Project Report

On

<u>Integrated Emergency Response Drone</u>

Submitted

In partial fulfilment

For the award of the Degree of

PG-Diploma in Unmanned Aircraft System Programming (PG-DUASP)

C-DAC, ACTS (Pune)

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Abstract

In today's world, **integrated emergency response drones** have become essential tools for disaster relief, search and rescue, and critical missions where every second counts. Designing an efficient drone for such high-stakes applications requires careful consideration of flight time, power consumption, and overall performance. In this study, we reviewed a conceptual emergency response drone designed in SolidWorks and identified several areas for improvement. By optimizing components, eliminating inefficiencies, and refining the overall design, we aimed to create a more reliable and energy-efficient drone. Each modification was tested, and its impact on performance was carefully analyzed. Our goal is to develop a drone that can operate longer, respond faster, and perform more effectively in real-world emergency situations.

List of Acronyms (Symbols) used in the report:

Symbol	**Symbol Description**
φ	Roll angle
θ	Pitch angle
ψ	Yaw angle
RPM	Revolutions per minute
F	Actual thrust applied plus weight of rotor.
C	Thrust rating from chart for 106 revolutions of life.
Y	Bearing thrust factor from chart
N	RPM of motor.
CI	Lift coefficient
V	Speed of moving object
ϱ	Density of fluid
A	Area of the wing
KV	Constant velocity of a motor

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1. Introduction

Unmanned aerial vehicles (UAV) are another name for Drone. Drone is a flying robot. Sometimes featured with GPS, the flying machine may be remotely controlled or can fly autonomously by programmed controlling flight systems. Drones are most often used in military services . However, it is also used for weather monitoring, firefighting, search and rescue, surveillance and traffic monitoring etc. In recent years, the drone has come into attention for a number of commercial uses. In late 2013, Amazon announced a plan to use unmanned aerial vehicles for delivery in the nearby area's future. It is known as Amazon Prime Air; it is estimated to deliver the orders within 30 minutes inside 10 miles of distance. So, it is clear that domestic usage of UAV has vast future possibilities in different fields rather than military usage.

Drones for military use were started in the mid-1990s with the High-Altitude Endurance Unmanned Aerial Vehicle Advanced Concept Technology Demonstrator (HAE UAV ACTD) program managed by the Defense Advanced Research Projects Agency (DARPA) and Defense Airborne Reconnaissance Office (DARO). This ACTD placed the base for the improvement of the Global Hawk. The Global Hawk hovers at heights up to 65,000 feet and flying duration is up to 35 hours at speeds approaching 340 knots and it costs approximately 200 million dollars. The wingspan is 116 feet and it can fly 13.8094 miles which is a significant distance. Motherland security and drug prohibition are the main needs Global Hawk was designed for. Another very successful drone is the Predator which was also built in the mid-1990s but has since been improved with Hellfire missiles. "Named by Smithsonian's Air & Space magazine as one of the top ten aircraft that changed the world, Predator is the most combat-proven Unmanned Aircraft System (UAS) in the world". The original version of the Predator, built by General Atomics, can fly at 25,000 feet for 40 hours at a maximum airspeed of 120. As we know all these names of drones and how powerful they are. Drone was classified into 4 major types.

1. Multi Rotor Drones
2. Fixed Wing Drones
3. Single Rotor Helicopter
4. Fixed Wing Hybrid VTOL

Multi Rotor Drones are classified also into types based on how many motors are attached to it.

1- Tricopter (3 rotors).

2- hexacopter (4 rotors).

3- Hexacopter (6 rotors).

4- Octocopter (8 rotors).

We have selected the Hexacopter to be designed, tested, and modified in our project.

1.1 : Project Definition.

A hexacopter is a type of unmanned aerial vehicle (UAV) designed for versatile aerial operations. UAVs are generally defined as aircraft without an onboard pilot, capable of either autonomous flight or remote control by a ground operator. These drones, often referred to as remotely piloted vehicles (RPVs), are widely used in various applications, including emergency response, where rapid deployment and reliability are critical.

Despite their advantages, UAVs—especially in industrial and emergency applications—can incur high maintenance and operational costs. While some drones feature autonomous flight modes, they often rely on basic waypoint navigation rather than advanced decision-making capabilities. Emergency response drones, particularly hexacopters, are ideal for aerial reconnaissance, search and rescue, and disaster assessment. Their size varies depending on the mission and the equipment they carry. For instance, a compact drone equipped with lightweight sensors is suitable for reconnaissance, whereas a larger model with cameras, LiDAR, thermal imaging, and communication systems is necessary for complex rescue operations.

Hexacopters, classified as rotorcraft rather than fixed-wing aircraft, generate lift through six vertically oriented rotors, ensuring greater stability, redundancy, and lifting capacity compared to smaller hexacopters. When integrated with high-resolution cameras and advanced software, emergency response drones can perform real-time imaging, automated inspections, and situational analysis, assisting in rapid decision-making during critical missions. These features make hexacopters an essential tool for modern emergency response and disaster management efforts.

1.2: Project Objectives.

This emergency response hexacopter is designed to deliver critical supplies in disaster zones, ensuring rapid deployment of medical aid, food, and survival kits when every second counts. By improving stability, flight time, and payload efficiency, we aim to create a drone that is both reliable and cost-effective. Key enhancements include retractable landing legs for versatile deployment, an optimized propeller configuration for better lift and endurance, and advanced sensors for precise payload drops and real-time situational awareness.

In addition to autonomous flight, the drone supports manual flying, giving first responders direct control in complex environments where automated navigation may be challenging. Beyond emergency relief, this hexacopter can assist in search-and-rescue operations, structural assessments, and 3D mapping with LiDAR, offering vital real-time data. Its ability to navigate hazardous areas, adapt to unpredictable conditions, and provide critical aid makes it an indispensable tool for disaster response teams. Designed for both automation and hands-on control, this drone ensures help reaches those in need—quickly, efficiently, and precisely.

1.2.1:Advantages of hexacopter.

Hexacopters offer several advantages that make them ideal for emergency response missions, where reliability, safety, and efficiency are critical:

- Simplified Design & Maintenance: Unlike traditional rotorcraft, hexacopters don't require complex mechanical linkages to adjust rotor blade pitch. This makes them easier to maintain and ensures quick deployment during emergencies.
- Increased Safety & Stability: With six rotors instead of four, hexacopters provide better flight stability and built-in redundancy—even if one motor fails, the drone can still land safely. This reliability is crucial when delivering medical kits, food, or rescue equipment in disaster zones.
- Safer for Close-Range Operations: Smaller rotors generate less kinetic energy, reducing potential harm in case of impact. Some hexacopters also feature enclosed rotor frames, allowing them to safely navigate through debris, collapsed structures, or crowded rescue sites.
- Optimized for Payload & Flight Efficiency: The balance between size, weight, and lift capacity makes hexacopters perfect for carrying emergency supplies while maintaining longer flight times—a game-changer for search-and-rescue teams.
- Versatile for Emergency Situations: Whether it's dropping life-saving kits, conducting thermal imaging at night, or mapping disaster zones with LiDAR, hexacopters can adapt to real-world rescue scenarios, providing first responders with essential aerial support.

With their stability, efficiency, and adaptability, hexacopters aren't just drones—they are lifelines in the sky, helping emergency teams deliver aid when and where it's needed most.

1.3: Project Specifications.

This project is applicable to hexacopter drone types such as Multi Rotor Drones, Fixed Wing Drones. The parts have been selected for this project which has the specifications as listed in table 1.1.

Table 1.1: The system measurements

Item	Name	Quantity	Weight in grams
1	Frame	1	740
2	Payload	1	880
3	ESC	6	72
4	Propeller	6	80
5	Lithium Polymer Battery 5200 mAh	1	360
6	Brushless motors	6	318
7	Flysky FS-i6x transmitter	1	15
8	GPS	1	40
9	Flight controller (Pixhawk 6C)	1	60
10	Mini PDB - Power distribution board	1	12
		Total estimated weight	**2577**

How to select our part in the drone?

1- Weight force: is the force of gravity. It acts in a downward direction—toward the center of the Earth. This will be about two part (Model weight and object weight)
2- Thrust force is opposite direction of the weight force and in the same direction of the fan (Propeller)

The main component of the drone and the model e used:-

1- Brushless DC motor: EMAX Multicopter motor MT2213 (With Prop1045 Combo) 935KV

2- Pixhawk: Pixhawk 6c Drone Flight Controller PX4 32 Bit Autopilot Flight Control Board

3- Frame: s550 hexacopter frame.

4- Gps: NEO-M8N (Ready To SKY) GPS Module with Compass for APM with extra connector for Pixhawk
5- Propeller: 10x4.5 inch - 1045/1045R CW CCW Propeller Pair for hexacopter (Black)

6- Electronic speed controller:_Emax BLHeli Series 30A ESC with Oneshot (Original)

7- Lipo battery : Orange 11.1V 5200mAh 40C 3S Lithium Polymer Battery Pack
8- RC (Transmitter & Receiver).:FLY SKY FS IA6B RF 2.4GHz 6CH PPM output with iBus port receiver
9- Telemetry:3DR Single TTL MINI Radio Telemetry 433MHz 500mW for PIXHAWK and APM FC
10- LIDAR-Plidar A2M12 360 degree laser scanner

Selection of the weight component will assure you the flight of the drone. Here important note that total weight shall not exceed the thrust force required.

How do we calculate and know the thrust force for a motor and propeller?

By Pinch test, the manufacturer will conduct this test on the many propellers and will give you the thrust on each propeller.
The Main parameter affecting the thrust force:

1- 3 Parameter in the propeller (Pitch, Diameter, Material) 2- One Parameter in the Motor (RPM)
3- One parameter in the atmosphere. (Air)

I will start with
1-**RPM**:

RPM will be function in two thighs A -KV

B -volt in the battery.

This will let me know the RPM for the motor. 935 KV motor powered by 11.1, the max RPM= 11.1 x 935= 10378 RPM.

2- **Propeller**

The size of the propeller will contain two numbers, for example 10 x 4.5 inch that mean 10 is diameter of propeller and 4.5 is the pitch. In theory the diameter is related to Thrust force, if the diameter increases the Thrust force will increase. Also, the pitch related to the speed of the drone, if we increased the pitch the speed will be increased but the problem if we increase the pitch the turbulence will occurred.

Figure 1. Propellers

Flight time

Before procuring any battery, you need to know

1- mAh

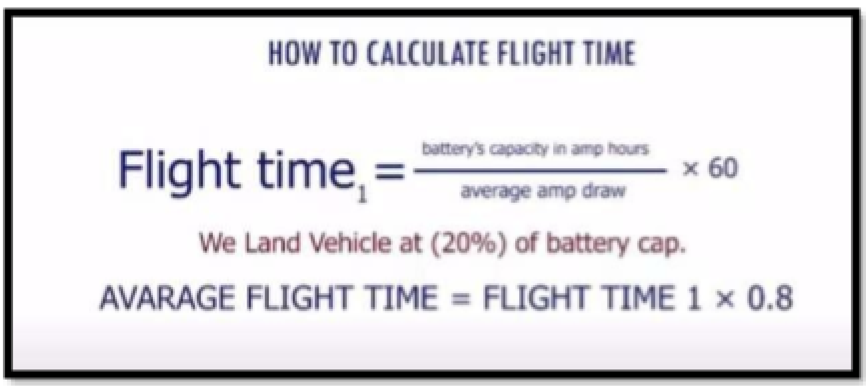
2- number of C which is the maximum discharge rate can produce by battery

3- The Volt, we should know this number to multiply with KV to get the Max RPO like example above.

How can we select the battery?

The main information that you need to know to select the write battery:

1- Lip Cells: For example in the battery we have 3s that mean 1 Cell = 4.7V so, 3 Cells= 4.7x3=11.1V. That means you can`t apply more than 11.1 volts to this battery.



2- Maximum Current: X Number of Motor = Max Ampere required (Battery must deliver this Ampere which is mentioned in the data specification)

1.2 Applications

In times of crisis, every second counts. Emergency response drones are designed to save lives, deliver aid, and provide real-time intelligence in the most challenging environments. Their ability to navigate disaster zones, carry critical supplies, and assist first responders makes them a game-changer in emergency situations.

