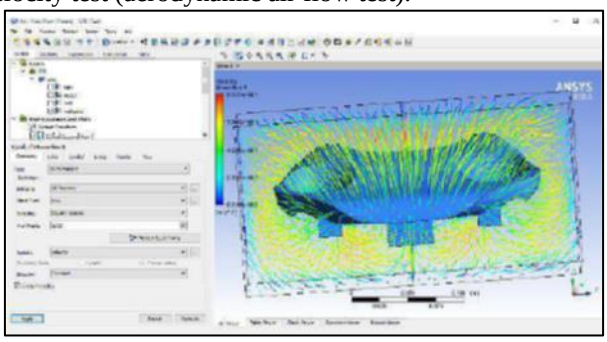


Fig. 12: Velocity Streamline

After analysing, we notified the stress developed (as shown in fig1.9). The fig indicates the maximum and minimum stress developed in the region. Based on that the following observation and values is being noted.

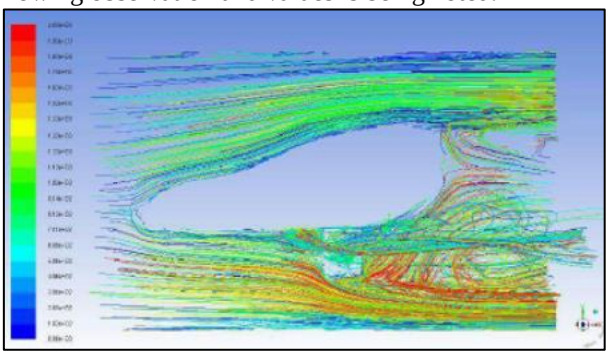


Fig. 13: Velocity Air Flow Diagram

In this we have created is surface view, streamline view and plotted the iteration graphs (as show in fig) using software analysis.

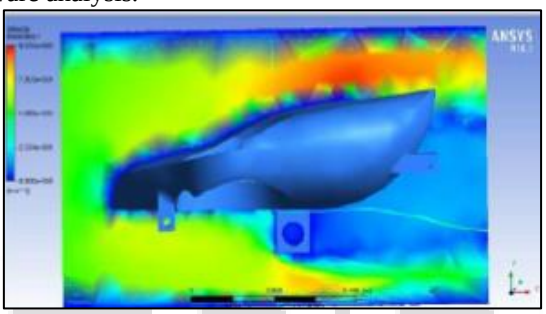


Fig. 14: Subsurface View

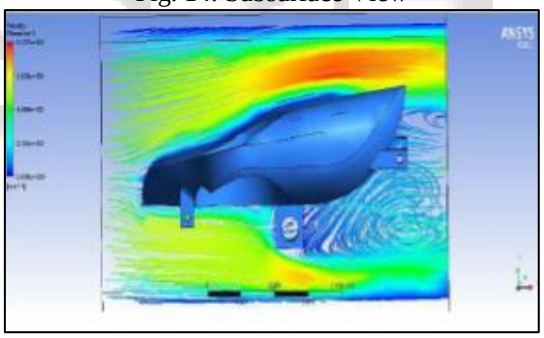


Fig. 15: Streamline View

VI. CONCLUSION

In this project we solely concentrate on the technological design and infrastructure being used to carry out surveillance along with some new development in this field. After having worked over this project for a year, finally we have got our opportunity, a platform where it is possible for us to represent our strength.

This project has been a door to heaven for all of us, since we always considered it to be our dream project. We want to show our success not as an individual but as a part of our country. Doing something innovative for our nation will be our greatest achievement possibly. And we believe that this project can become a great help when visioned through the eyes of the research and development system.

The output of this project can lead the defence system of our country to a respectful and accomplished state.

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