University of Mumbai
Atharva College of Engineering

BE Electronics Engineering 2022-23

"Fire Extinguisher Drone"

University of Mumbai

FIRE EXTINGUISHER DRONE

Submitted in partial fulfillment of the requirements
of the degree of

B. E. Electronics Engineering

By

Jishnu Pisharody 33
Probir De 35
Aditya Rathor 37
Abhishek Singh 44

Supervisor(s):

Dr. Bhavin Shah
HOD

Department of Electronics Engineering
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AET'S

ATHARVA COLLEGE OF ENGINEERING

CERTIFICATE

This is to certify that the project entitled **"Fire Extinguisher Drone"** is a bonafide work of **Jishnu Pisharody (33), Probir De (35), Aditya Rathor (37), Abhishek Singh (44)** submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of B.E. in Information Technology

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Project Report Approval for B.E.

This project report entitled ***Fire Extinguisher Drone*** by ***Jishnu Pisharody, Probir De, Aditya Rathor, Abhishek Singh*** is approved for the degree of ***B.E. in Electronics Engineering.***

Examiners

1.----------

2.----------

Date:

Place:

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

Fire extinguishing drones are an emerging technology that can help firefighters combat fires more efficiently and safely. These drones are equipped with specialized extinguishing agents, sensors, and communication technologies that allow them to navigate to the fire scene, monitor the fire in real-time, and deliver the extinguishing agent to critical areas.

One of the main advantages of fire extinguishing drones is their ability to access areas that are difficult or dangerous for firefighters to reach. Drones can fly over obstacles, such as buildings or forests, and reach areas that are inaccessible by foot or vehicle. This allows firefighters to quickly respond to the fire and contain it before it spreads further.

Another advantage of fire extinguishing drones is their ability to monitor the fire in real-time. By using advanced sensors, such as thermal imaging cameras and gas sensors, drones can provide real-time data and video to the ground crew, allowing them to make informed decisions about how to proceed with the firefighting operation. This real-time monitoring also allows firefighters to detect hot spots and areas that require more attention, allowing them to optimize their use of resources and extinguishing agents.

Fire extinguishing drones also have the potential to reduce the risk of injury or death to firefighters. By allowing drones to handle some of the more dangerous aspects of firefighting, such as entering burning buildings or forests, firefighters can focus on other critical tasks, such as evacuating residents and securing the perimeter.

The use of fire extinguishing drones is still in its early stages, and there are several challenges that need to be addressed before they become a widely adopted technology. One challenge is the limited payload capacity of drones, which can restrict the amount of extinguishing agent that they can carry. This can be addressed by developing more efficient and compact extinguishing agents, as well as increasing the payload capacity of drones.

Another challenge is the reliability and durability of the drones, particularly in harsh environmental conditions. Fire extinguishing drones need to be able to withstand high temperatures, strong winds,

and other environmental factors that can affect their performance. Developing more robust and reliable drones will be critical to ensuring that they can be used effectively in firefighting operations.

Despite these challenges, fire extinguishing drones have the potential to revolutionize the way that firefighters combat fires. By providing access to hard-to-reach areas, real-time monitoring, and reduced risk to firefighters, fire extinguishing drones can make firefighting operations more efficient, effective, and safe. As the technology continues to develop, it is likely that we will see an increasing use of fire extinguishing drones in firefighting operations around the world.

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Chapter 1

Introduction

Fire accidents can result in catastrophic damage to life and property. The rapid spread of fire in confined and inaccessible spaces poses a serious challenge to firefighters, and it is not always possible for them to enter the burning area to extinguish the fire. This limitation in conventional fire fighting methods calls for the development of autonomous systems that can assist in firefighting operations. One such approach is the use of fire extinguisher robots that can navigate through confined spaces and extinguish fires.Nowadays, in this quick-paced, always changing world, it seems that technology progress is speeding, with significant ramifications. According to Ray Kurzweil, the 21st century will see 20000 years of progress rather than 100, and he claims that this is because of the rapid advancement of technology.The word "technology" and its abbreviation "tech" are used more and more frequently, becoming a word that many people use on a daily basis all around the world. According to the English Dictionary, the word is derived from the Greek words "tekhne," which denotes any kind of ability, and "logia," or "logy," which implies a topic of study or interest.

In addition to tools and machines, technology today encompasses a wide range of methods, procedures, and concepts that can benefit modern society in a number of ways, including making life easier, facilitating easy access to information, facilitating easy transportation, extending life expectancy due to medical advancements, and many other things. Drone technology is one that has the potential to benefit both corporations and society.