- **Search and Rescue:** When time is running out, drones equipped with thermal cameras, LiDAR, and GPS can quickly locate missing persons, stranded survivors, or injured victims—even in dense forests, collapsed buildings, or rough terrain where human rescuers struggle to reach.
- **Emergency Supply Delivery:** In disaster zones or medical emergencies, drones can air-drop life-saving supplies—from medical kits, food, and water to defibrillators and EpiPens—reaching those in need faster than any ground team could.
- **Disaster Assessment & Damage Mapping:** With high-resolution cameras and 3D mapping technology, drones provide real-time aerial insights to emergency teams, helping them assess damage, identify blocked roads, and plan safe evacuation routes.
- **Firefighting Assistance:** Equipped with thermal imaging, drones can detect hidden fire hotspots, track fire movement, and guide firefighters to critical areas, reducing the risk to human lives. Some even assist by dropping fire-retardant payloads in hard-to-reach areas.
- **Flood & Storm Monitoring:** When floodwaters rise or hurricanes strike, drones provide an aerial perspective, helping emergency teams locate stranded people, identify safe escape routes, and assess the severity of the situation—all without putting rescuers at unnecessary risk.
- **Medical Emergency Response:** Seconds matter in medical crises. Drones can be deployed to deliver life-saving medications or devices before paramedics arrive, ensuring that critical care reaches victims in time.
- **Law Enforcement & Crisis Management:** In hostage situations, natural disasters, or mass evacuations, drones offer real-time surveillance from above, helping authorities monitor crowds, assess threats, and make informed decisions—all while keeping first responders safe.

With their speed, precision, and adaptability, emergency response drones aren't just tools; they are lifelines in the sky, ensuring help arrives faster, smarter, and safer—when it matters most.

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2.Literature Review.

2.1: Project background.

s550 hexacopter is a specific model of a foldable hexacopter frame , a well-known brand in the drone and hexacopter industry. Here's a general background on this type of project:

Frame: s550 hexacopter Frame

Introduction to the hexacopter Frame

s550 hexacopter is a hexacopter frame, which means it's a framework designed to house the various components of a drone, such as the motors, electronic speed controllers (ESCs), flight controller, and battery. The "550" in its name refers to its diagonal motor-to-motor distance, which is 550 mm.

Purpose and Functionality

The primary purpose of this frame is to provide a robust, lightweight, and stable platform for building a custom drone. Its foldable design allows for easy transportation and storage, making it ideal for users who need to travel with their drone or who have limited space.

Design and Features

Material: The frame is often constructed from high-quality carbon fiber, which offers a balance between strength and light weight. This material contributes to the durability and overall performance of the drone.

Compatibility: Designed to accommodate a variety of components, including large batteries and high-power motors. This flexibility allows users to customize their drone according to their specific needs, whether for aerial photography, racing, or other applications.

Stability and Performance: The design aims to provide a stable flight experience by ensuring a balanced and rigid frame. This stability is crucial for achieving smooth flight and accurate control.

Market Context

The demand for high-performance, customizable drones has been growing across various sectors, including hobbyist, commercial, and professional fields. s550 hexacopter caters to this demand by offering a high-quality, versatile frame that can be tailored to different uses.

Challenges and Considerations

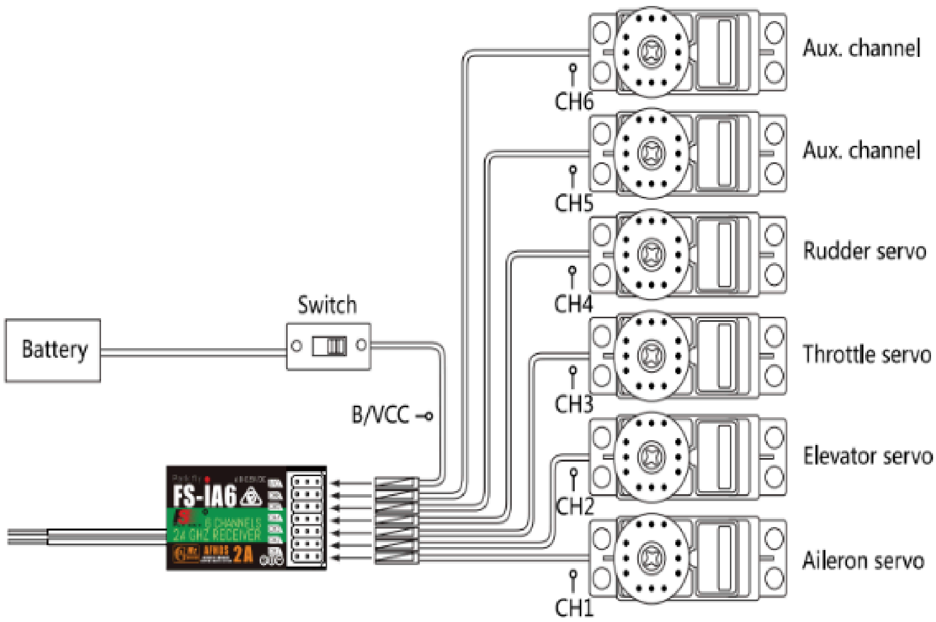
Complexity of Assembly: Building a drone with a custom frame can be complex, requiring knowledge of various components and their integration.

Cost: High-quality frames can be expensive, and the total cost of building a drone includes not only the frame but also the other components such as motors, controllers, and batteries.

Regulations: Depending on the region, operating a drone for commercial purposes may require adherence to specific regulations and obtaining necessary permits.

Overall, s550 hexacopter foldable hexacopter frame represents a blend of advanced design and functionality, catering to the needs of drone enthusiasts and professionals seeking a customizable and portable drone solution.

Figure 2. shows the specification for the brushless motor we will use in our drone.



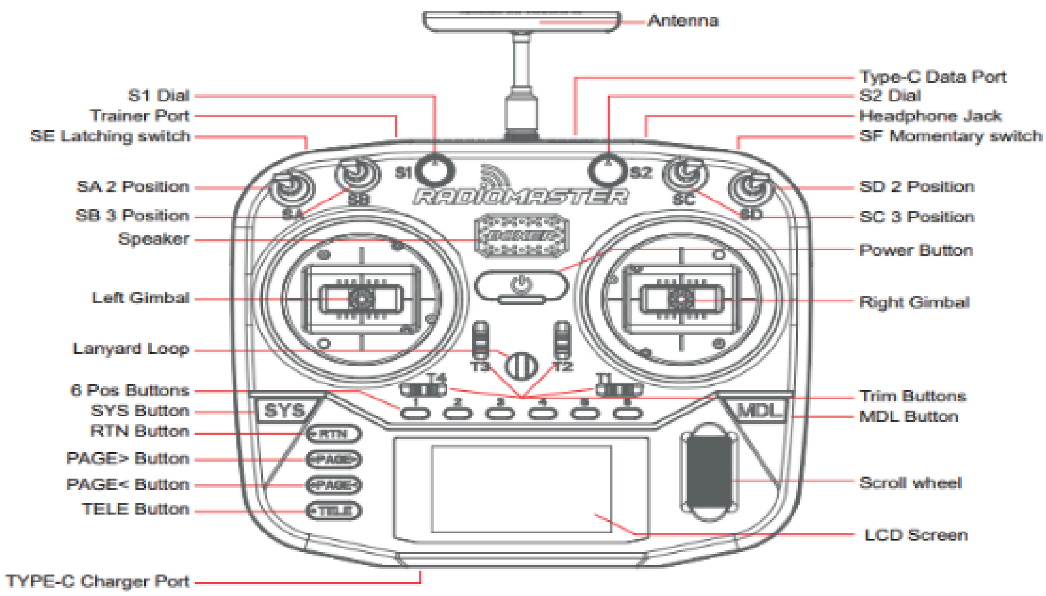


Figure 3 & 4 show that the transmitter and receiver we will use to control the drone

Figure 5

Figure 5 show the Telemetry

Figure 6

Figure 6 show the Tarot TL65B01

Figure 7 ESC

Figure 8 Battery

Figure 9 Flight Controller (Pixhawk)

Figure 10 LIDAR

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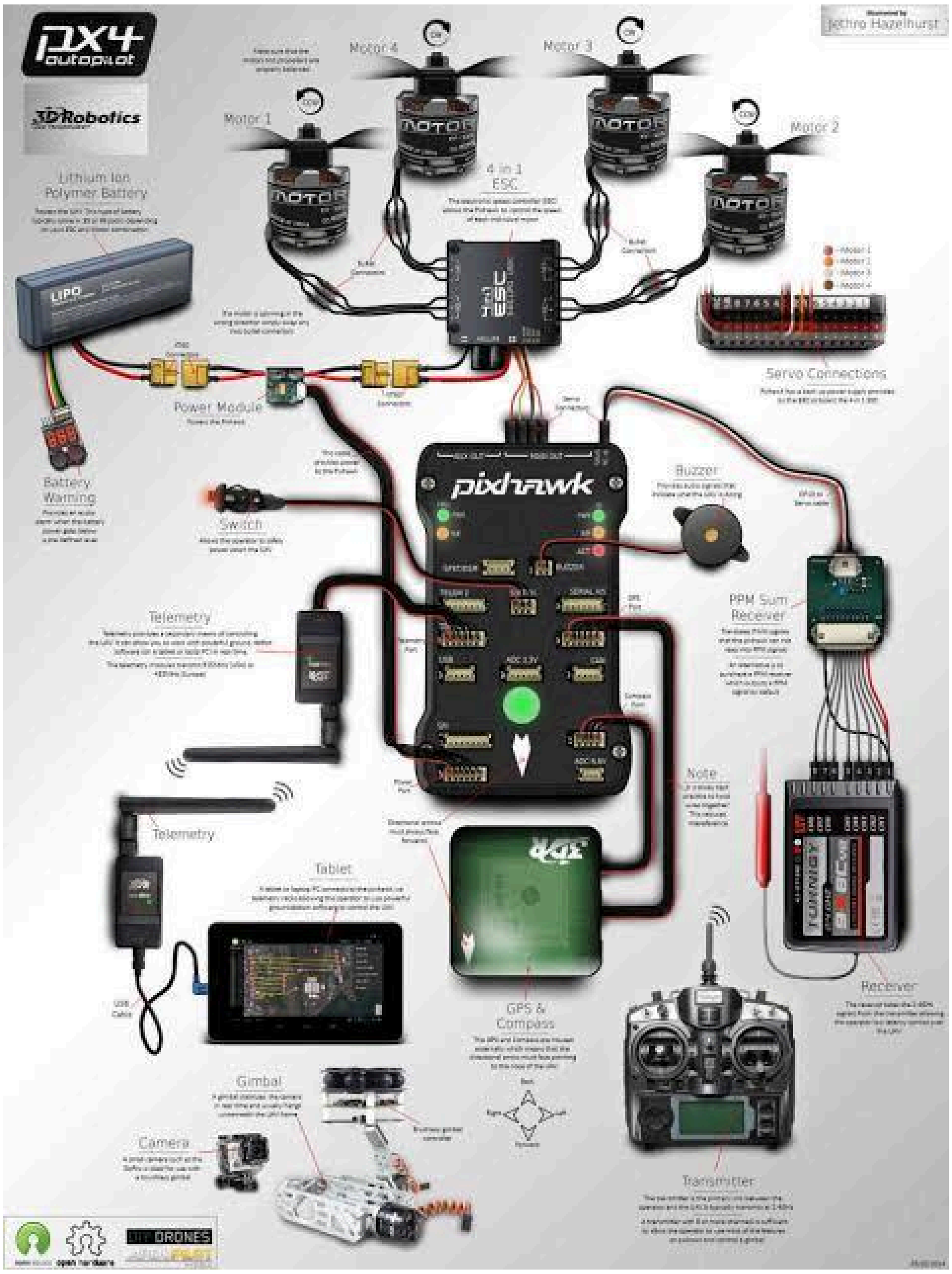


Figure 11 All connections with Pixhawk

2.2: Modelling of hexacopter dynamics.

This section presents the basic hexacopter dynamics. The basic idea of the movement of the hexacopter is shown in the following figure. It can be seen from the figure that the hexacopter is simple in mechanical design compared to helicopters. Movement in the horizontal frame is achieved by tilting the platform whereas vertical movement is achieved by changing the total thrust of the motors. But hexacopter have certain difficulties with the control design.

