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DESIGNING AN INTELLIGENT SMART VTOL DRONE USING FLYSKY TRANSMITTER AND PIXHAWK CONTROLLER FOR HIGH-RISK RESCUE AND MILITARY OPERATIONS.

Engr. Shazia Feroz[*1], Syed Kumail Abbas Zaidi[2], Basit Ahmad[3], Mudassar Rafique[4], Saifullah Zadran[5], Muhammad Hassan[6]

*[*1]Department of Electronics Engineering Technology, Benazir Bhutto Shaheed University of Technology and Skill Development, Khairpur Mir's, Sindh, Pakistan.*
[2]Department of Electrical and Computer Engineering, Lamar University, Texas, United State of America.
[3]Department of Electrical Engineering, NFC Institute of Engineering and Technology Multan, Punjab, Pakistan.
[4]Department of Electrical Engineering, Superior University Lahore, Punjab, Pakistan.
[5]Department of Robotics and Artificial Intelligence, National University of Sciences and Technology (NUST), Islamabad, Pakistan.
[6]Department of Electronics Engineering Technology, Benazir Bhutto Shaheed University of Technology and Skill Development, Khairpur Mir's, Sindh, Pakistan.

[*1]shaziaferoz@bbsutsd.edu.pk, [2]szaidi2@lamar.edu, [3]basitahmad3884@gmail.com, [4]mudassarrafique737@gmail.com, [5]saifullah_zadran@outlook.com, [6]hassan24@gmail.com

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Corresponding Author: *

Abstract

The development of intelligent unmanned aerial vehicles (UAVs) has revolutionized the field of high-risk rescue and military missions, offering enhanced capabilities in remote and hazardous environments. This paper presents the design and implementation of a smart Vertical Take-Off and Landing (VTOL) drone, utilizing a FlySky Transmitter and a Pixhawk Controller for autonomous flight operations. The proposed drone integrates advanced navigation and control algorithms, enabling seamless performance in dynamic and complex terrains. The FlySky Transmitter ensures robust communication between the drone and the operator, while the Pixhawk Controller manages the flight stabilization, sensor integration, and autonomous mission execution. The system is designed to support both manual and autonomous flight modes, with intelligent features such as obstacle detection, real-time video streaming, and automatic emergency procedures. Through extensive flight testing, the drone's performance is evaluated in various high-risk scenarios, demonstrating its potential to enhance mission effectiveness and safety in critical applications such as search and rescue operations and military surveillance. The findings highlight the system's reliability, adaptability, and potential for future integration with advanced AI technologies, positioning it as a valuable tool for high-risk environments. The paper concludes with a discussion on the future prospects of smart VTOL drones, addressing both technical challenges and ethical considerations in their deployment.

INTRODUCTION

Unmanned Aerial Vehicles (UAVs), commonly known as drones, have revolutionized various sectors with their versatility and efficiency. Among the myriad of UAV designs, Vertical Takeoff and Landing (VTOL) drones stand out for their unique capability to navigate both vertically and horizontally, making them invaluable assets in applications ranging from civilian rescue missions to military operations. This research delves into the design and development of a Smart VTOL Drone meticulously tailored to meet the exacting demands of these critical operations. Over the last few years, most of the space provided by the landscape of emergency response and military engagements has been deeply transformed and the aerial platforms are evolving in order to respond to the new difficult problems. However, traditional fixed wing and rotorcraft are, of course, rather limited; they are both effective in their own ways but are limited in maneuverability and adaptability to a dynamic environment [1]. The VTOL drones, which can smoothly transition between a quick vertical, while hovering, in order to a horizontal flight mode, appear to be a fascinating solution to the challenges. We intend to apply the most advanced state of the art in aerodynamics, propulsion, and autonomous navigation to design and build a Smart VTOL Drone that surpasses the strict design requirements for today's rescue and military operations. In this introduction, an overview of the project's objectives and methodology, and the expected outcomes are given for better understanding to explore the complex process of designing and developing a Smart VTOL Drone. By conducting thorough research, designing intelligently, and testing meticulously, we seek to improve on UAV technology and best practices of UAV practices, both in rescue and military operations. In the days ahead, we are excited to discover new frontiers of aerial mobility, and to change forever the paradigm of mission effectiveness, operational efficiency and safety.