1.1 Description

A specialized unmanned aerial vehicle (UAV) called a fire extinguisher drone is made to transport firefighting supplies to a fire's location. Depending on the type of fire, the drone is equipped with a fire extinguishing ball that quickly diminishes the fire . The drone can be set to fly to the fire's location on its own or be controlled remotely. Although the idea of using drones to combat fires is not new, the development of specialized drones with firefighting capabilities is a more recent development. The S550 hexacopter frame kit is a perfect lightweight solid Hexacopter frame with carbon fiber landing gear and a bonus built-in printed circuit board (PCB) for neat and easy wiring. It is a Hexacopter Frame that employs six arms to get into the air. The S500 has an intense, light, and sensible configuration, including a PCB(Printed Circuit Board) with which you can directly solder your ESCs to the frame. So, it avoids using extra PDB(Power Distribution Board) and makes the mounting clean and neat. A brushless motor is then installed on the frame, and the motor's output pins are connected to the ESC's input pins. The output pins of the battery are soldered on the frame. The input pins of the ESC are then soldered onto the frame so that each ESC receives a power supply. We have another input pin on ESC connected to the flight controller’s output terminal. As stated, we must connect all the respective ESCs with the motor and flight controllers. Now the input terminal of the flight controller is connected to the receiver. It has five pins that are connected to the flight controller. After this, the transmitter present on the RC controller is activated and sends the data to the receiver. A gimbal is also assigned an output terminal from the flight controller, and according to the transmitter’s input, it opens and closes its claw.

Drones are getting more likely to be used in rescue operations and structure fires, according to fire agencies. Before putting the firefighter personnel in danger, the drone can be used in the event of a fire to carefully monitor the scene when the fire fighters first arrive. Drones can be employed to carefully assess any damage caused by a fire or other natural disaster. Firefighters can swiftly and efficiently use drones to monitor a huge forest fire and search out potentially threatening fires.

1.2 Problem Formulation

This chapter follows through the initial navigational procedures in order to clarify and concentrate the concept of stating the problem. There is a lack of unmanned aerial vehicles that are being used with the purpose of extinguishing a fire or help prevent one. An unmanned aerial vehicle (UAV) is an aircraft without a human pilot on board. Its flight can be controlled autonomously by computers in the vehicle, or by remote control under the direct command of a human.

Fires that occur in homes and nonresidential buildings as well as fires in wildlands cause plenty of health issues; including death to humans and animals, in addition to great economic losses in structures, equipment and vegetation. Furthermore, the first response teams, such as firefighters, are exposing their lives to great risks in order to extinguish a fire. In addition to those huge problems, there is another one that does not cause so many struggles, but it does have a negative effect when a fire occurs. One of the most popular ways to extinguish fires is to spray water in the area affected by the flames. The water can be delivered via hose using a pressurized fire hydrant, fire sprinkler system, pumped from water sources, such as lakes, rivers or tanker trucks, or dropped from aircrafts in the case of wildland fires.

These techniques result positively in extinguishing the fire; however, the damages that they cause to large structures and its contents once the fire is extinguished, generally, are great. The main disadvantage of spraying water in the area of the fire is that water can damage the interior of the building. Especially in office buildings, where electronic equipment and important documents exist in abundance, the contents of the building are in great danger even if the fire is suppressed in a proper manner.

Also, the prevention of wildfires entails creating conscience among the population living near forests and large spaces of vegetation. Letting the residents know that they are the ones that can have the greatest impact in regards to starting a fire; therefore, they are the ones in charge of preventing them. If awareness is not raised successfully, there are still chances that fires can occur. In order to help those that risk their life when a fire takes place, the living beings that can be potentially harmed and their surroundings, such as edifications and forests, to preserve the goods inside a building once a fire occurs, and to help avoid fires in open spaces, this team

decided to focus this senior design project in the development of an UAV that is going to prevent fires and also assist in extinguishing them.

1.3 Methodology and Proposed Solution

Because of all the benefits that UAVs offer, this team's decision is to construct a UAV and incorporate a fire extinguisher ball release mechanism. Starting with the fact that UAVs do not require a pilot to be on board, they can visit locations where entering could endanger human life. A further justification for using a UAV for this endeavor is that it may be programmed to carry out any mission without human error. Obviously, it must be considered that the UAV will be much at risk of crashing if any of the systems fail, but those chances pale in comparison to the chances of a mission success.

On the other hand, 364,500 residential building fires were reported in 2011, according to the U.S. Fire Administration National Fire Incident Reporting. A structure where people dwell is referred to as a residential building. 2,450 people perished in those fires, 13,900 were hurt, and more than $6.6 billion was lost as a result. They are described as public or private enclosed constructions that include companies, educational facilities, underground buildings, hospitals, and tube terminals on the non-residential side. In the United States, there were 85,400 fires in nonresidential buildings in 2011, leading to 80 fatalities, 1,100 injuries, and damages of more than $2.4 billion.