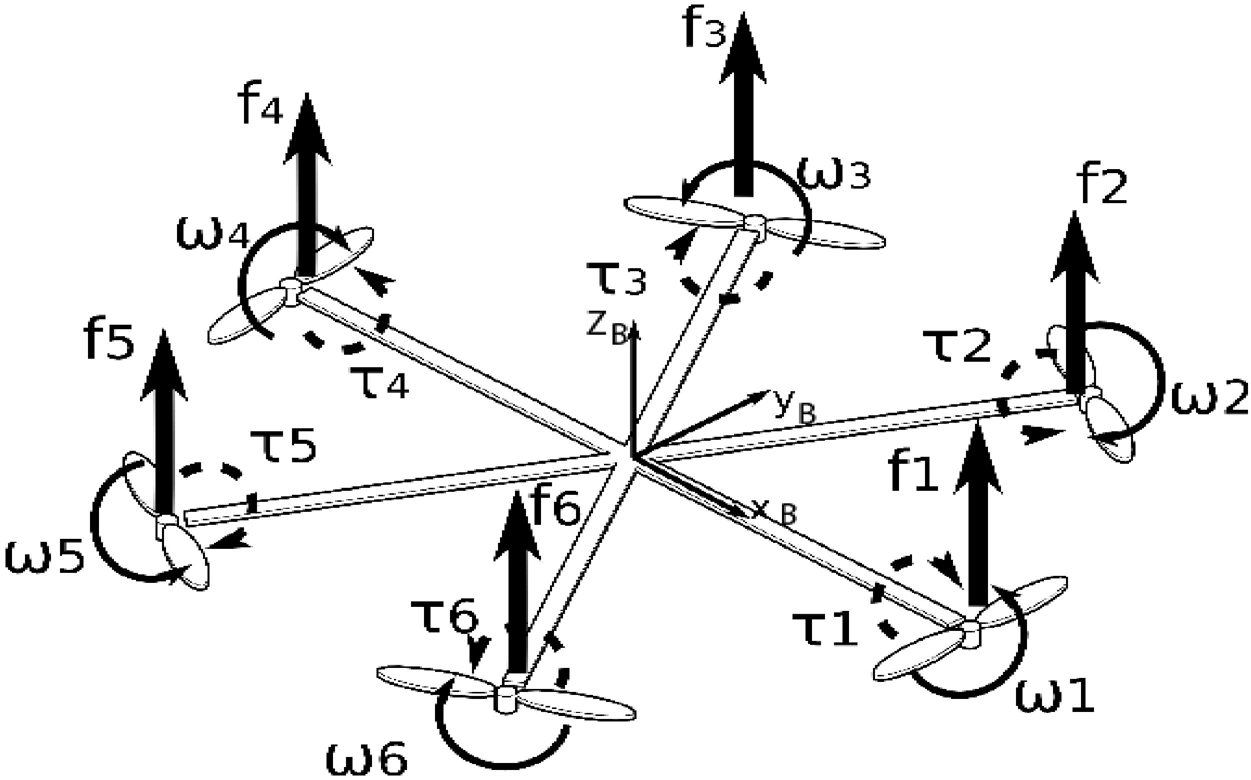


Figure 11: Basic Flight movements of a hexacopter

A coordinate frame of the hexacopter is shown in the figure below.

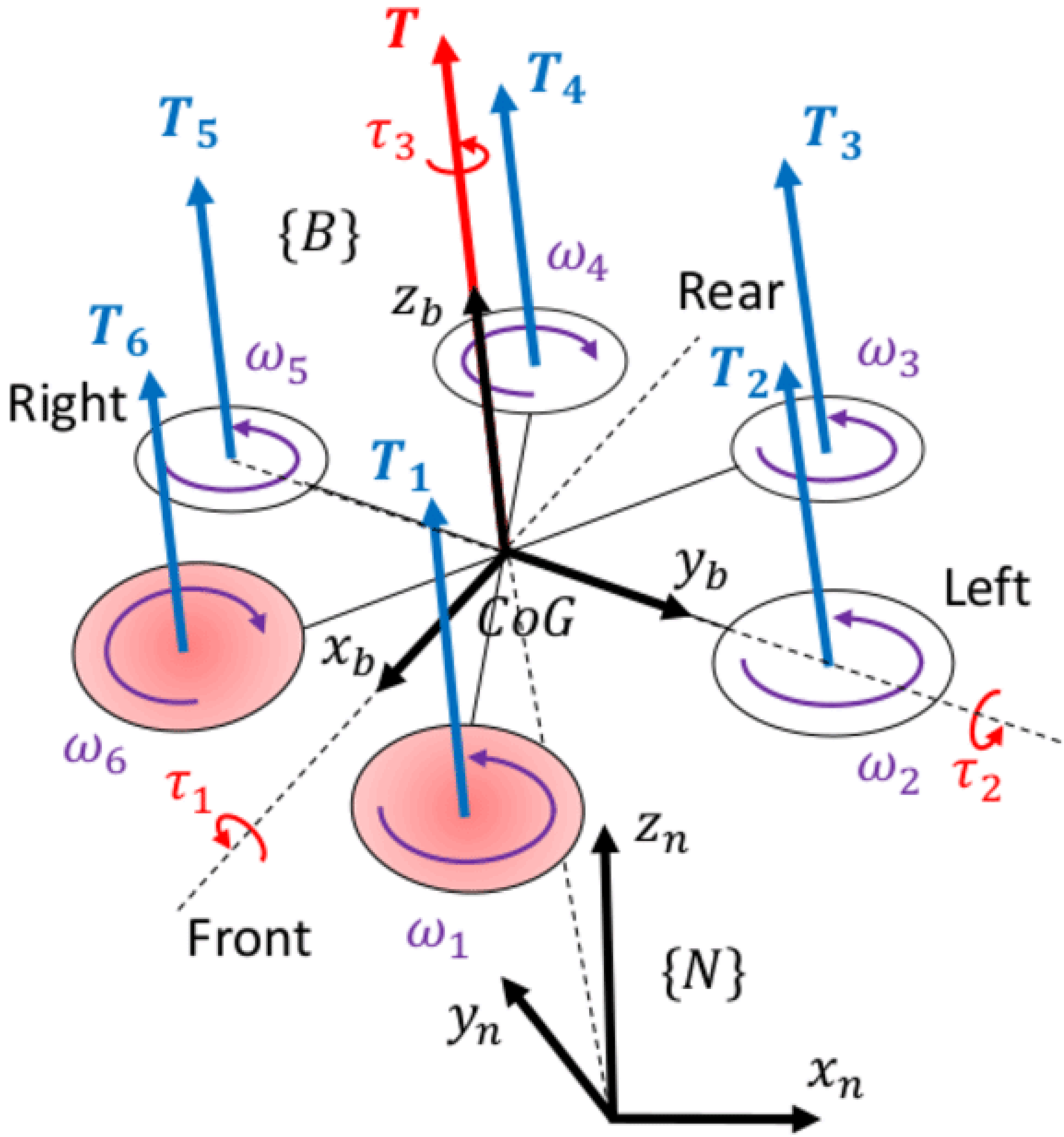


Figure 12: hexacopter coordinate system

The hexacopter is designed on the following assumptions:

- The structure is supposed to be rigid.
- The Centre of Gravity and the body fixed frame origin are assumed to coincide.
- Thrust and drag are proportional to the square of the propeller's speed.
- The propellers are supposed to be rigid.
- The structure is supposed to be axis symmetrical
- The rotation matrix is defined to transform the coordinates from Body to Earth co-ordinates using Euler angles φ- roll angle, θ- pitch angle, ψ- yaw angle.
- About by φ, by θ and by

Special attention should be given in the difference between the body rate measured ***p, q, r*** in Body Fixed Frame and the Tait- Bryan angle rates expressed in Earth Fixed Frame. The transformation matrix from [**φ θ ψ**]$^{\mathbf{T}}$ to [p q r]$^{\mathbf{T}}$ is given by:

$$\begin{bmatrix} p \\ q \\ r \end{bmatrix} = \begin{bmatrix} 1 & 0 & -\sin\theta \\ 0 & \cos\phi & \sin\phi\cos\theta \\ 0 & -\sin\phi & \cos\phi\cos\theta \end{bmatrix} \begin{bmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix}$$

Moreover, the rotation matrix of the hexacopter's body must also be compensated during position control. The compensation is achieved using the transpose of the rotation matrix.

$$R(\phi,\theta,\phi) = R(x,\phi)R(y,\theta)R(z,\psi)$$

$$R(x,\phi) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\phi & -\sin\theta \\ 0 & \sin\phi & \cos\phi \end{bmatrix}$$

$$R(y,\theta) = \begin{bmatrix} \cos\theta & -\sin\psi & 0 \\ \sin\psi & \cos\psi & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$R(z,\psi) = \begin{bmatrix} \cos\psi & -\sin\psi & 0 \\ \sin\psi & \cos\psi & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

3. System Design.

3.1 : Design Constraints

Payload Capacity

Constraint: The frame must support the weight of additional equipment such as MG995 servo motor , LiDAR sensors, or other surveying instruments.

Consideration: Ensure the frame's maximum payload capacity is not exceeded. This affects flight stability and battery life.

Flight Duration

Constraint: The drone needs to operate for extended periods to cover large flood affected areas or perform continuous monitoring.

Consideration: Battery life and power consumption must be optimized. Choose high-capacity batteries and ensure the frame supports their weight.

Weather Resistance

Constraint: Drones used for emergency response often operate in various weather conditions.

Consideration: The frame and components should be resistant to moisture, dust, and temperature extremes. Consider adding protective enclosures if necessary.

Stability and Precision

Constraint: Accurate data collection requires stable flight and precise control.

Consideration: The frame must provide rigidity and minimize vibrations. Balance the frame well and use high-quality, well-calibrated components.

Regulatory Compliance

Constraint: Drones must adhere to local aviation regulations and privacy laws.

Consideration: Ensure the drone meets all regulatory requirements for commercial use in your region, including registration and operational limits.

3.2 Design Methodology

Component Selection

Frame: Choose s550 hexacopter frame for its robustness, foldability, and payload capacity.

Motors and ESCs: Select motors and ESCs that provide adequate thrust and stability for the frame and intended payload.

Flight Controller: Use a reliable flight controller with GPS and advanced flight modes to ensure precise navigation and stability.

Sensors: LiDAR and other delivery instruments based on the specific requirements of the disaster management

System Integration

Mounting: Design custom mounts or use existing solutions to securely attach payloads to the frame. Ensure the payload is balanced to maintain flight stability.

Power Management: Integrate high-capacity batteries and ensure that power distribution is optimized for all components. Consider using battery management systems to monitor power levels and extend battery life.

Connectivity: Implement reliable communication systems for data transmission and control. This includes telemetry systems and, if necessary, real-time data streaming.

Testing and Calibration

Initial Testing: Conduct ground tests to check the stability of the drone with the payload attached. Perform hover tests to ensure the drone can handle the weight without excessive vibration.

Flight Testing: Perform test flights in controlled environments to validate flight performance, stability, and data accuracy. Adjust settings as needed to optimize performance.

Calibration: Calibrate sensors and cameras to ensure data accuracy. Regularly check and recalibrate as needed.

Field Operation

Planning: Plan missions with detailed flight paths and data collection parameters. Use mission planning / Q ground control software if available.

Execution: Ensure the drone operator is trained and follows safety protocols. Monitor real-time data to adjust flight paths and settings as needed.

Maintenance and Upgrades

Regular Maintenance: Perform routine checks and maintenance to ensure the drone remains in good working condition. This includes inspecting the frame, motors, and electronics.

Upgrades: Stay updated with new technology and components that could enhance the drone's performance or capabilities. Upgrade parts as needed to keep the system current and efficient.

By addressing these constraints and following a structured design methodology, you can effectively utilize s550 hexacopter Frame for payload dropping applications, ensuring reliable and accurate performance

3.1 Design Engineering Standard.

Engineering standards should be followed in each component of our system. In this section, we described each component that has been selected for our project.

3.2 Theory and Theoretical Calculations.

Component	Details
Lithium Polymer Battery 5200 mah	Power supply for our drone
Brushless motors	Motors to rotate the propeller and left the drone
Flysky FS-i6x	To control the drone wirelessly.
Electronic speed controller	Speed controller
Pixhawk 6c Drone Flight Controller PX4 32 Bit Autopilot Flight Control Board	To monitor the drone operations
Propellers	To generate the thrust power.
Gps	allows its precise location to be known at all times.
LIDAR	to create highly detailed 3D models of construction sites.
Telemetry	to provide information such as position (coordinate point), altitude, direction, and some information that shows the condition of the aircraft in real time when the air vehicle operates.

3.1.1 : Thrust Application.

Thrust is the force which moves an aircraft through the air. Thrust is used to overcome the drag of an airplane, and to overcome the weight of a rocket. Thrust is generated by the engines of the aircraft through some kind of propulsion system.

How to calculate thrust for motors?