Since the mid 20th century, the VTOL (Vertical Takeoff and Landing) drones have come a long way from experimental aircraft, to advanced, multifunctional platforms. Such VTOL technology had first been demonstrated by exploring the possibility of vertical takeoff and landing using the highly ambitious prototypes, like Harrier Jump Jet and Bell XV 3. First, the early innovations of these ideas were, for the most part, on manned aircraft [2]. Since the end of the 20th century however military applications have taken prominence and the form they have taken is the Bell Boeing V22 Osprey, an airplane, half helicopter. With the advent of unmanned aerial vehicles (UAVs) in the 21st century, the era for VTOL technology had come. During the early 2000s, there was focus on making improvements in materials, propulsion systems and control technologies to help build more practical and versatile VTOL drones [3]. Widespread use of quadcopters in the 2010s introduced drone use to the mainstreaming, which inspired further innovations in VTOL designs for everything from the commercial to the civilian. Currently, VTOL drones are possessed by modern advancements including autonomous navigation, AI empowered systems, and hybrid electric propulsion. Their applications have become broader in industries such as emergency response, military operations, logistics and even urban air mobility. In recent years, VTOL drones have more and more been adopted for important jobs such as the delivery of medical supplies, firefighting, and reconnaissance missions. With technology moving forward, VTOL drones are essential aids for the resolution of complicated issues and the enhancement of operational efficiency in different areas. They are now being developed further and an even greater role in the future of aviation and unmanned systems is promised [4].

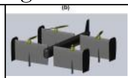
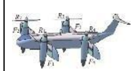
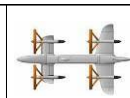
In context of scientific researches about VTOL capable platforms, NASA GL-10 is about 30 kg weight, and it has 2 hours of flight endurance [5]. It flies between 15 and 30 m/s, and its service ceiling is about 5000 ft. It has ten motors on it, of which eight are placed on the main wing, and two are placed on the tail. A conceptual aircraft study, named as a convertible tail-sitter UAV, with two counter-rotating propellers, is designed [6]. VertiKUL is developed by Researchers at KuLeuven. It is a quadcopter-tail-sitter flying wing with only VTOL control elements that achieves transition through tilting fuselage. SUAVI, which is mainly designed for surveillance, has 17 m/s cruise speed [7]. They have mainly studied the controller and avoided the aerodynamical complexity as much as possible. The whole aircraft, which has four rotors and 4.5 kg take-off weight, is manufactured from carbon fiber. It has symmetry in the pitch axis due to using two tandem wings, which are identically the same and placed sequentially [8]. This symmetry provides to design a less complicated flight controller. However, the aerodynamic performance is affected negatively since the backward wing is affected by the front wing. QTW-UAV, which has 24 kg take-off weight, is designed as four-motored [9]. The wings generate lift while rotors tilted because of the accelerated air by rotor blades in VTOL mode. This feature helps them to have one more input to maneuver the aircraft during the VTOL and transition modes. The AVIGLE, which is capable of performing the mission between 0 and 40 m/s velocity range has 10 kg take-off weight. This aircraft, which has a different design from the others, is designed to have two rotors [10]. The moment is balanced by using a small fan blade; that is, we can say that this UAV has three rotors in total. It is made from carbon fiber. This type is considered riskier than the others since the aircraft will become uncontrollable in case of a rotor loss. Another study by [11] performed hover for a tri- copter fixed-wing UAV configuration. Also, another tail-sitter aircraft is developed with a coaxial propulsion system, and they have performed hover with this aircraft. The QUX-02A [9], which has two wings and four rotors, has a 4.2 kg take- off weight, and it is capable of doing missions between 10 and 25 m/s velocity. In another study [12], a tail-sitter configuration with variable pitch propellers is utilized. Stone developed a T-wing tail-sitter UAV with two counter-rotating propellers in 2005. Another interesting example is TURAÇ, which is a flying wing-tiltrotor with a ducted fan configuration. It has a 4.2 m wingspan, 25 m/s cruise speed, and 47 kg maximum take-off weight with 8 kg payload [13]. Korea Aerospace Research Institute has designed and manufactured a Tilt-Rotor Aircraft for the Smart UAV development program. For the sake of the program, they built a scaled model and tested it successfully. The aircraft maximum take-off weight is approximately 210 kg with 250 km/h top speed. It has an endurance of 5-6 hours, and its wingspan is about 5 m [14].

Table 1: VTOL UVV Types

					
	Tail-sitter	Ducted fun	Tilt-wing	Tilt-rotor	Quadrotor-FW
Control	2	4	3	3	4
Transition	3	4	3	3	4
Hovering capability	1	3	4	3	4
Horizontal flight	3	2	4	4	2
Energy efficiency	4	2	5	5	2
Mechanical complexity	4	2	4	3	5
Payload volume	2	1	4	3	2

Table 1 shows that Tilt-Wing Platforms come forward per VTOL UAV types. Therefore, in this study, a Tilt-Wing VTOL capable UAV will be studied. Some examples of Tilt-Wing UAVs can be seen in Table 2 [15]. The objective of these studies (Table 2) was to make an aircraft that has a less complicated flight controller compared to literature designs, although this reduces the aerodynamic performance.