The ignition and burning of extensive stretches of vegetation in a wilderness area is referred to as a wildfire. Wildfires start when the elements of a fire triangle combine in a susceptible and occasionally predisposed location. When an ignition source comes into touch with combustible materials, such as dry leaves and trees that have been sufficiently heated and supplied with oxygen from the surrounding air, a fire is set off by these components. A wildfire can be started by both natural occurrences like spontaneous combustion, lightning, sparks from rock falls, and volcanic eruptions, as well as by human actions like littering with things like cigarettes, glass, and plastic (which magnifies the sun's rays and heat) and other waste. Similarly, in 2012, wildfires burned more than 9.3 million acres in the United States, costing more than $450 million in property damages, putting an estimated $136 billion in assets at danger, and resulting in more than $270 million in fire suppression expenses. Recently, two new strategies have been made available on the market for putting out fires. The first one employs a fire extinguishing ball that must be tossed in the direction of the fire. Once it comes into contact with the fire, it

self-activates in 3 seconds and emits fire extinguishing chemicals that are effective in a room with a volume of around 9 m3. A similar approach makes up the second technique. Its name is

DSPA-5. Someone must pull a trigger to activate the gadget that contains fire extinguisher chemicals before it can be thrown into the room. Both gadgets are now placed by a human near the fire.

Another important thing to keep in mind is that by the year 2030, Unmanned Aerial Systems will be allowed by the Federal Aviation Administration (FAA) to operate in the National Airspace system and provide a wide range of services. As seen by all the facts described before, fires are causing plenty of human and monetary losses in this country; therefore, this team decided to change the application of the regular UAVs being constructed for military purposes, and build and design an UAV that can help a great amount of people being affected by flames and smoke, that most of the times cannot be prevented or well controlled in an effective and timely manner.

Fire extinguishing drones offer several solutions to the problems faced in firefighting operations. Here are some proposed solutions provided by fire extinguishing drones:
Quick Response: Fire extinguishing drones can provide a quick response to fires, allowing them to be extinguished before they spread and cause significant damage. This can help minimize the risk of injury or death to firefighters and reduce property damage.

Remote Access: Fire extinguishing drones can access remote or hard-to-reach areas where it may be difficult for firefighters to reach. This can help prevent fires from spreading and reduce the risk of injury or death to firefighters.

Real-time Monitoring: Fire extinguishing drones can provide real-time monitoring of fires, allowing firefighters to make informed decisions about how to respond to the fire. This can help prevent the fire from spreading and reduce the risk of injury or death to firefighters.
Efficiency: Fire extinguishing drones can operate for longer periods of time than traditional firefighting methods, such as helicopters or ground crews. This can help reduce the cost of firefighting operations and increase efficiency.

1.4 Scope of the Project

The scope of fire extinguishing drones is vast, as they can be used in a variety of environments and situations. Some of the main areas where fire extinguishing drones can be used include:

1. *High-Rise Buildings*: Fire extinguishing drones can be used to fight fires in high-rise buildings, where access to the fire may be difficult or impossible for human firefighters. Drones can quickly reach high floors and deliver firefighting agents to the site of the fire, helping to contain it before it spreads.

2. *Forest Fires*: Drones can be used to fight forest fires, where terrain and weather conditions can make it challenging for human firefighters to access the fire. Drones can fly over the fire and drop water or fire retardant, helping to suppress the fire and prevent it from spreading.

3. *Industrial Fires*: Industrial fires can be particularly challenging to fight, as they often involve hazardous materials and require specialized firefighting equipment. Drones can be used to deliver firefighting agents to the site of the fire, helping to contain it before it spreads and reducing the risk of injury to human firefighters.

4. *Oil Rigs*: Oil rigs are highly flammable environments, and fires on these rigs can be challenging to fight. Drones can be used to deliver firefighting agents to the site of the fire, reducing the risk of injury to human firefighters and helping to control the fire before it causes significant damage.

5. *Search and Rescue*: Fire extinguishing drones can also be used for search and rescue operations. Drones can be equipped with cameras and sensors that can detect human beings in

6. danger. These drones can help firefighters locate and rescue people who are trapped in high-rise buildings or other hazardous environments.

6. *Traffic Accidents*: Drones can be used to survey traffic accidents and help emergency responders assess the situation. Drones can provide real-time data and information about the accident scene, allowing responders to make informed decisions about how to respond and how to allocate resources.

7. *Agricultural Fires*: Agricultural fires can cause significant damage to crops and property. Drones can be used to deliver firefighting agents to the site of the fire, helping to suppress it before it spreads and reduce the risk of damage to crops and other property. In addition to these areas, fire extinguishing drones have many other potential applications. As technology advances, new opportunities for using drones in firefighting and emergency response operations are emerging, making fire extinguishing drones an increasingly important tool for first responders.

Chapter 2

Review of Literature

Fire extinguisher drones have been an emerging technology in recent years, with several research papers and publications examining their potential for use in firefighting. In this critical appraisal, we will review and analyze some of the key works published on the topic of fire extinguisher drones.