Basic Life Formula - Ball Bearings

Life in Hours $= (C / P)^3 * 10^6 = (C / FY)^3 * 10^6$

Terminology:

- C = Thrust rating from chart for 10^6 revolutions of life.
- F = actual thrust applied plus weight of rotor.
- Y = Bearing thrust factor from chart
- N = RPM of motor

4. Theoretical calculation for selecting out motors thrust power:

Calculated weight = 2580gm
Weight of Drone = 1200 g

Payload = 880gm

The voltage (V)	Paddle size	current (A)	thrust (G)	power (W)	efficiency (G/W)	speed (RPM)	Working temperature (° C)
11	EMAX8045	1	110	11	10.0	3650	
		2	200	22	9.1	4740	
		3	270	33	8.2	5540	
		4	330	44	7.5	6200	
		5	390	55	7.1	6700	
		6	440	66	6.7	7150	
		7.1	490	78.1	6.3	7400	36
	EMAX1045	1	130	11	11.8	2940	
		2	220	22	10.0	3860	
		3	290	33	8.8	4400	
		4	370	44	8.4	4940	
		5	430	55	7.8	5340	
		6	480	66	7.3	5720	
		7	540	77	7.0	5980	
		8	590	88	6.7	6170	
		9	640	99	6.5	6410	
		9.6	670	106	6.3	6530	43

From above Weight of Drone

Thrust for each motor = 2580 / 6 = 430
So each motor must be able to generate a thrust power of 430 g
So EMAX motor is available
Based on above Chart of EMAX Multicopter motor MT2213 (With Prop1045 Combo) 935KV
we get
Current = 5 A at 50 % Thrust at 430 g Thrust
Thrust = 430 g (One motor)
So,
Total Thrust for drone is 2580 g at 50 % of Throttle.

We need at least 8 Minutes of flight time for delivery of kit as per our desired area,
So

We take Orange 11.1V 5200mAh 40C 3S Lithium Polymer Battery for calculation.
Battery Specification

Weight (g):	360
Output Voltage (VDC)	11.1
Charge Rate (C)	1 ~ 3
Discharge Plug	XT-60
Balance Plug	JST-XH
Length (mm):	134
Width (mm):	40
Height (mm):	27
Max. Burst Discharge (C)	80C(416.0A)
Max. Charge Rate	5 C
Max. Continuous Discharge	40C(208.0A)
Shipping Weight	0.4 kg
Shipping Dimensions	15 × 5 × 4 cm

From above specification chart
We get ,

Discharge Rate = 40 C
Battery Capacity = 5200 mAh
= 5200/1000
= 5.2 Ah

Total weight of the Drone (W) = 2580 grams
Number of Motor (N) = 6
So we need thrust of 2580/6 = 430 g per motor
By using motor chart from above
We get ,

Current for one motor = 5 A
Total current required for all motor = 5 * 6 =30 A

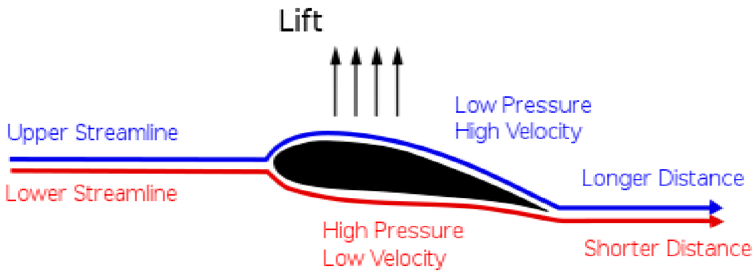
Calculate Endurance of Drone =

T = Battery Capacity * 75% / Total Current
= 5.2Ah * 75% / 30 A
= 0.1733 Hr
= 0.1733 Hr * 60
= 7.6 Min (Time)

DUCTING EFFECT ON PROPELLER EFFICIENCY AND THRUST

According to Bernoulli's equation, the pressure is low where the airspeed is high, and high where the airspeed is low in the case of a flat sheet or aero-foil. In the case of aero-foil, the speed of the air passing at the upper portion is high causing the pressure drop as compared to the bottom portion of aero-foil where the pressure is higher. This effect causes the aero-foil lift due to pressure difference.

Figure 13: Aero-foil design and profile



The construction of the propeller consists of several blades that are attached to the hub or boss. The attachment is done by either forging or welding. The blades/ aero-foils are at an inclined angle and organized in such a way that the blades are rotated in any direction depending upon the way the thrust should come out. These blades behave like a wing moving through the air causes lift when the air streamlines passing through wing air will be deflected down and the reaction will cause lift of a wing. Propeller works on the principle of Newton's third law of motion that “Action and reaction are equal in magnitude but opposite in direction”. According to Bernoulli, the air passing at the top portion of the aero-foil moves quickly as compared to lower portion cases the pressure drop at the top portion.

This effect is another cause of aero-foil lift. Propeller blades block the flow of air moving from top to bottom and spinning due to centrifugal force. When the air from the higher pressure region (bottom portion) to the lower pressure region (top potion) it causes the vortex creation at the tip of aero-foil where the high and low-pressure mixes and causes heated the air and noise is created due to molecular movement of air, hence making noise, and a large amount of energy is wasted. To prevent the formation of vortex we provide a fence against the blades, prevent the mixing of high-pressure air with low-pressure air. However, the energy that is previously wasted into vortex creation is now used in the lifting of aero-foil, because of protecting it from mixing and causes stronger lift. There are two ways of increasing the efficiency of the propeller by placing it in a duct.

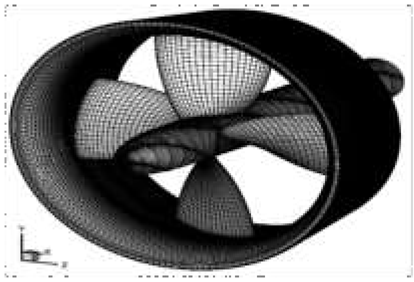


Figure 14

When the propeller is placed inside the tube it will prevent vortex formation because the gap between the tip of the aero-foil and the wall of the tube is very small and little leakage occurred. Due to this construction the efficiency of the propeller in a duct increase. Therefore, the propeller operating in the duct is more efficient than the propeller working in the free region. The second way is to make a curved portion at the edges of the duct, hence causing more lift. The curve portion looks like an annular wing at the top of the duct. The air passing through the annular wing/ curve portion is very quick causes the low-pressure region near the curve. The pressure behind the curve portion of the duct is normal atmospheric pressure because no air is moving behind the curve portion. Due to the pressure difference, the whole duct will move forward and causes it to lift the whole duct. It will cause the aero-foil lift in the forward direction as that of the propeller itself without any expense, no input energy is used, and get more free energy thus increasing the efficiency of the propeller. The combination of lip (Annular wing) and the duct itself increases the performance of the propeller. If the clearance between the duct and the tip of the blade is too much it will cause the turbulent flow around the tip of the blade and hence much power is a loss. This gap should be kept very small.

4.1.1: Brushless motor and reason for using it instead of normal motors.

Brushed DC motors depend on a mechanical system to transfer current, while AC and brushless DC gear motors use an electronic mechanism to control current. We used brushless motor instead of normal motors due to the following:

1- Motor Construction: see figure 15 for more explanation

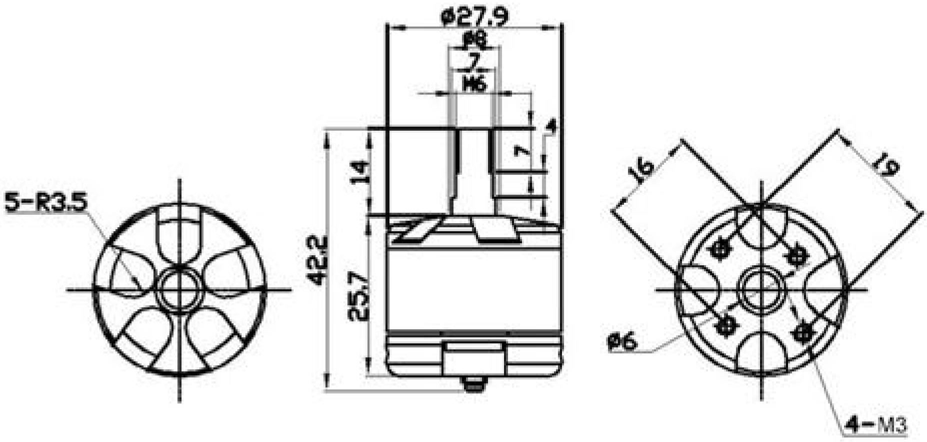


Figure 15: shows the motor construction

2- Efficiency: in figure 16, we can see the different efficiency between DC & AC motors.

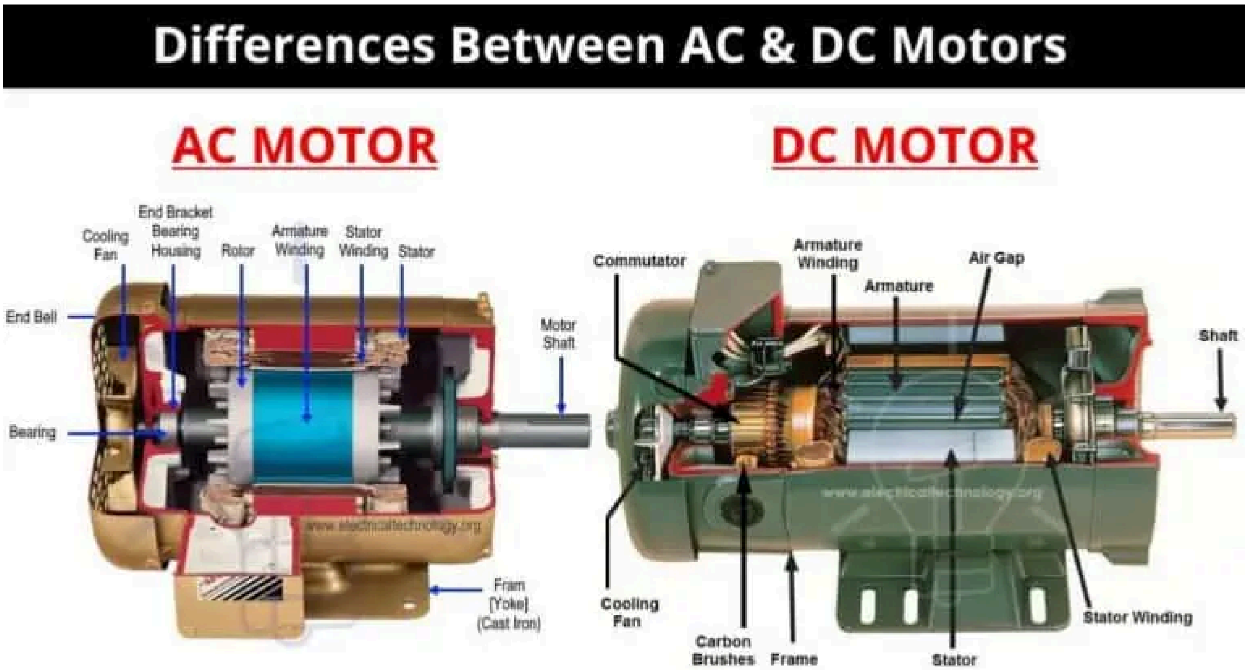


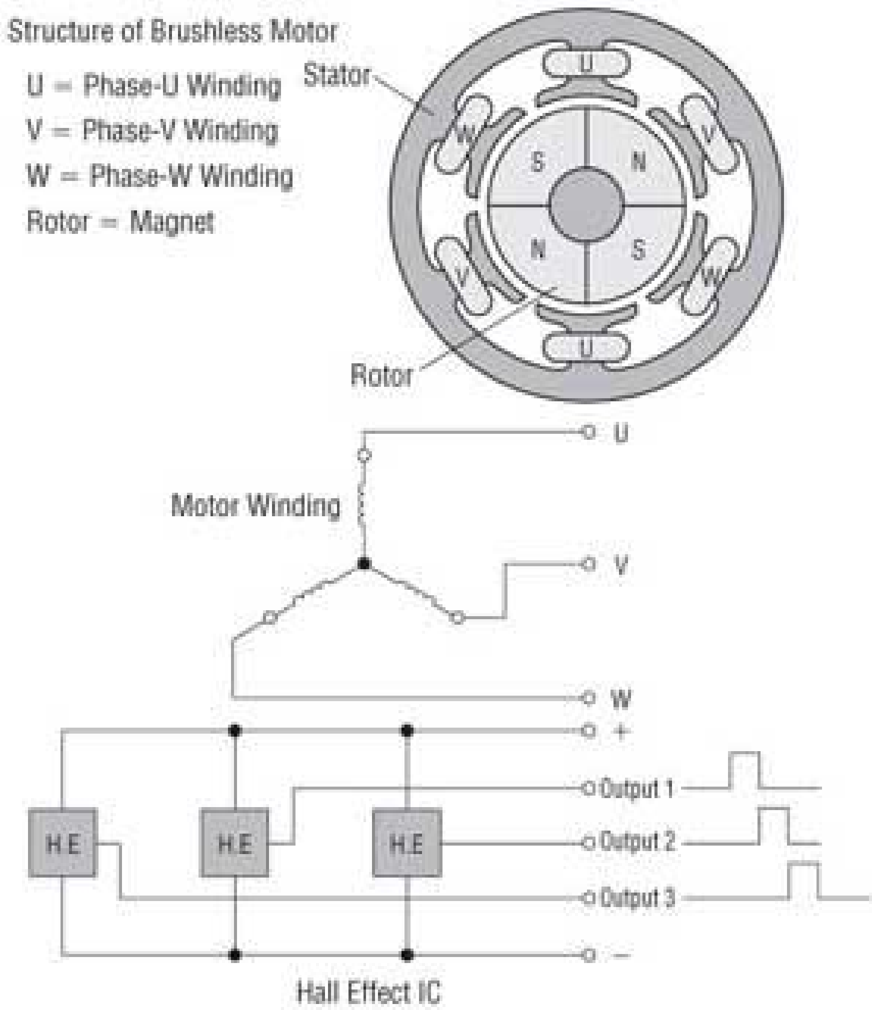
Figure 16

3- <u>Service and Maintenance</u>

4- <u>Speed Stability.</u>

5- <u>High Speed Operation:</u> As shown in figure 17

Figure 17



4.1.2 : Calculation thrust for motors.