Table 2: Tilt-Wing UAVs

							
	SUAVI	**NASA GL-10**	**QTW-UAV**	**AVIGLE**	**QUX-02A**	**HARVee**	**QTW-UAS FS4**
Driven By	Electric Driven	Hybrid Driven	Electric driven	Electric driven	Electric driven	Electric driven	Electric driven
Concept	Quad Tilt Wing	Tilt-Wing	Quad Tilt Wing	Tilt-Wing	Quad Tilt wing	Tilt-Wing	Quad Tilt wing
Made of	Composite	Composite	Composite	Composite	Foam	Wood	Composite
Wing Pos.	Mid wing	High Wing	High Wing	High wing	High Wing	Mid-Wing	High wing
Max. Weight	4.46 kg	30 kg	24 kg	10 kg	4.2 kg	27 lb	30 kg
Rotor Num.	4 Rotors	10 Rotors	4 Rotors	3 Rotors	4 Rotors	2 Rotors	4 Rotors
Fuselage	1 m	1.85 m	1 m	1.85 m	1.1 m	4.5 ft	1.86 m
Wing span	1 m	3.16 m	1 m	2 m	1.38 m	5.7 ft	1.80 m
Chord length	0.25 m	0.25	0.3 m	0.35	0.132 m	N/A	0.30 m
AR	4	12.8		5.7	5.23	N/A	6
Opt./Max. speed	40/60 km/h	22.7/- m/s	-/150 km/h	15/40 m/s	10/25 m/s	15/- m/s	100/150 km/h
Speed Range	0-60 km/h	0-??? m/s	0-150 km/h	0-40 m/s	10-25 m/s	N/A	0-150 km/h
Payload	N/A	2 kg	5 kg	1.5 kg	N/A	N/A	5 kg
Endurance	60 min	120 min	15 min	60 min	N/A	N/A	60 min

This paper explores the design and implementation of such a drone, with a specific focus on its applications in high-risk rescue and military operations. The paper will detail the drone's system architecture, flight control, and intelligence features, as well as the results from performance testing in real-world mission scenarios. By examining the effectiveness and reliability of the drone, this research aims to contribute to the development of intelligent, autonomous UAV systems that can enhance the safety and success of high-risk missions.

2- Problem Statement:

In today's technology-driven world, the demand for smart drone systems that can interact with humans and assist in areas like deliveries, healthcare, and daily life is rapidly growing. However, as the scope and complexity of drone applications expand, so do the challenges in designing, developing, and implementing these systems. Availability of composable, intelligent and affordable drones is still a large gap despite the growing need for them. Many traditional drone systems are expensive and come with complex, unintuitive interfaces which makes them, for example, unfeasible for smaller scale applications, education purposes, medical use or budget constrained environments. Closing this affordability gap is critical to democratise drone technology and allow more industries and centres of learning to benefit from it. There are a number of obstacles and limitations that make it hard to transport objects or people. To overcome these challenges, innovative solutions are needed to enable drones to be more practical, user friendly, and affordable to the wide range of scenarios and needs.

- **Firefighters and Narrow Streets:** Fire fighters usually strive to fix this hard to fix road. In urban /older parts of the city areas, streets are crowded and often under 10 metres wide. These tight spaces could be difficult or impossible to get a fire truck or other emergency vehicle that is normally quite large through them.

- **Inaccessible Areas:** Military operations often require access to remote or difficult-toreach areas, such as rugged terrains, dense forests, mountains, or urban environments with restricted access.
- **Logistical Challenges:** Delivering essential supplies like weapons, ammunition, food, and medicine to troops in these inaccessible areas poses significant logistical challenges. Traditional vehicles might not be able to traverse these terrains, and manual transportation could be too slow or dangerous.
- **Operational Efficiency:** The inability to deliver necessary supplies promptly can impact the effectiveness of military operations. Soldiers might face shortages of critical supplies, affecting their combat readiness, health, and overall mission success.

To address above mentioned issues, this research aims to design and develop a smart VTOL drone that combines cheap, readily available materials such as thermopile sheet and aluminum stick, glue stick, tape and some others materials and electronic Components. The goal is to create a smart VTOL drone to provide a solution of emergency delivery affordable, adaptable and user-friendly solutions that can transform aviation Industries, in a variety of applications. This research therefore seeks to bridge the affordability gap and improve the adaptability and accuracy of VTOL drone, ultimately offering solutions to the challenges faced by Various industries, educational institutions and the wider community in integrating Drone into everyday operations. We propose a solution to address these challenges by developing a versatile VTOL (Vertical Takeoff and Landing) drone that can be remotely Controlled. This drone is designed to support various Critical functions, including firefighting, air Ambulance services, transporting military supplies, and responding to emergency and disaster Situations.