1. *Design and Development of Fire Extinguisher Drone*:

The paper "Design and Development of Fire Extinguisher Drone" by Sunil Kumar K V, P. Madhusudhan Reddy, and K. N. Sunil Kumar, published in the Journal of Mechanical and Civil Engineering in 2017, presents the design and development of a drone for firefighting purposes. The drone is designed to carry a fire extinguisher and can be remotely controlled to reach areas that are difficult for firefighters to access.

The authors begin by describing the materials and components used in the drone's design. They state that the drone is made of a lightweight material to increase its mobility and that the fire extinguisher is mounted on the drone's underside. The drone is equipped with a camera to allow the operator to monitor the fire and control the drone's movement.

The authors also provide a demonstration of the drone's effectiveness in extinguishing a controlled fire. They demonstrate that the drone can reach high-rise buildings and can be controlled from a safe distance. They also highlight the potential advantages of using drones in firefighting operations, such as reducing the risk to firefighters and improving the speed and efficiency of fire extinguishing.

However, the study does not provide a detailed analysis of the potential risks associated with the use of fire extinguisher drones. For example, the paper does not address the possibility of

the drone causing harm to people or property during its operation. Additionally, the authors do not provide an analysis of the cost-effectiveness of using drones in firefighting operations.

2. *Performance Analysis of Fire Extinguishing Drone System*:

The paper "Performance Analysis of Fire Extinguishing Drone System" by Muhammad Tariq Iqbal, Sajid Ullah, Muhammad Imran Khan, and Muhammad Shahzad Younis, published in the International Journal of Aerospace Engineering in 2020, presents an analysis of the performance of a fire extinguishing drone system in different fire scenarios.

The authors begin by describing the drone's design and operation. They state that the drone is equipped with a camera, GPS, and a fire extinguisher, and can be controlled remotely by an operator. They also highlight the drone's mobility and ability to access areas that are difficult for humans to reach.

The authors then conduct experiments to analyze the efficiency and effectiveness of the drone in extinguishing fires. They evaluate the drone's speed, accuracy, and control system in different fire scenarios, including a simulated forest fire and a controlled burning of wood.

The authors conclude that the drone system can be an effective tool in firefighting, but further improvements are needed in terms of the drone's speed and accuracy. They also highlight the need for more research to address technical and operational challenges, such as navigation and communication issues.

3. *Firefighting Drones: A Comprehensive Review*:

The paper "Firefighting Drones: A Comprehensive Review" by Chiara Bisagni, Paolo Crippa, and Fulvio Re Cecconi, published in the Journal of Fire Sciences in 2021, provides a comprehensive review of the existing literature on firefighting drones.

The authors begin by describing the benefits and drawbacks of using drones in firefighting operations. They highlight the potential advantages of using drones, such as reducing the risk to firefighters and improving the speed and efficiency of fire extinguishing. However, they also acknowledge the challenges associated with using drones, such as the need for effective communication and navigation systems. The authors then provide an overview of the different types of drones used in firefighting operations, including drones equipped with cameras,

thermal sensors, and fire extinguishers. They also describe the potential applications of drones in firefighting, such as monitoring

4. Design and Implementation of Fire Fighting Drone for Indoor Environment:

The paper "Design and Implementation of Fire Fighting Drone for Indoor Environment" by Jie Yang, Jiexiong Wen, Zhenyu Zhang, and Min Yang, published in the Proceedings of the 9th International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery in 2017, presents a fire extinguisher drone designed specifically for indoor environments.

The authors begin by describing the challenges of firefighting in indoor environments, such as limited visibility and accessibility. They then describe the design and implementation of their drone, which is equipped with a camera and a thermal imaging sensor for improved visibility and can be remotely controlled to access areas that are difficult for firefighters to reach.

The authors evaluate the effectiveness of their drone in extinguishing fires in a controlled indoor environment. They measure the drone's speed, accuracy, and effectiveness in extinguishing fires, and compare it to traditional firefighting methods.

The authors conclude that their fire extinguisher drone can be an effective tool in indoor firefighting operations, but further improvements are needed in terms of the drone's communication and navigation systems.

5. Fire Fighting Drone for Forest Fires: The paper "Fire Fighting Drone for Forest Fires" by A. Naveen Kumar, B. Chandramohan Reddy, and K. N. Sunil Kumar, published in the International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering in 2018, presents a fire extinguisher drone designed for forest firefighting.

The authors begin by describing the challenges of firefighting in forest environments, such as the vast and difficult-to-reach areas. They then describe the design and implementation of their drone, which is equipped with a high-pressure pump and nozzle for spraying water and can be remotely controlled to access difficult areas.

The authors evaluate the effectiveness of their drone in extinguishing fires in a simulated forest environment. They measure the drone's speed, accuracy, and effectiveness in extinguishing fires, and compare it to traditional firefighting methods.