Thrust for motors is calculated by following procedure:

1. First of all, calculate the weight of the drone including the objects that the drone will carry during its flight. Multiply the weight of the drone by two to determine the minimum thrust. Again add 20% of this calculated weight to get total weight.

Calculated weight = 2× [weight of drone + weight of carried objects]

Total weight =2× [weight of drone + weight of carried objects] + [0.2×calculated weight]

2. And finally divide total weight by number of motors

$$\frac{\textit{calculated weight} + [0.2 \times \textit{calculated weight}\,]}{\textit{Numbers of motors}}$$

4.1.3 : Power Lift Calculation.

When a body moves through a fluid, fluid always applies a force on the surface of the moving body. Lift is one component of that applied force. Lift always applied perpendicular to the direction of motion of the object. When an airfoil shape moves through the air, the stream lines on the upper side of the airfoil are closer than the lower side of the airfoil. According to where streamlines are closer, pressure will be lower. This pressure difference creates a lift. Power of lift is calculated by the following formula:

$$\textit{Power of Lift} = CI \times \frac{\rho . V^2}{2} \times A$$

Where 'CI' is lift coefficient, ρ is density of fluid, V is speed of moving object and area of wing.

4.1.4 : Flight time calculation formula for our drone.

Time of flight can be calculated by using following formula

$$Time\ of\ flight\ of\ drone = \boldsymbol{t} = \frac{Battery\ capacity \times Battery\ discharge}{Average\ amp.}$$

Where 't' is the time of flight in hours. To get the time of flight in minutes divide it by 60. Average Amp are amperes of batteries.

$$Time\ of\ flight\ of\ drone = t = \frac{Battery\ capacity(60) \times Battery\ discharge(11.1)}{Average\ amp(100\ ).} = 6.6\ hours$$

4.1.5 : Relation of Power consumption in drone and number of propellers blades.

The number of propellers blades vary according to the situation of carried load. A higher number of propeller blades will make an addition to the carried load. As the weight of the drone increases the power consumption of the drone will also increase. Smaller blades are installed on smaller motors having high KV rating. Larger fan blades are installed with motors which have low KV rating. In figure 18, it explains how the propellers work in the drone.

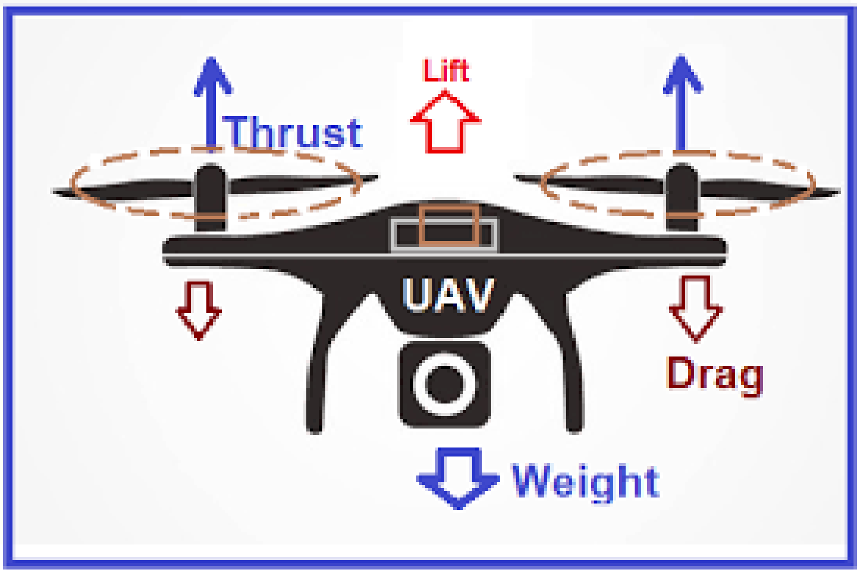


FIGURE 18

4.1.6 : making graph and data table of thrust power and power consumption to get flight time data.

Power consumption of a drone can be calculated by the following formula:

Power consumption=Battery capacity × Battery discharged

By taking power consumption on the y-axis and average amperes on x-axis a graph can be drawn. The slope of these graphs will give the time of flight of that drone.

4.1.7 : Stability and body rigidity.

When building a drone, two rules should be taken in considering having a stable flight.

1- The first rule is to have a rigid body. If the body were fixable. Flying won't be stable and the drone will face a lot of unbalanced movement and angular movement.
   A rigid harness support should be added to the drone if the body were fixable as it is a low cost solution and highly increases the stability and rigidity.
2- The harness support we used in our drone is designed as X shape. Made of Fiberglass and has a 5 mm thickness. It has two supports one on the top and the other one is at the bottom all tightened through the fixable plastic drone body by long 8 bolts.
3- The second rule is to have the flight controller board installed and attached completely in the body where it doesn’t move or tilt while flying and moving the drone, because once it tilts slightly it will react by increasing the motor power to be in the level that it was celebrated in.

5: System analysis and testing.

5.1 Programming and calibration.

Calibration is done using ardupilot software.

- Compass calibration where gps is used for drones here in this window in Figure 19.