3- Research objective:

The primary objective of this research is to design and develop an intelligent smart VTOL (Vertical Take-Off and Landing) drone that utilizes the FlySky Transmitter and Pixhawk Controller to enhance the effectiveness and reliability of high-risk rescue and military missions. Specifically, this study aims to:

- To design and build an smart VTOL drone prototype utilizing readily available, reasonably priced materials as thermo pole, aluminum, plastic tape and others components.
- Objective for proper positioning and stability of the VTOL drone during landing and takeoff to prevent accidents and enhance operational safety.
- Objective for Pickup of the Object and Final Demonstration the drone's capability to accurately locate, pick up, and transport objects to specified destinations, showcasing its effectiveness in real-world scenarios.
- The drone will be designed to carry various payloads, it has including mechanical gripper to pick and place anybody or any type of materials like medicines, weapons, food delivery to pick and drop destination using with the help of gripper. The drone in medial usage like an ambulance .and also include highresolution cameras, thermal sensors, and cargo delivery mechanisms, to accommodate a wide range of mission requirements.
- To implement robust communication systems enabling real-time data transmission between the drone and ground control stations, including telemetry data, video streaming, and command and control communication, ensuring seamless mission coordination and situational awareness.

4- Methodology:

In this section, the design and implementation of the proposed firefighting drone has been presented in detail. The proposed firefighting system's block diagram has been demonstrated in Figure 1. The subsequent paragraphs provide a description of the hardware and software needed to construct the firefighting drone.

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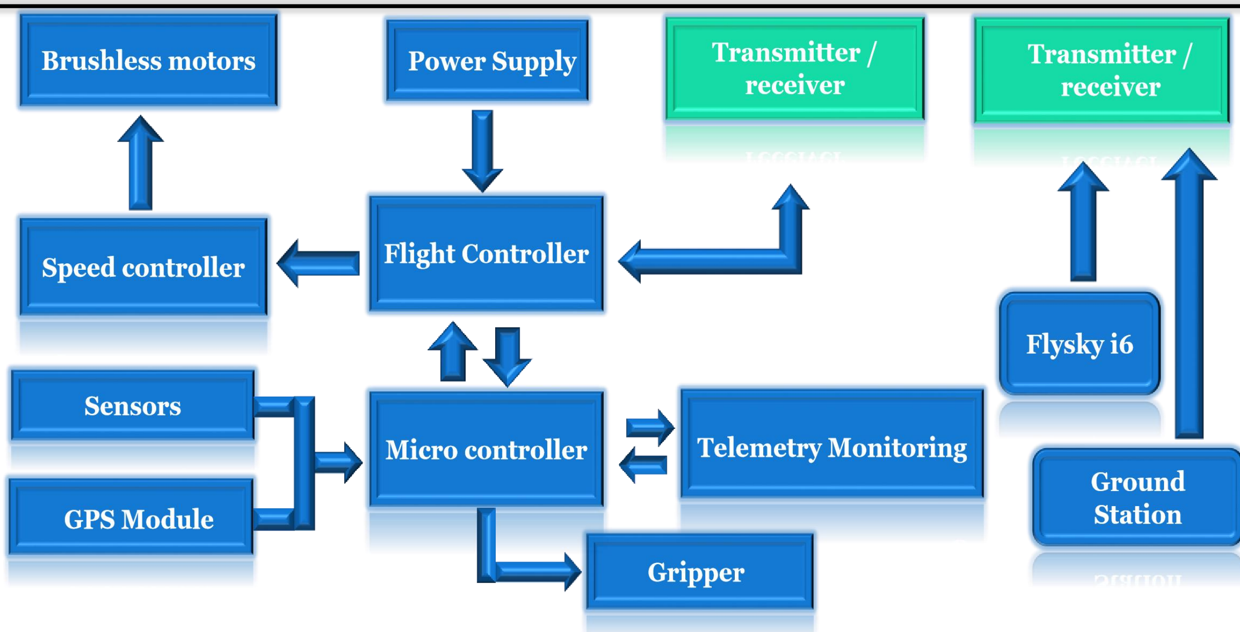

Figure 1: Block diagram of the proposed drone.

4.1- Hardware tools/components

4.1.1- FLYSKY I6 TRANSMITTER:

A radio control system used to remotely control unmanned aerial vehicles (UAVs), drones, is the FlySky i6 transmitter. It is the interface between the operator (pilot) and the drone to have accurate control on the drone's flight behavior, maneuvers and operational modes. The main handheld unit which contains such components as controls, antennas, and display screen. The common instrumentation includes joysticks, switches, buttons, digital display to access and adjust the various setups and functions. The receiver unit is installed on the drone, this unit receives the signal from transmitter and passes on the signal to flight control system of the drone. It is used to decode the pilot's commands in order to perform corresponding actions like throttle, pitch, roll and yaw. Moreover, the FlySky i6 transmitter uses the radio frequency band (usually 2.4GHz) and the modulation technique, frequency modulation (FM) or amplitude modulation (AM), to transmit the control signals to the receiver unit located on the drone's onboard [16]. The transmitter and receiver pair are bound together using a unique identification code to ensure secure and reliable communication. The FlySky i6 transmitter offers various features and functionalities, including:

- Multiple channels for controlling different aspects of the drone's flight dynamics and onboard systems.
- Dual-rate and expo settings for adjusting control sensitivity and response.
- Programmable mixing options for customizing control inputs and flight behavior.
- Telemetry capabilities for monitoring real-time flight data such as battery voltage, signal strength, and altitude.
- Model memory for storing and recalling settings for multiple drone configurations or pilot preferences.