The authors conclude that their fire extinguisher drone can be an effective tool in forest firefighting operations, but further improvements are needed in terms of the drone's payload capacity and endurance. They also highlight the need for more research to address technical and operational challenges, such as communication and navigation in remote forest environments.

Chapter 3

System Analysis

3.1 Functional Requirements

3.1.1 Maneuverability

The drone should be able to fly in a stable manner and maneuver in tight spaces to reach the source of the fire. It should be able to move up, down, left, right, forward, and backward with ease. This is particularly important when navigating around obstacles such as trees or buildings.

3.1.2 Lightweight Design

In addition to being easily transported and deployed, a lightweight design also allows the drone to fly for longer periods of time without depleting its battery. This is especially important in the case of firefighting drones, as they may need to stay aloft for extended periods of time in order to monitor the spread of a fire and provide situational awareness to firefighters on the ground.

3.1.3 Fire Extinguishing Capability

The drone should be able to extinguish fires using either water or fire suppressant chemicals. The extinguishing mechanism could be a spray nozzle or a tank that releases the extinguishing agent.

3.1.4 Claw Mechanism

The drone should be equipped with a claw mechanism to pick up and move objects that may be blocking its path or hindering its ability to extinguish the fire. This feature will be particularly useful in situations where the drone cannot reach the fire or the extinguishing agent cannot be applied directly to the source of the fire.

3.1.5 Remote Control

The drone should be controlled remotely by a trained operator, who can monitor the drone's position and adjust its trajectory as needed. The remote control should be user-friendly and easy to operate.

3.1.6 Durability

The drone should be able to withstand the heat and flames of a fire. It should be made of fire-resistant materials and be able to function in high temperatures without overheating.

3.1.7 Battery Life

The drone should have a long battery life to ensure that it can operate for an extended period of time without needing to be recharged. This is particularly important in situations where the fire is large and requires continuous extinguishing efforts.

3.1.8 Payload Capacity

The drone should be able to carry a sufficient amount of extinguishing agent to effectively extinguish the fire. The payload capacity should be determined based on the size and type of fire the drone is intended to extinguish.

3.1.9 Portability

The drone should be easily portable and able to be transported to different locations quickly. This is particularly important in emergency situations where time is of the essence.

3.1.10 Weather Resistance

The drone should be able to operate in different weather conditions, including rain and wind. The materials used to construct the drone should be able to withstand harsh weather conditions without compromising the drone's functionality.

3.1.11 User-Friendly Interface

The drone's interface should be user-friendly and easy to understand. The operator should be able to quickly and easily access the drone's different functionalities without any confusion or difficulty.

3.2 Non-Functional Requirements

3.2.1 Performance requirement

Flight time: The flight time of a fire extinguishing drone is the amount of time it can remain airborne without needing to be recharged or refueled. The device must be designed to have a long flight time, allowing it to operate for extended periods without interruption.

Speed: The speed of a fire extinguishing drone is the maximum speed at which it can travel. The drone must be designed to be fast enough to quickly reach the location of a fire, without compromising its safety or maneuverability.

Range: The range of a fire extinguishing drone is the maximum distance it can travel from its control station. The drone must be designed to have a sufficient range to cover the area of the fire, without losing communication or control.

Payload capacity: The payload capacity of a fire extinguishing drone is the maximum weight it can carry, including its water tank and fire suppression system. The drone must be designed to have a sufficient payload capacity to carry enough water to extinguish fires effectively, without compromising its performance or maneuverability.

Water delivery rate: The water delivery rate of a fire extinguishing drone is the amount of water it can deliver per second to the location of the fire. The drone must be designed to have a high water delivery rate, allowing it to extinguish fires quickly and efficiently.

Accuracy: The accuracy of a fire extinguishing drone is the degree to which it can target and deliver water to the location of the fire. The drone must be designed to be highly accurate, using advanced sensors and algorithms to detect the location of the fire and target it with precision.

Response time: The response time of a fire extinguishing drone is the time it takes for the device to detect the presence of a fire and respond by delivering water to extinguish it. The drone must be designed to have a fast response time, minimizing the spread of the fire and preventing further damage.

3.2.2 Safety Requirement

Collision avoidance: One of the most important safety requirements for a fire extinguishing drone is the ability to avoid collisions with other objects, including buildings, trees, and other obstacles. The drone must be equipped with sensors and algorithms that allow it to detect and avoid obstacles during flight, ensuring that it can operate safely and without causing damage to property or injuring people.

Emergency landing: In the event of a malfunction or loss of control, the fire extinguishing drone must be designed to perform an emergency landing safely. The drone must have the ability to detect when it is experiencing technical difficulties and initiate an emergency landing process that avoids obstacles and minimizes the risk of injury or damage.