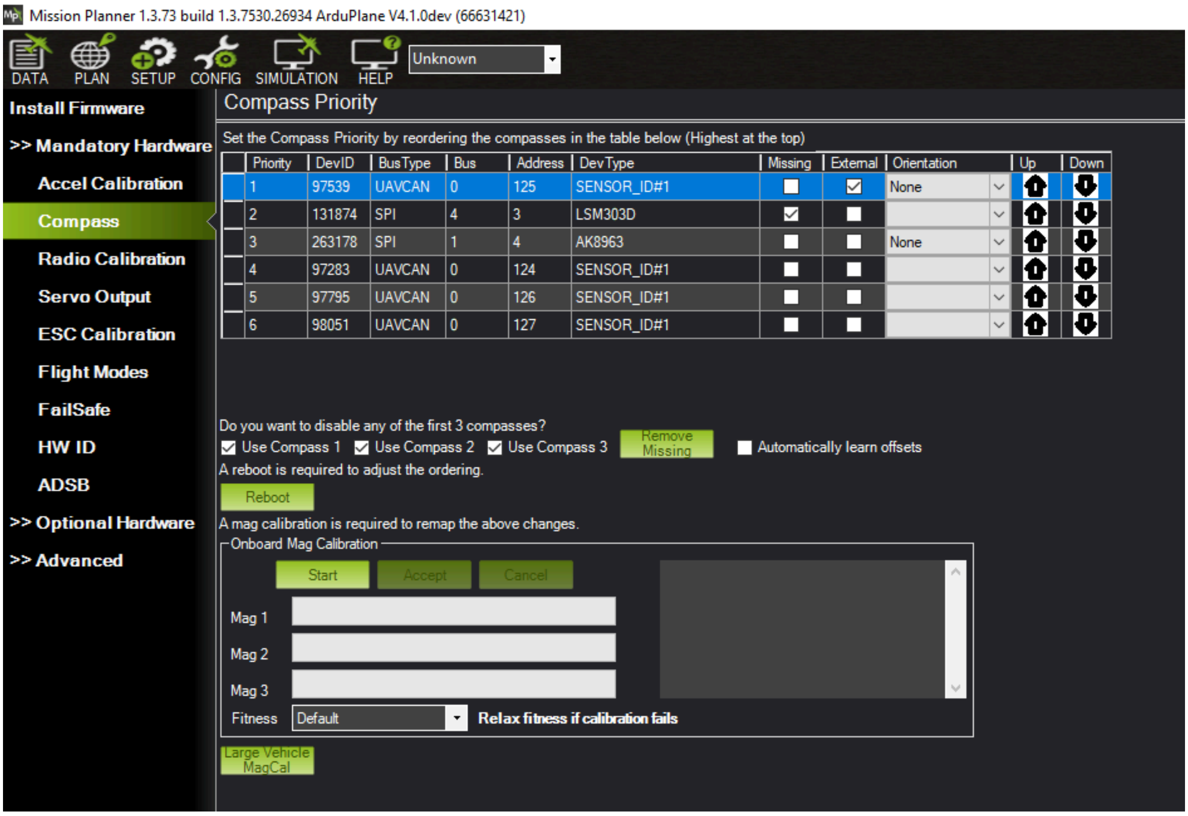


Figure 19: compass calibration

RC Transmitter Flight Mode Configuration

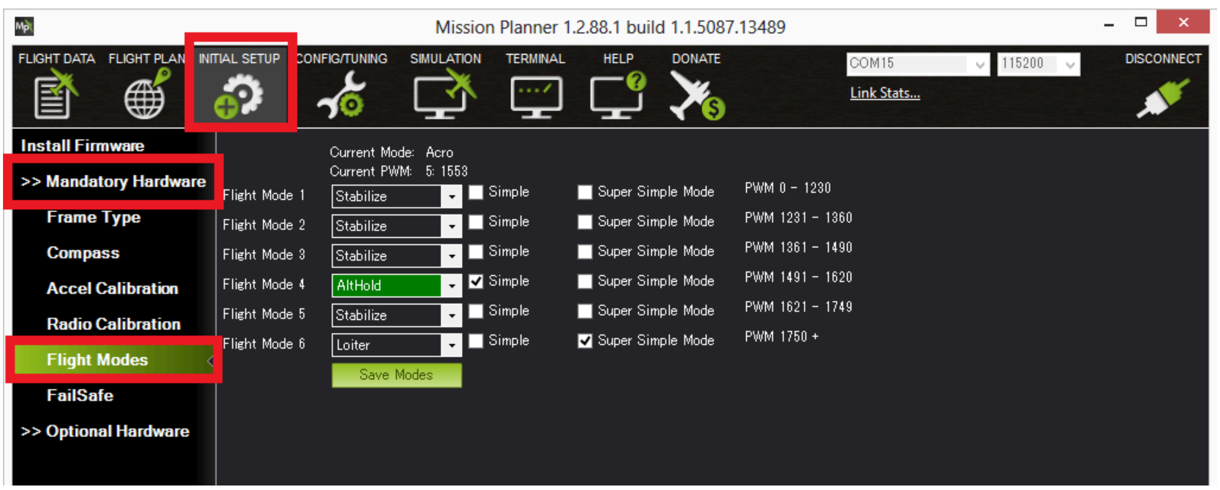


Figure :RC Transmitter

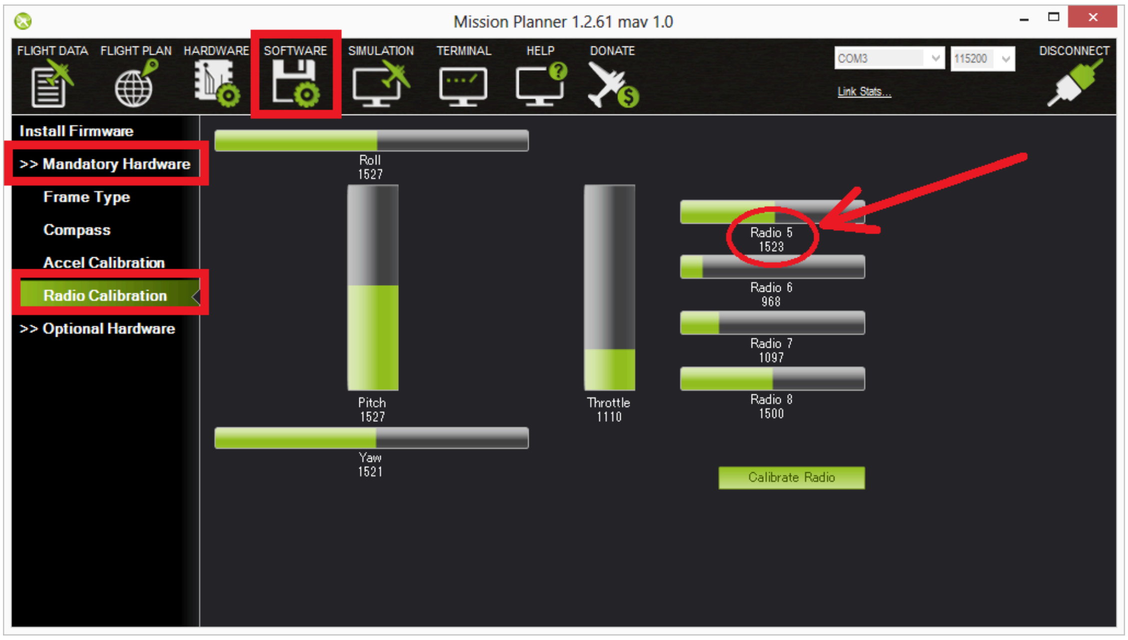
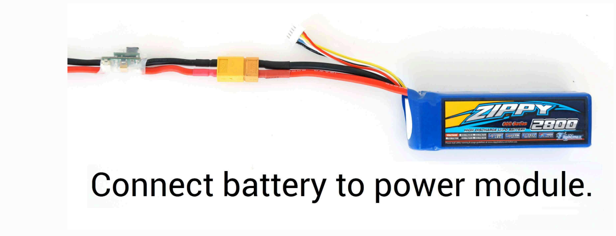


Figure :Radio Calibration

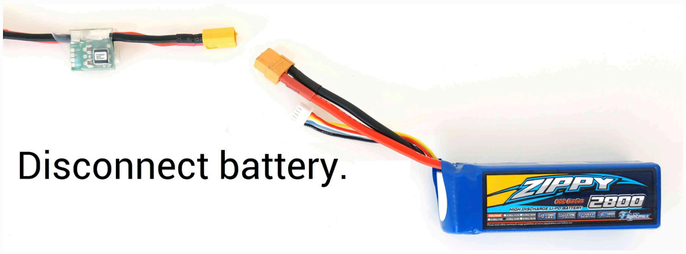
ESC Calibration

1. Turn on your transmitter and put the throttle stick at maximum.

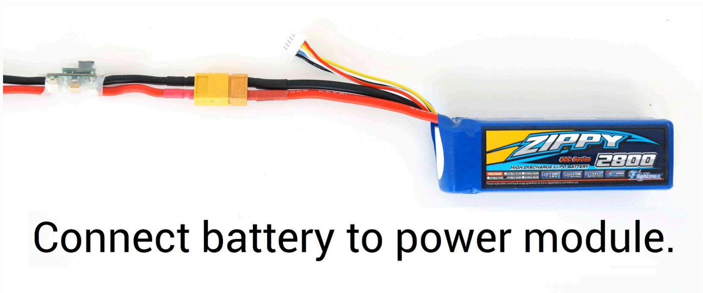
2. Connect the Lipo battery. The autopilot's red, blue and yellow LEDs will light up in a cyclical pattern. This means that it's ready to go into ESC calibration mode the next time you plug it in.



3. With the transmitter throttle stick still high, disconnect and reconnect the battery.



4. For Autopilots with a safety switch, push it until the LED displays solid red



5. The autopilot is now in ESC calibration mode.

Set throttle to minimum.

6. Wait for your ESCs to emit the musical tone, the regular number of beeps indicating your battery's cell count (i.e. 3 for 3S, 4 for 4S) and then an additional two beeps to indicate that the maximum throttle has been captured.
7. Pull the transmitter's throttle stick down to its minimum position.
8. The ESCs should then emit a long tone indicating that the minimum throttle has been captured and the calibration is complete.
9. If the long tone indicating successful calibration was heard, the ESCs are "live" now and if you raise the throttle a bit they should spin. Test that the motors spin by raising the throttle a bit and then lowering it again.
10. Set the throttle to minimum and disconnect the battery to exit ESC-calibration mode.

Semi Automatic ESC-by-ESC Calibration

1. Connect to the autopilot from a ground station such as the Mission Planner and set the ESC_CALIBRATION parameter to 3
2. Disconnect the battery and USB cable so the autopilot powers down
3. Connect the battery
4. The arming tone will be played (if the vehicle has a buzzer attached)
5. If using an autopilot with a safety button (like the Pixhawk) press it until it displays solid red
6. You will hear a musical tone then two beeps
7. A few seconds later you should hear a number of beeps (one for each battery cell you're using) and finally a single long beep indicating the end points have been set and the ESC is calibrated
8. Disconnect the battery and power up again normally and test as described below

Testing

Once you have calibrated your ESCs, you can test them by plugging in your LiPo. Remember: no propellers!

- Ensure your transmitter's flight mode switch is set to "Stabilize Mode".
- Arm your copter
- Give a small amount of throttle. All motors should spin at about the same speed and they should start at the same time. If the motors do not all start at the same time and spin at the same speed, the ESC's are still not properly calibrated.
- Disarm your copter

LIDAR Tool

RPLIDAR A2 development kit includes the matched tools used for evaluating RPLIDAR's performance and initial development. After connecting the RPLIDAR A3 with PC via USB cable and connecting the power adapter to the USB cable, users can observe the cloud map of the environment scanning point collected by the RPLIDAR in Robo Studio and start development based on the SDK.

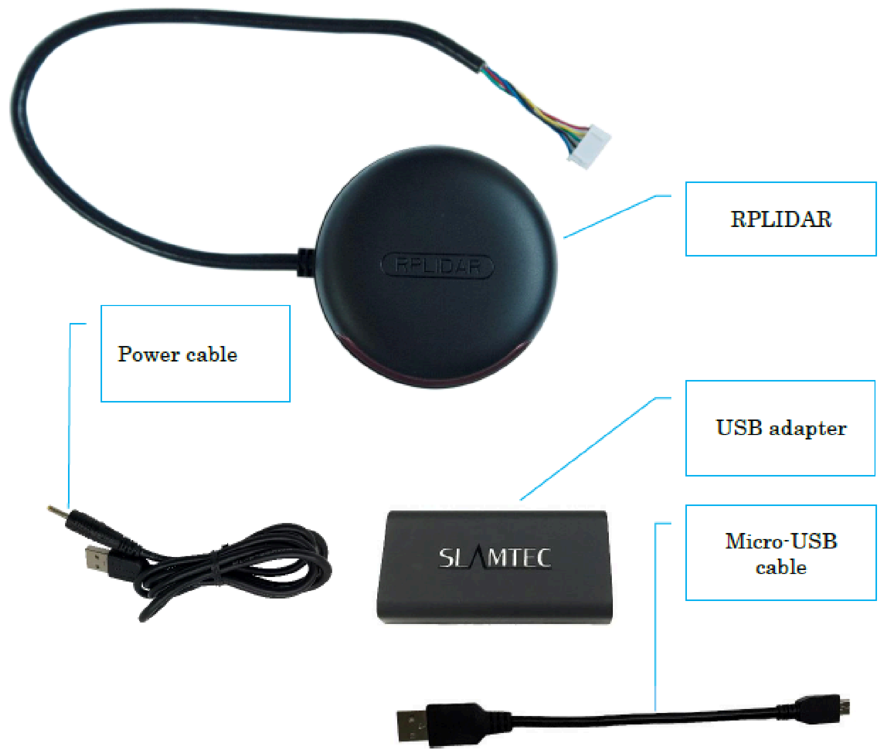
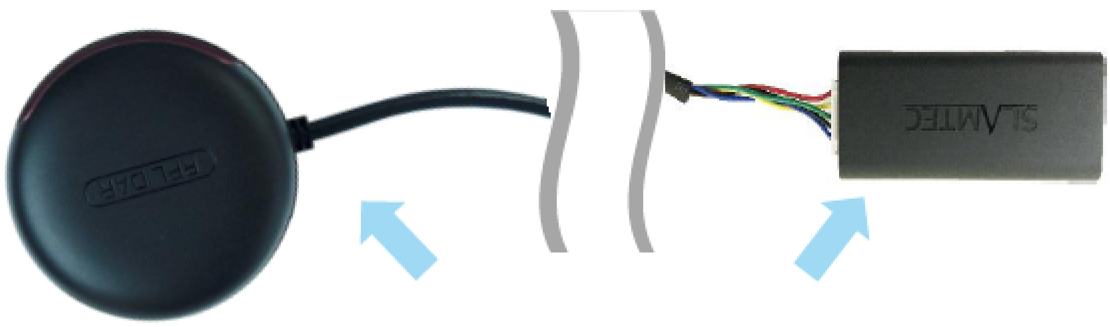


Figure: LIDAR

Connection

1) Connect RPLIDAR A2 with the USB adapter.



2) Connect the USB adapter to your PC via the Micro-USB cable. If the PC is on, after connecting the USB cable to your PC and connecting the power adapter to the USB cable, the indicator light of the USB will light up but the RPLIDAR will not start scanning.

SLAMTEC provides a Lidars plugin in Robo Studio for users in test and evaluation. You can view the scan result directly in the UI and save the scan result to files for further processing. This GUI demo can only run under Windows. For Linux and MacOS users, please refer to the other simple demo provided in the SDK. Please make sure you have connected RPLIDAR to PC by using USB adapter and installed the device driver correctly before running the demo application in Robo Studio. Launch Robo Studio and log in.