Figure 2 shows the Fly Sky i6 transmitter.

Figure 2: Fly Sky i6 transmitter

4.1.2- PIXHAWK FLIGHT CONTROLLER:

Pixhawk is a compact, highperformance autopilot system used in UAVs (unmanned aerial vehicles) such as drones. The core of the drone, the flight dynamics, navigation and payload operations are managed by it. Central processing unit (CPU) that contains microcontroller, sensors and input and output interfaces is called main controller unit. The sensor data is processed and flight control algorithms are executed so that the drone is stabilized and autonomous flight commands are executed. The flight controller includes various sensors, like gyroscopes, accelerometers, magnetometers, and the barometers, which are integrated to sense the drone's orientation, velocity, altitude and the environmental conditions. Global Positioning System GPS receiver: To give accurate position and velocity information, which allow for autonomous navigation and to way point. The Pixhawk flight controller receives data from onboard sensors and the calculated drone orientation, velocity, and position in real time constantly. It then compares this to the flight parameters that were set by the pilot or autonomous flight algorithms that are desired. The flight controller changes the drone's motor speeds, control surfaces, or other actuator outputs based on deviation between desired and actual states so that the drone stabilizes its flight and stays on the given trajectory [17]. This is a closedloop control process that takes place hundreds of times per second to achieve smooth and stable flight under challenging conditions. Furthermore, Pixhawk flight controller supports advanced capabilities such as waypoint navigation, altitude hold, return to home, and geofencing to plan and execute autonomous missions. Telemetry links allow the communication of the pilot or ground control station, to send real time telemetry data in order to keep remote monitoring and control of the drone operations. The Pixhawk fight controller is presented in Figure 3.

Figure 2: Pixhawk fight controller.

4.1.3- ELECTRONICS SPEED CONTROLLER (30A-ESC):

The Electronic Speed Controller (ESC) is a crucial component in the propulsion System of drones and other electric-powered vehicles. It regulates the speed and Direction of electric motors by adjusting the power supplied to them based on Commands received from the flight controller. Power Stage: The power stage consists of MOSFETs (Metal-Oxide-Semiconductor Field-Effect Transistors) or other power transistors that control the flow of current from the battery to the motor. It amplifies the signal from the flight controller to Modulate the motor's speed. Microcontroller: The microcontroller interprets commands from the flight controller And generates signals to control the power stage. It monitors motor speed and current Draw to ensure safe and efficient operation. Input/output Interfaces: The ESC typically features input connectors for power (Battery) and signals from the flight controller, as well as output connectors for the Motor. Some ESCs may also include additional interfaces for telemetry, Programming, or auxiliary functions. When the ESC receives a command from the flight controller, it processes the signal and adjusts the power delivered to the motor. This adjustment is achieved by modulating the duty cycle of the power signal, which controls the motor's speed and direction of rotation [18]. To ensure safe operation, the ESC monitors motor speed and current draw, staying within predefined limits. It also incorporates protective features like overcurrent protection, thermal protection, and voltage cutoff to prevent damage to the motor, ESC, or battery. Additionally, the ESC communicates bidirectionally with the flight controller, providing feedback on motor performance while receiving updated speed commands. This allows for closed-loop control, ensuring precise motor speed regulation and responsive throttle performance during flight. Figure 8 shows the Electronics speed controller.

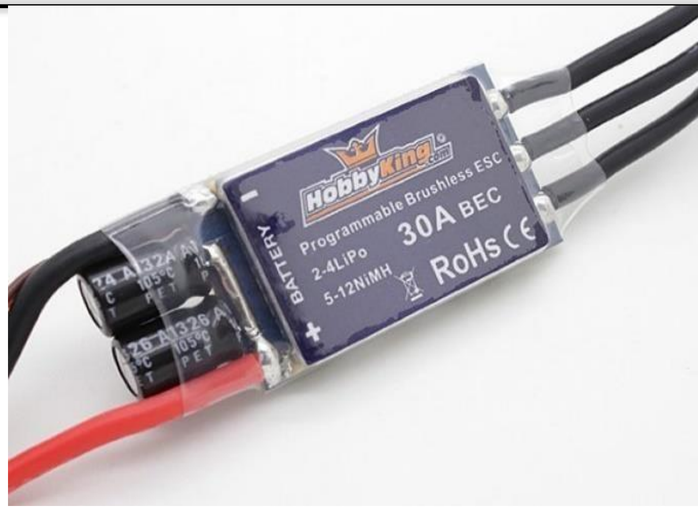

Figure 8: Electronic Speed Controller

4.1.4- BRUSHLESS MOTORS:

Brushless motors are advanced electric motors which have their application as much in drones, RC aircraft, electric vehicles and industrial applications. They are unlike other brushed motors, eradication of physical brushes and commutations results in higher efficiency, reliability, and performance. Brushless motors are key propulsion components used in drones where electronic commutation is used to finely control the timing of current flow to windings of the motor. In this process the position of the rotor is sensed using Hall Effect sensors or back electromotive force (EMF) feedback to energize the motor's three phase windings sequentially to create a rotating magnetic field. The rotor spins and smooth, continuous rotation is provided by sequential energizing of motor phases by the ESC. Brushless motors give way over brushed motors through better power to weight ratio, smoother operation, higher efficiency and also reduced maintenance. The efficiency, weight and reliability requirements of aerial drones make these attributes suitable for such applications. Being electronic controlled, with high power density in a compact volume and low maintenance needs, brushless motors are the reliable and agile flight performers for most modern electric propulsion systems.

4.1.5- A 3S LIPO (LITHIUM POLYMER) BATTERY:

A rechargeable battery commonly found in drones, remote controlled car toys and other electronic devices. A 3S battery pack is named as such because it contains a number of cells connected in series (S) with each cell in the pack having a nominal cell voltage of 3.7 volts, thus giving the total nominal voltage of the pack a value of 11.1 volts. Each cell of the 3S LiPo battery pack is lithium polymer and nominal 3.7 volts per individual cell. On the other hand, a 3S pack has a total nominal voltage of 11.1 volts because when 3 cells are connected in series, their voltages are additive. Batteries with higher capacity allow for longer operating times before they have to be recharged again. The chargers for LiPo batteries are specially designed to safely charge lithium polymer cells. In order to protect the battery from damage, and prevent unsafe operation, it is important to have proper charging procedure, which includes: setting proper voltage and current limits, balance each cell to its desired voltages, and monitor the charging process. During use, the battery's stored energy is discharged to power the electronic device it is connected to. It is important to monitor the battery's voltage during discharge to prevent over-discharging, which can damage the cells and reduce the battery's lifespan. LiPo batteries should be stored at a partial state of charge (around 50% of capacity) in a cool, dry place to maximize their lifespan [19]. Proper storage helps prevent selfdischarge and minimizes the risk of damage due to temperature extremes.

4.1.6- MECHANICAL GRIPPER:

Mechanical Gripper is a device that provides capability of grasping, holding and manipulating the objects in various applications like in Robotics, Automation, Manufacturing and Material Handling. In the case of drones, mechanical gripper is frequently used as payload attachment for the tasks like object retrieval, delivery and manipulation. Gripping mechanism: Two or more jaws move relatively to each other for opening and closing around the object to be grasped. Serrated on textured surfaces may be present on the jaws to enhance the grip. Actuators are those which provide for a mechanical force that opens and closes the gripper jaws. Examples of different kinds of an actuators may be an electric motor, pneumatic cylinder, hydraulic piston or a servo motor. Structure: It is a structural support that comes with an actuator, jaws and related mechanism. It is typically mounted to the drone's payload attachment system. Control System: The control system interfaces with the drone's flight controller and operator input to command the gripper's operation, including opening, closing, and releasing objects. It may include sensors for detecting object presence, grip force, and position feedback.

4.2- SOFTWARE SELECTION:

An open source ground control station (GCS) software used for configuring, planning. Plane, Copter and Rover have a ground control station named as Mission Planner. it can be used in configuration utility or supplementary a dynamic control when flying with the autonomous vehicle, it can work with Windows only. it has several important features in planning, execution and watching drone mission.it is mainly to help plan, execute and observe a drone mission. It is an Open Source versatile and powerful ground control station (GCS) Software that is capable of composing, planning and tracking missions of autonomous vehicles such as drones, aeroplanes, copters, rovers, etc. Mission Planner allows users to configure different parameters and settings of their autonomous vehicles. Setting up flight modes, tuning PID Controllers, calibrating sensors, configuring telemetry options is included as well. Users can plan missions using a Mission Planner with intuitive interface. In order to create waypoints, choose flight paths, set altitude and speed parameters, follow mission specific actions like camera triggers or payload drops, etc. During mission execution, mission planner serves as a dynamic control supplement for autonomous vehicles that executes the plans generated within the context of waypoints, interactive constrictions and linear planning. It sends commands to the vehicle according to how the mission is planned, that is to say, controls its flight behavior, navigation and the payload operations in real time. Monitoring: During mission execution, Mission Planner provides real-time telemetry data and status updates from the vehicle. This includes information such as GPS position, altitude, battery voltage, attitude, and sensor readings. Users can monitor the vehicle's performance and make adjustments as needed. Data Analysis: Mission Planner allows users to log and analyze mission data postflight [20]. This includes reviewing telemetry logs, plotting flight paths, analyzing sensor data, and assessing mission outcomes for performance evaluation and optimization. Compatibility: Mission Planner is compatible with Windows operating systems only. It supports a wide range of autonomous vehicle platforms, including ArduPilot-based drones, Pixhawk-based UAVs, and other MAV Link-compatible systems. Mission Planner plays a crucial role in the planning, execution, and monitoring of drone missions, offering users a comprehensive and user-friendly interface for configuring, controlling, and analyzing autonomous vehicle operations. Figure 9 shows the software operation images.

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Figure 9: Some software operation images.

5- Results:

The smart VTOL drone has culminated in a highly functional and efficient system. The motorized drone is operated with precision, offering a wide range of applications within the defence engineering industry, medical and education and rescue missions. It meets the necessary standards for performance and reliability. The vtol drone is adept at handling average loads, making it an excellent choice for various tasks. Its simplicity of operation and minimal maintenance requirements make it a user-friendly solution. In its current configuration. While it's important to acknowledge the relatively higher initial cost of development, the low operating costs and the potential for further enhancements make it an attractive investment. This drone is ripe for modifications that can further improve its operational efficiency, expanding its potential applications. Therefore, we recommend the adoption of this vtol drone technology within the army and rescue departments for commercial production. Its versatility, efficiency, and room for growth make it a valuable addition.

Since the hybrid VTOL has been designed for payload deliveries for local communities in distress during emergencies, a study detailing the typical conditions of such a mission has been formulated and flight tested. The experiment was designed and conducted. The experimental mission profile proposed is shown in the figure 10.

The mission profile consists of six steps

VTOL take off

Forward Transition

Forward Cruise Flight

VTOL transition

Loiter and Payload Drop

6. VTOL Landing

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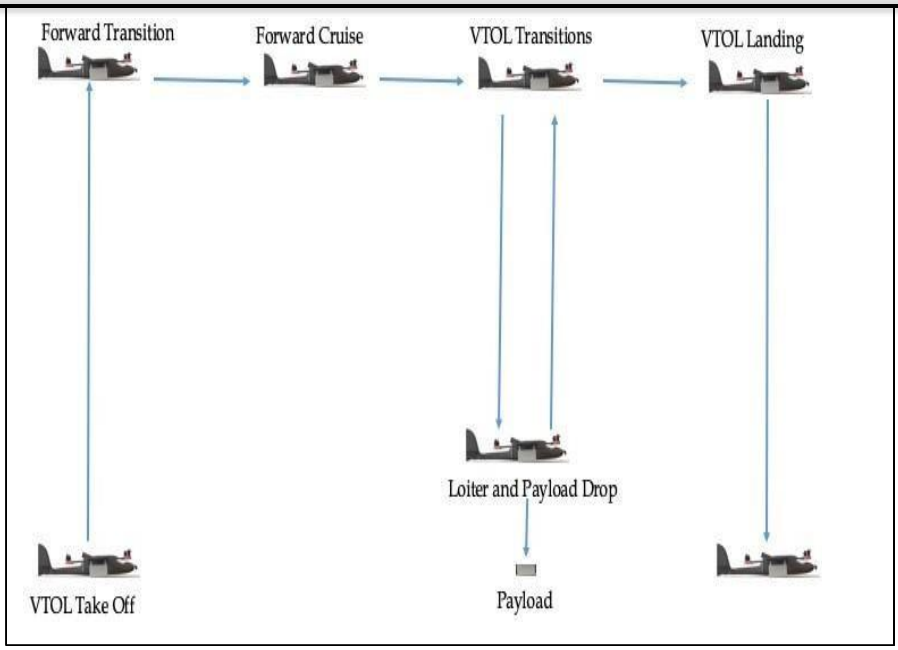

Figure 10: Mission Profile planned for the experiment

VTOL take off or simply vertical take-off is the first mode where the plane takes off vertically with the help of quad motors to a specific height. Then the plane goes into forward transition mode, where the tractor motors are engaged by the flight controller. The plane then flies in an assisted mode till it reaches its transition velocity, after which the plane switches to forward cruise flight. The plane continues to fly in cruise mode till the payload drop location is reached. As the plane approaches the drop location it under goes a transition from forward cruise to VTOL mode where the quad motors are reengaged and the plane now has the ability to vertically hover or loiter. Depending on the payload package the plane either descends to the ground for the package delivery or drops it from a specific predetermined altitude. After the payload drop the plane again ascends to the cruise altitude and undergoes transition to forward cruise flight. At this point the plane can return to the launch position or it can continue in its forward path depending on the mission. Once it reaches the designated landing location, the plane again undergoes transition to VTOL mode and vertical lands with the help of quad motors. The distance we can fly a drone depends on its battery life. And transmission remotely and telemetry technology 1km to 6 km using telemetry technology and cargo load carry range depends on thrust .it can carry small packages or light weight equipment around 1 to 5kg. Figure 11 Shows the image of smart VTOL Drone.