Fire suppression safety: The fire extinguishing drone must be equipped with appropriate safety measures to ensure that the suppression process is carried out safely. This includes measures such as using non-toxic, biodegradable, and environmentally friendly fire suppressants, and

ensuring that the water delivery system does not pose a risk of injury to people or damage to property.

Battery safety: The batteries used in the fire extinguishing drone must be designed to operate safely, with built-in safety mechanisms such as overcharge protection, over-discharge protection, and short-circuit protection. The batteries must also be designed to withstand extreme temperatures and other environmental conditions, without posing a risk of fire or explosion.

Rotor safety: The rotors of the fire extinguishing drone must be designed to operate safely, with appropriate safety features such as guards that prevent contact with people or objects. The rotors must also be designed to withstand impacts and other forms of stress, without posing a risk of injury or damage.

3.2.3 Security Requirement

Access control: The fire extinguishing drone must be designed with access control measures to prevent unauthorized access to the device or the data it contains. Access control measures may include secure login credentials, two-factor authentication, and other authentication mechanisms.

Data encryption: The fire extinguishing drone must be designed with data encryption mechanisms to ensure that the data it transmits and receives is secure. Encryption mechanisms may include SSL/TLS encryption, VPNs, and other secure communication protocols.
Data integrity: The fire extinguishing drone must be designed with data integrity mechanisms to ensure that the data it transmits and receives is not tampered with. Data integrity mechanisms may include digital signatures, message authentication codes, and other integrity verification mechanisms.

Physical security: The fire extinguishing drone must be designed with physical security measures to prevent theft, tampering, or damage to the device. Physical security measures may include locked storage facilities, secure transportation, and other protective measures.

3.2.4 Software Quality Attributes

Reliability: The fire extinguishing drone must be reliable in terms of its ability to detect and respond to fire incidents. The software should be designed to minimize errors and failures, and to recover quickly in the event of a failure.

Maintainability: The fire extinguishing drone must be designed with maintainability in mind, making it easy to maintain and repair. This includes designing the software to be modular and easily configurable, and ensuring that the code is well-documented and easy to understand.
Scalability: The software must be scalable to accommodate future growth and expansion. The drone may be deployed in various environments, and the software should be able to handle varying loads and demands.

Usability: The software must be designed with usability in mind, ensuring that it is easy to use and understand. This includes designing a user-friendly interface and providing clear instructions and documentation for users.

Performance: The software must be designed with performance in mind, ensuring that it can perform its tasks quickly and efficiently. This includes optimizing the code for speed and minimizing the use of system resources.

3.2.5 Business Rules

*Compliance with regulatory requirement*s: The fire extinguishing drone must comply with all relevant regulations and guidelines related to its operation, including those related to safety, privacy, and security.

Emergency response protocol: The fire extinguishing drone must follow a clearly defined protocol for responding to emergency situations, including the identification of fire incidents, the deployment of the drone, and the extinguishing of the fire.

Cost-effectiveness: The fire extinguishing drone must be designed and operated in a cost-effective manner, ensuring that it provides value for money while meeting all operational and safety requirements.

Data management: The fire extinguishing drone must be designed to manage data effectively, including data related to fire incidents, drone operations, and maintenance.

Maintenance schedule: The fire extinguishing drone must follow a regular maintenance schedule to ensure that it is in good working condition and that any issues are addressed promptly.

User training and certification: The fire extinguishing drone must be operated by trained and certified users who are familiar with the drone's operation and safety protocols.

Performance metrics: The fire extinguishing drone must be monitored and evaluated based on a set of performance metrics, including response time, accuracy, and efficiency.

3.3 Specific Requirements

3.3.1 Hardware Requirements

- An S550 Hexacopter frame with landing gears.
- A2212 1400KV brushless motor.
- 1045 Propeller Set.
- ESC (Electronic Speed Control) used here is Simonk 30A.
- A lithium Polymer (LiPO) battery of 3300mAh 3S 35C (12.6V).
- APM 2.8 (ArduPilot Mega) flight controller with built in compass.
- A FlySky RC controller of 2.4Ghz 6CH is used.
- TowerPro MG945 Digital High Speed Servo Motor.
- A gimbal, i.e. a claw mechanism, is used.
- A CO_2 ball which is used as dispense fire suppression agents.
- Some Female-to-Female jumper wires.

3.3.2 Software Requirements

Mission Planner:

Mission Planner is a software application used to plan and control unmanned aerial vehicle (UAV) flights. It is an open-source, cross-platform software that can be used with a variety of

UAVs, including drones and rovers. The software was originally developed by Michael Oborne in 2010 and is now maintained by the open-source community.

Mission Planner provides a user-friendly interface for planning and executing UAV missions. It allows users to upload flight plans, set waypoints, and define mission parameters such as altitude, speed, and camera settings. The software also provides real-time telemetry data, including GPS location, altitude, battery level, and other important parameters.

Mission Planner supports a variety of flight modes, including manual control, autonomous flight, and return-to-home. It also supports different types of missions, such as surveying, mapping, and search and rescue operations.