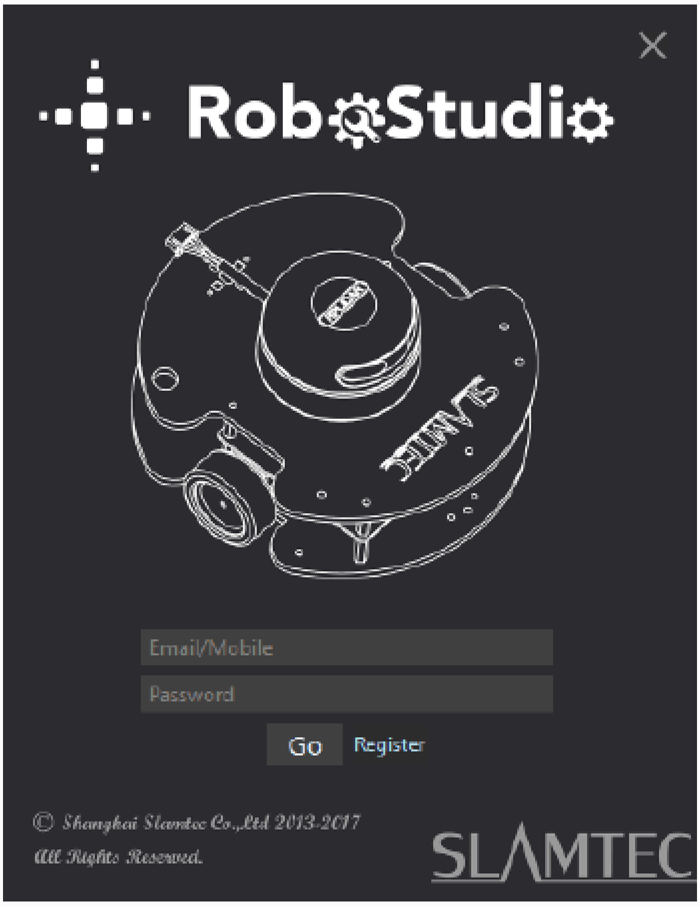


Figure:Login Page

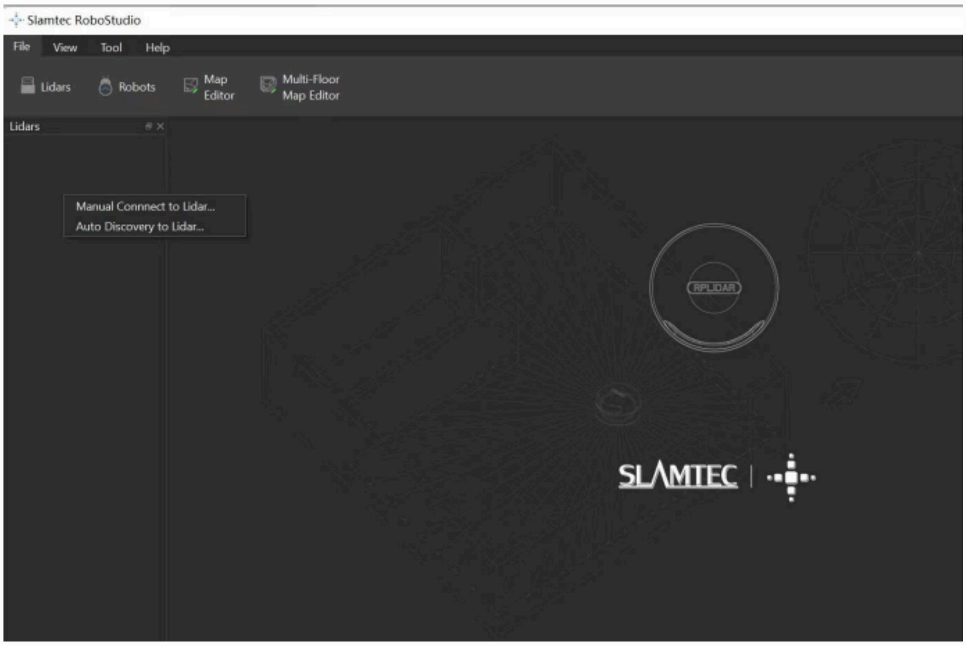


Figure: LIDAR plugin

Button	Function	Description
	Restart RPLIDAR	Restart scan core to clear internal errors
	Save Scan Data	Save current scan data to the local file
	Stop Scan	Scan core enter power save mode
	Start Scan	Scan data will be displayed after scan core starting work
	Work Mode Switch	Switch among different work modes to fit in specific environments
	Adjust Motor Speed	Adjust the motor speed as required

Figure:supported commands

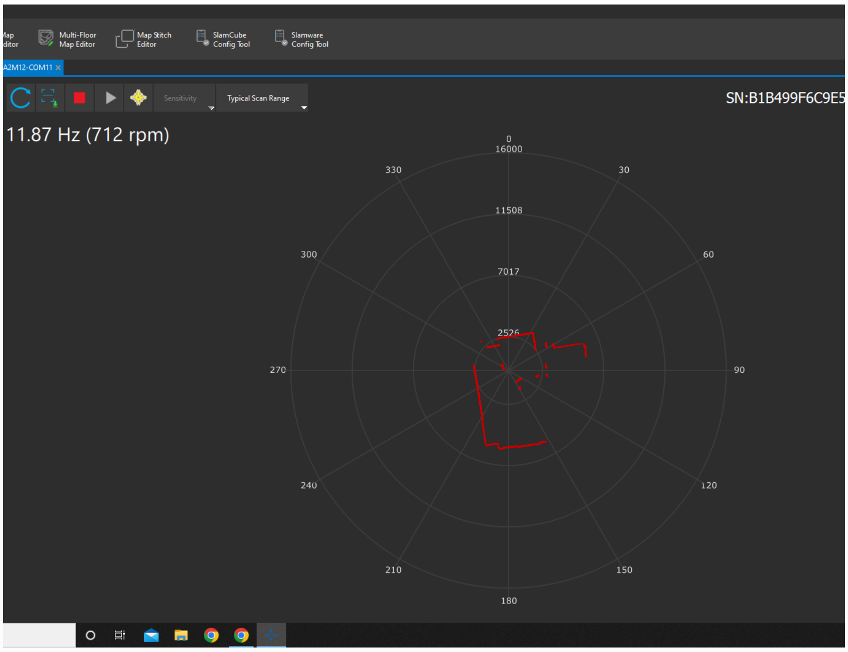


Figure: Scan Outline

Motor Speed Adjustment

During the running process, different motor rotating speed can be achieved by pressing the button, which can fit in different working environments or meet specific requirements. There will be a speed adjustment dialog box and dash board popped up for users to enter required speed. After entering a value, the motor will work as the settled rotating speed automatically. User can also drag the sliding handle to the required rotating speed.The current actual rotating speed will show in the upper left corner of the major work area. For instance, the actual rotating speed in the following screenshot is 11.92Hz.

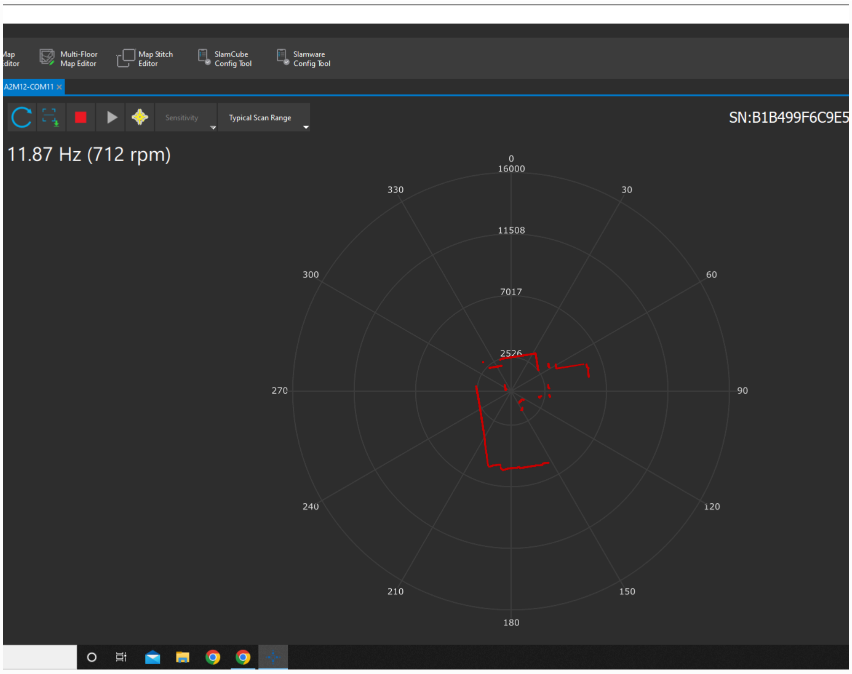
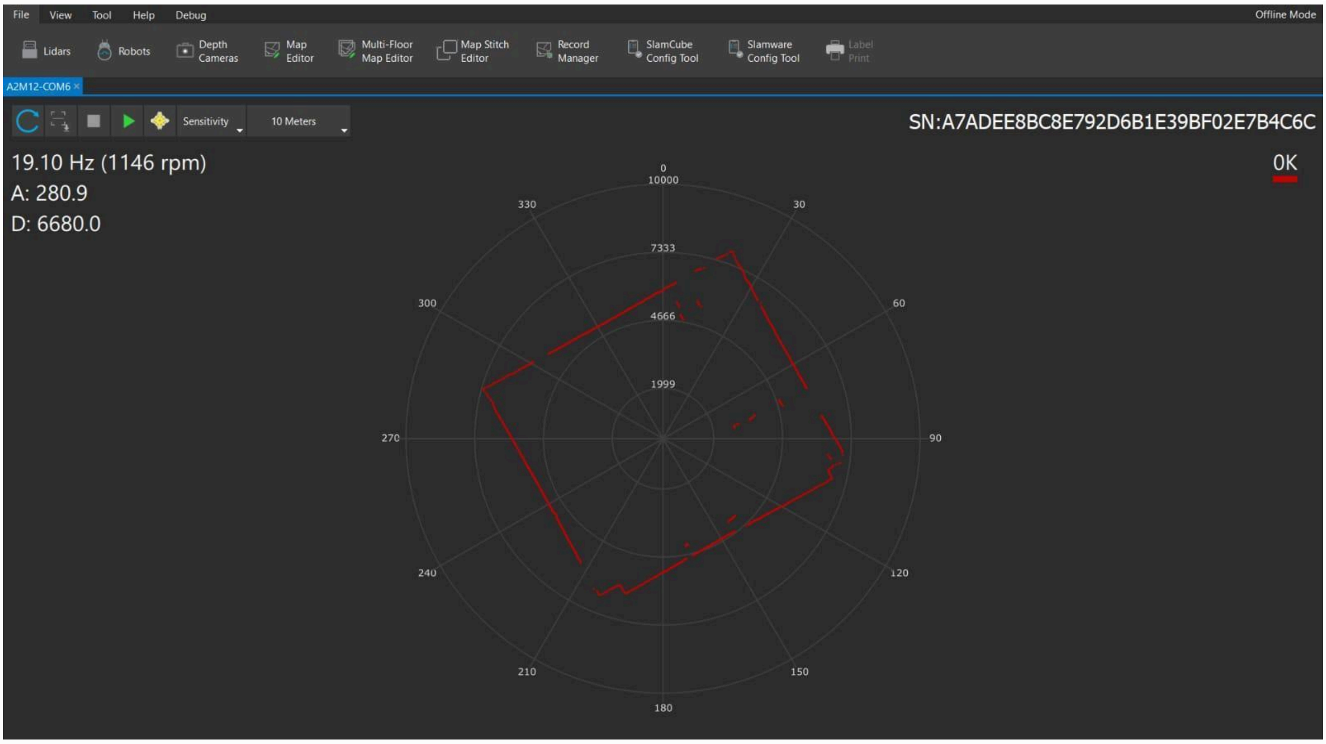
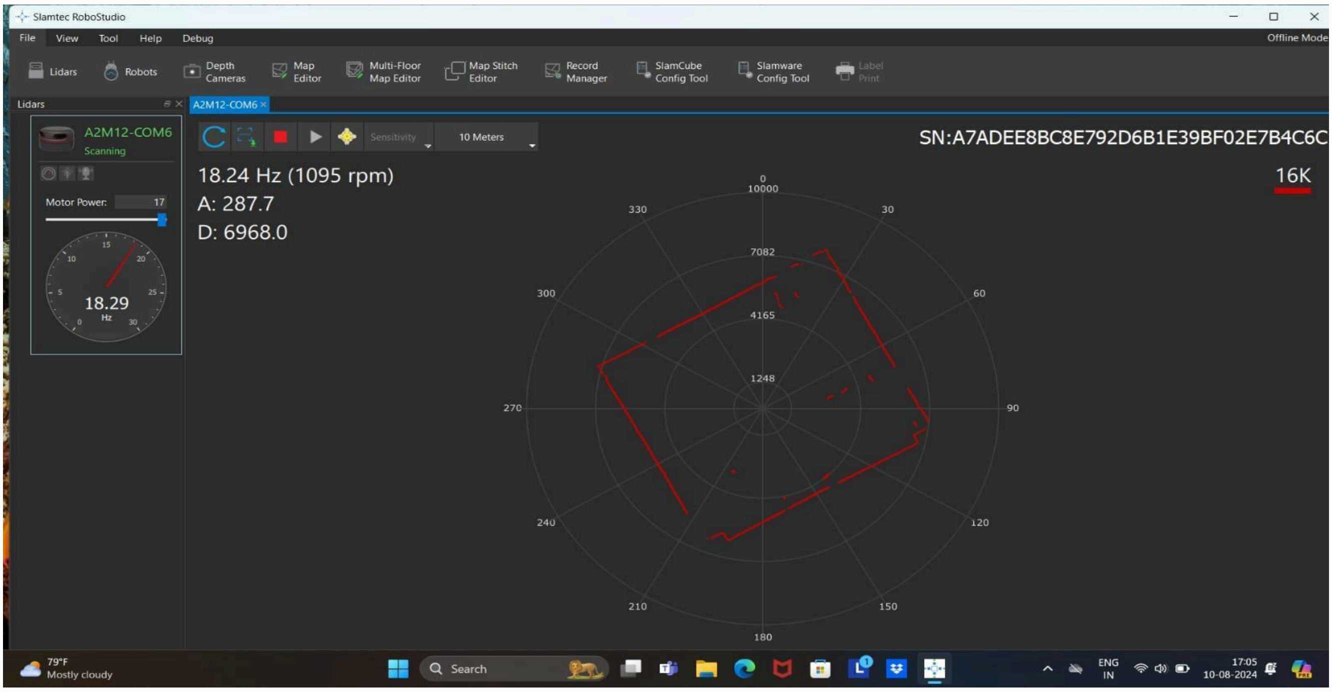


Figure: Motor Speed Adjustment

Results:


File
View
Tool
Help
Debug
Offline Mode
Lidars
Robots
Depth Cameras
Map Editor
Multi-Floor Map Editor
Map Stitch Editor
Record Manager
SlamCube Config Tool
Slamware Config Tool
Label Print
A2M12-COM6
Sensitivity
10 Meters
SN:A7ADEE8BC8E792D6B1E39BF02E7B4C6C
19.10 Hz (1146 rpm)
A: 280.9
D: 6680.0
0K
0
10000
7333
4666
1999
330
30
300
60
270
90
240
120
210
150
180


Slamtec RoboStudio
File
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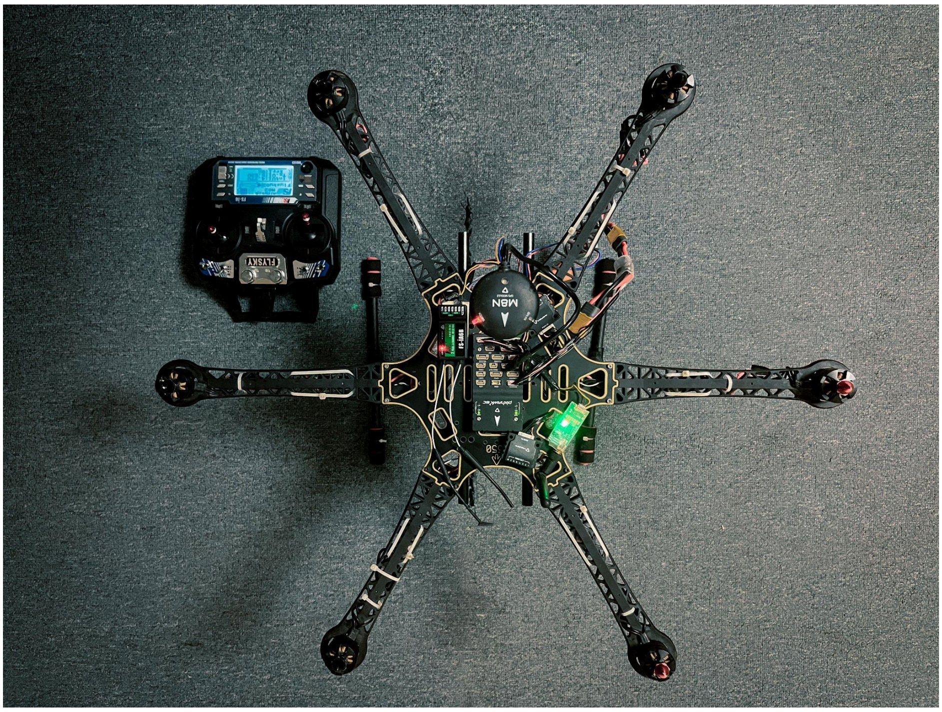
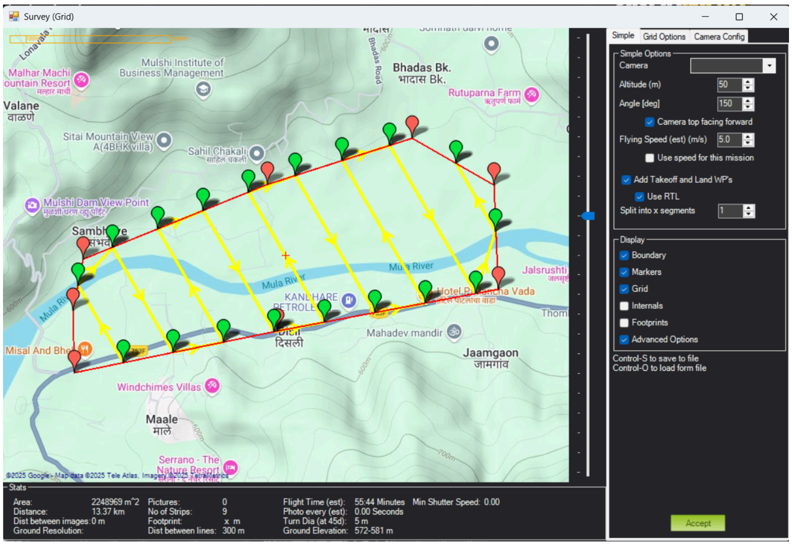
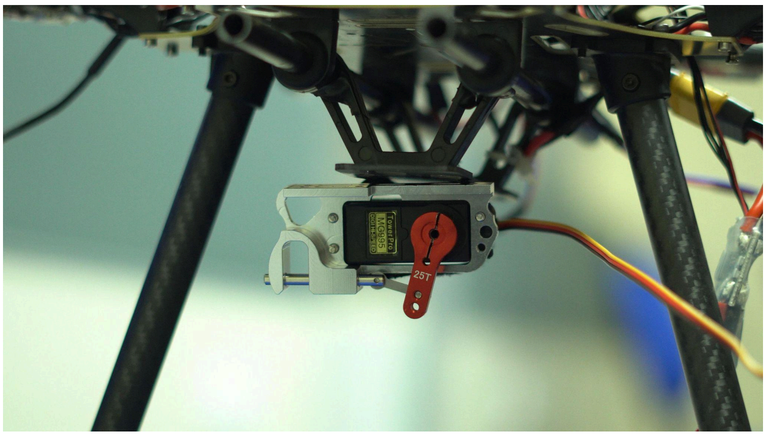
Lidars
Robots
Depth Cameras
Map Editor
Multi-Floor Map Editor
Map Stitch Editor
Record Manager
SlamCube Config Tool
Slamware Config Tool
Label Print
Lidars
A2M12-COM6
Scanning
Motor Power:
17
18.29
Hz
A2M12-COM6
Sensitivity
10 Meters
SN:A7ADEE8BC8E792D6B1E39BF02E7B4C6C
18.24 Hz (1095 rpm)
A: 287.7
D: 6968.0
16K
0
10000
7082
4165
1248
330
30
300
60
270
90
240
120
210
150
180
79°F
Mostly cloudy
Search
ENG
IN
17:05
10-08-2024

6: Project Result







7.Conclusion

In conclusion, the integration of a hexacopter for emergency response in flood-hit areas presents a significant advancement in disaster management. Floods often lead to difficult-to-reach locations where traditional rescue methods may fail, making the ability to deploy drones a game-changer for first responders. The hexacopter, with its six rotors and advanced maneuverability, can provide rapid aerial access to regions affected by floods, enabling real-time assessment of the disaster zone. This capability allows rescue teams to identify critical areas that require immediate attention, such as people trapped in inaccessible locations, flooded roads, or areas with debris, without putting human lives at risk.

The use of high-resolution cameras, infrared sensors, and LIDAR technology enables the hexacopter to gather crucial data, even in poor visibility conditions, such as during heavy rain or at night. This data is invaluable for mapping flooded regions, detecting temperature changes to locate survivors, and assessing damage to infrastructure. Furthermore, the hexacopter can be equipped with payload capabilities that allow it to carry and deliver medical supplies, food, or communication devices to stranded individuals or rescue teams.

Another key advantage of the hexacopter is its ability to operate autonomously, reducing the need for manual intervention and ensuring that the drone can continue to function in challenging environments. With precise flight control systems, the hexacopter can navigate through obstacles such as trees, power lines, and tall buildings, which are common in flooded urban areas. Additionally, its ability to maintain stability and lift in turbulent weather conditions further enhances its reliability in emergency scenarios.

The real-time data transmission capabilities of the hexacopter also allow for seamless communication with emergency response teams, enabling them to make informed decisions quickly and effectively. The aerial view provided by the drone can guide the positioning of ground-based rescue teams and help optimize their efforts. By acting as a force multiplier, the hexacopter enhances the overall effectiveness of the rescue mission and increases the chances of saving lives.

Furthermore, the potential for continuous improvement in the technology behind hexacopters can further expand their use in disaster response. As battery life improves, flight times will increase, allowing drones to cover larger areas in a single mission. The incorporation of artificial intelligence and machine learning could also enable more sophisticated analysis of the data collected, improving decision-making and resource allocation.

In conclusion, the hexacopter presents a transformative solution for emergency response in flood-hit areas, providing faster, safer, and more efficient means of saving lives, delivering aid, and gathering critical data. The successful implementation of this technology highlights the potential of drones in disaster management, and as further advancements are made, hexacopters could become an indispensable tool for first responders. The ongoing development of UAV technologies promises to expand the role of drones in mitigating the impacts of natural disasters, offering a powerful and versatile tool to support humanitarian efforts in the future.

8.FUTURE SCOPE

The future scope for the hexacopter project in emergency response for flood-hit areas is vast and promising, with numerous opportunities for improvement, expansion, and integration of emerging technologies. Some potential directions for future development include:

1. Enhanced Autonomy and AI Integration

- **Autonomous Navigation:** The future scope could involve further developing the hexacopter's autonomous flight capabilities, allowing it to navigate through complex environments without human intervention. Incorporating advanced AI algorithms for real-time decision-making could enable the drone to detect hazards, identify survivors, and prioritize mission-critical areas more effectively.
- **AI-Powered Data Analysis:** With the integration of machine learning, the hexacopter could analyze the collected data on the fly, such as identifying survivors, detecting floodwater patterns, or assessing structural damages. AI could automatically flag the most critical locations for rescue teams, optimizing response efforts.

2. Longer Flight Durations and Improved Energy Efficiency

- **Battery Technology Advancements:** The performance of the hexacopter can be significantly improved with advances in battery technology. Longer battery life and faster charging systems would allow for extended operational hours, ensuring continuous support during extended rescue operations, which are common in large-scale disasters.
- **Energy Harvesting:** Research into energy harvesting methods, such as solar-powered drones or drones that can recharge mid-flight using wireless power transmission, could further extend operational time without needing to land frequently for recharging.

3. Swarm Technology and Multi-Drone Coordination

- **Swarm Operations:** In the future, a network of hexacopters could be deployed in a coordinated swarm, allowing for multiple drones to cover larger areas efficiently. Swarm technology would enable drones to work together, avoiding collisions, sharing data, and enhancing mission coverage. This would be particularly useful in flood-hit areas, where large regions need to be surveyed quickly.
- **Collaborative Rescue Operations:** Multiple drones could be tasked with various roles, such as aerial surveillance, delivering supplies, or rescuing individuals from different vantage points. This would ensure faster and more comprehensive rescue operations.

4. Improved Payload and Specialized Equipment

- **Advanced Sensor Integration:** Future hexacopters could carry more advanced sensors, including multi-spectral imaging, radar, or chemical sensors, to detect survivors trapped in debris or submerged under floodwaters. These sensors would help pinpoint survivors with greater accuracy.

- **Larger Payloads for Heavy Equipment:** The future scope could also include hexacopters capable of carrying heavier payloads, such as large medical kits, water pumps, or even lightweight rescue equipment (like ropes or inflatable rafts) to assist flood victims.
- **Robotic Arm Attachments:** Integration of robotic arms or grabbers could allow hexacopters to assist in physically moving small debris, releasing individuals trapped under wreckage, or performing simple tasks like opening floodgates or turning valves to prevent further damage.

5. Real-Time Communication Networks and Data Sharing

- **Disaster Communication Networks:** Hexacopters could play a vital role in establishing temporary communication networks in areas where infrastructure has been destroyed. Drones equipped with communication relay systems could assist in providing satellite or 4G/5G connectivity to ground teams, enhancing coordination and information sharing.
- **Cloud-based Data Processing:** The collected data from hexacopters could be processed and stored in real-time on cloud platforms, making it instantly available to emergency responders and humanitarian organizations for decision-making.

6. Expanded Disaster Response Applications

- **Application Beyond Floods:** While the hexacopter is designed for flood response, its capabilities could be expanded to other disaster types, such as wildfires, earthquakes, or hurricanes. Drones could be used to assess fire behavior in wildfire-prone areas, locate survivors trapped in collapsed buildings after an earthquake, or deliver emergency supplies to isolated communities during hurricanes.
- **Search and Rescue in Other Environments:** Future versions could also be used in difficult terrains, such as mountains, forests, or rural areas, expanding the operational scope of the technology in global disaster relief efforts.

7. Regulatory and Safety Improvements

- **Regulatory Frameworks for Drone Operations:** As drones become more common in disaster response, the development of global and regional regulations for drone flights, particularly in crowded or urban areas, will be essential. Future efforts could include close collaboration with governments to develop airspace management systems that allow drones to operate safely during emergency situations.
- **Enhanced Safety Features:** To ensure reliability during operations in high-risk environments, hexacopters can be designed with more robust safety features, such as redundant systems (e.g., dual GPS systems, backup motors) to ensure that drones can continue to operate even if one component fails.