Figure 11: DRONE IMAGS

6- Future Work:

While the Smart VTOL Drone project has achieved significant milestones in the design and development of a versatile aerial platform for rescue and military operations, there are several avenues for future research and improvement. The following outlines potential directions for future work to enhance the capabilities, performance, and applicability of VTOL drones in various operational scenarios:

6.1- Autonomous Navigation and AI Integration:

Further research into advanced artificial intelligence (AI) algorithms for autonomous navigation, obstacle detection and avoidance, and adaptive decision-making.

Integration of machine learning techniques to enhance the drone's ability to learn from past missions, adapt to changing environments, and optimize mission planning and execution in real-time.

6.2- Sensing and Perception:

Exploration of advanced sensor technologies, including radar, and multispectral imaging, to enhance the drone's situational awareness and perception capabilities.

Integration of computer vision algorithms for object detection, classification, and tracking, enabling the drone to identify and respond to dynamic environmental conditions and mission objectives.

6.3- Payload Integration and Versatility:

Research and development of modular payload systems to accommodate a wider range of mission-specific equipment, sensors, and tools, such as medical supplies, communication relays, and environmental monitoring devices.

Integration of swappable payload modules for rapid reconfiguration and adaptation to diverse mission requirements, including search and rescue, surveillance, reconnaissance, and payload delivery.

6.4- Energy Efficiency and Endurance:

Investigation of advanced energy storage systems, including fuel cells, hybrid powertrains, and high-energy-density batteries, to extend the drone's endurance and operational range.

Development of energy-efficient propulsion systems and aerodynamic designs to optimize flight efficiency and reduce power consumption during hover, transition, and cruise phases.

6.5- Human-Machine Interaction and User Interface:

Design and implementation of intuitive user interfaces and ground control stations for enhanced human-machine interaction, mission planning, and real-time monitoring.

Incorporation of augmented reality (AR) and virtual reality (VR) technologies to provide operators with immersive situational awareness and enhanced decision-making capabilities during mission execution.

6.6- Interoperability and Multi-Domain Integration:

Investigation of interoperability standards and protocols to facilitate seamless integration with existing command and control systems, aerial platforms, and ground-based assets.

Research into multi-domain mission planning and coordination strategies to enable collaborative operations between VTOL drones, manned aircraft, ground vehicles, and personnel in dynamic and contested environments.

7- Conclusion:

In conclusion, the design and development of the Smart VTOL Drone for rescue and military operations represent a significant advancement in UAV technology, offering a versatile and efficient aerial platform tailored to meet the demanding requirements of modern-day missions. Throughout this project, we have meticulously addressed key challenges and objectives, leveraging advancements in aerodynamics, propulsion systems, autonomous navigation, payload integration, and communication technology. The culmination of our efforts is a state-of-the-art aerial platform that excels in agility, versatility, and reliability. The Smart VTOL Drone's ability to seamlessly transition between vertical and horizontal flight modes, coupled with its modular payload capabilities and advanced navigation algorithms, positions it as a valuable asset in a wide range of applications, including search and rescue missions, disaster response operations, reconnaissance missions, surveillance, and tactical support in military operations. Our comprehensive testing and validation procedures have demonstrated the efficacy and robustness of the Smart VTOL Drone under various environmental conditions and mission scenarios. The integration of safety features, redundancy mechanisms, and interoperability with existing command and control systems further enhances its operational reliability and effectiveness. Moving forward, continued research and development efforts will be essential to further enhance the capabilities and performance of the Smart VTOL Drone. This includes exploring advancements in materials science, sensor technology, artificial intelligence, and energy storage systems to improve efficiency, autonomy, and mission endurance. Additionally, ongoing collaboration with emergency responders, military personnel, and other stakeholders will be crucial to ensure that the Smart VTOL Drone meets the evolving needs and requirements of endusers. In conclusion, the Smart VTOL Drone represents a significant step forward in UAV technology, offering enhanced mission capabilities, operational efficiency, and safety in rescue and military operations. By leveraging cutting-edge technology and fostering collaboration and innovation, we can continue to push the boundaries of what is possible in aerial mobility and make a meaningful impact on the world.

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