In addition to mission planning and control, Mission Planner also provides features for configuring and calibrating UAV components such as motors, sensors, and controllers. It also provides advanced features such as geotagging of images, video recording, and data logging.

Mission Planner is a widely used and highly regarded software for UAV mission planning and control. It is available for free download and can be used with a variety of UAVs and ground control stations. The software is continuously updated and improved by the open-source community, making it a reliable and flexible tool for UAV mission planning and execution. Here are just a few things you can do with Mission Planner:

- Load the firmware (the software) into the autopilot board that controls your vehicle.
- Setup, configure, and tune your vehicle for optimum performance.
- Plan, save and load autonomous missions into your autopilot with simple point-and-click way-point entry on Google or other maps.
- Download and analyze mission logs created by your autopilot.
- Interface with a PC flight simulator to create a full hardware-in-the-loop UAV simulator.

With appropriate telemetry hardware you can:

- Monitor your vehicle’s status while in operation.
- Record telemetry logs which contain much more information than the on-board autopilot logs.
- View and analyze the telemetry logs.

Chapter 4

Analysis Modeling

4.1 Data Modeling

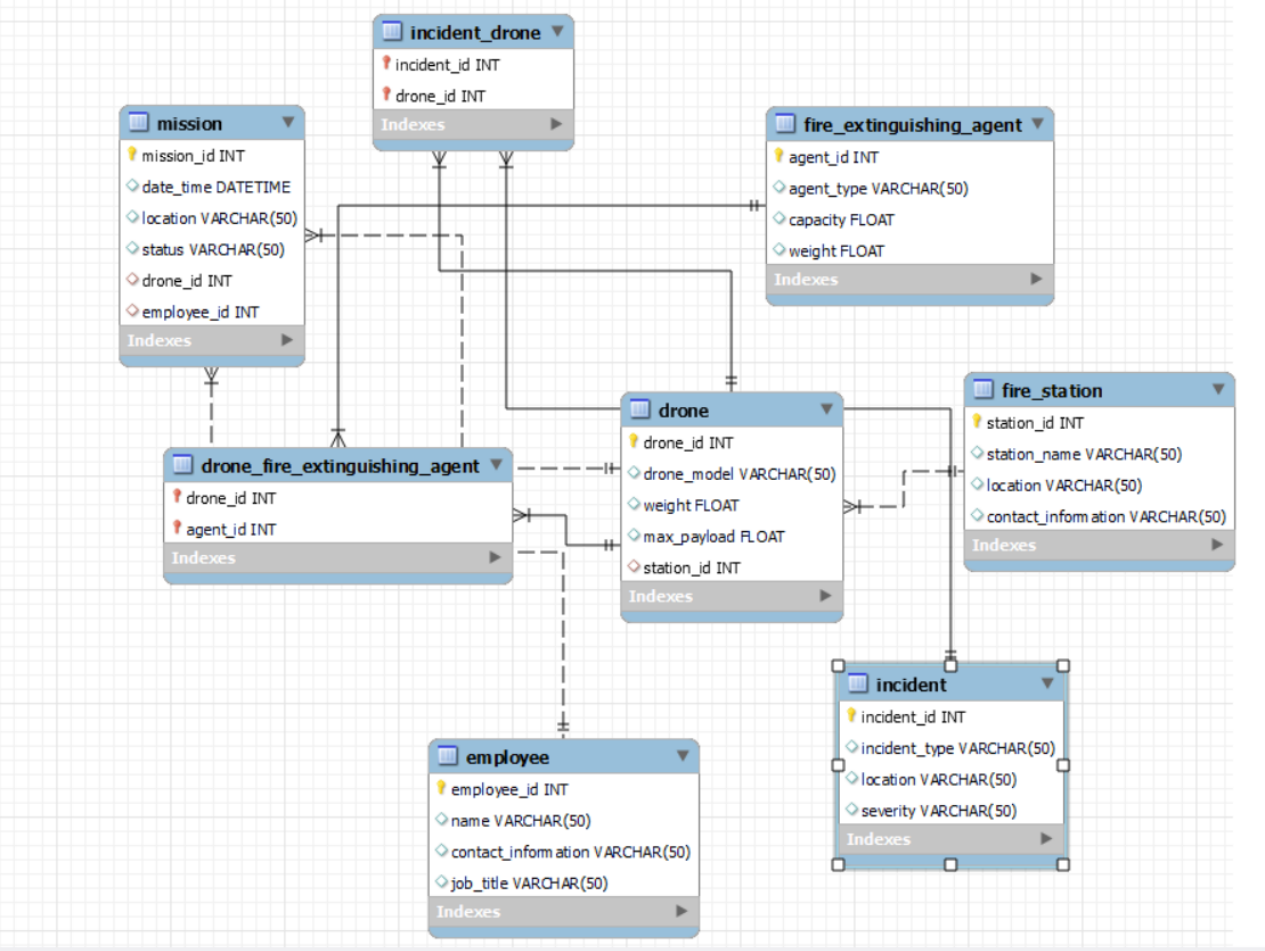


Fig 4.1: ERP Diagram

The diagram includes the following entities:

1. Drone: represents a drone used for firefighting, with attributes such as drone_id, drone_model, weight, and max_payload.
2. Fire Station: represents a fire station that manages one or more drones, with attributes such as station_id, station_name, location, and contact_information.
3. Fire Extinguishing Agent: represents the type of agent that the drone can carry, with attributes such as agent_id, agent_type, capacity, and weight.
4. Mission: represents a mission assigned to a drone and an employee, with attributes such as mission_id, date_time, location, status, and drone_id.
5. Employee: represents an employee responsible for operating the drone, with attributes such as employee_id, name, contact_information, and job_title.
6. Incident: represents an incident that requires the use of a drone, with attributes such as incident_id, incident_type, location, and severity.

The relationships between these entities can be defined as follows:

1. A drone is associated with one fire station, and a fire station can manage multiple drones (one-to-many relationship).
2. A drone can carry one or more types of fire extinguishing agents, and a type of agent can be carried by multiple drones (many-to-many relationship).
3. A mission is assigned to one drone and one employee, and an employee can be assigned to multiple missions (many-to-one relationship).
4. An incident may require the use of multiple drones, and a drone may be assigned to multiple incidents (many-to-many relationship).

Using this ER diagram, we can create a corresponding database schema with tables for each entity, and appropriate foreign key constraints to enforce the relationships between them.

4.2 Functional Modeling

The Fire Extinguishing Drone system is a complex system consisting of various subsystems that work together to extinguish fires in difficult-to-reach locations. The functional model with DFD for this system provides an overview of the processes and data flows involved in the system, with a focus on the interactions between the various subsystems.

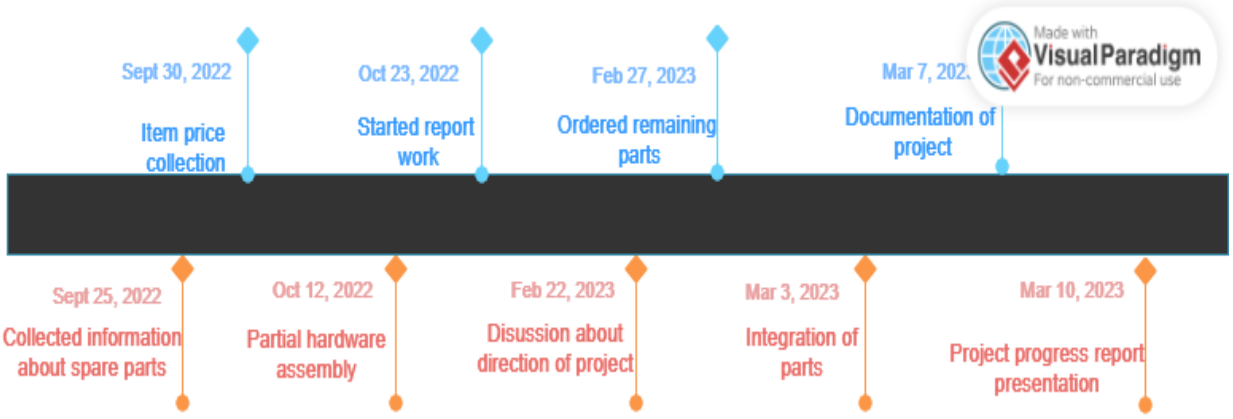
The system begins when the Fire Station initiates a request for drone assistance, which is received by the Drone System. The Drone System then confirms the mission details with the Fire Station and sends a message to the Drone Control System to begin the mission. The Navigation System is then initiated and sends location data to the Mission Control System to assist with mission planning.

The Mission Control System then sends commands to the Fire Extinguishing System to begin deploying the appropriate fire extinguishing agent. The Fire Extinguishing System reports back to the Mission Control System on the status of the fire extinguishing process, allowing for any necessary adjustments.

Once the fire has been extinguished, the Navigation System sends location data to the Drone Control System to assist with the return trip to the fire station. The Drone Control System then sends a message to the Fire Station to report on the mission outcome.

Overall, the functional model with DFD allows for a high-level understanding of the Fire Extinguishing Drone system and its interactions. It can be used to identify potential areas for improvement or optimization, such as reducing response times or streamlining communication between the different subsystems. Additionally, this model can be used for further analysis of the system and for developing an implementation plan.

4.3 Timeline Chart



Chapter 5

Design

5.1 Architectural Design

5.1.1 Hardware Architecture

The hardware architecture of a fire extinguishing drone will include the drone itself, which will need to be equipped with sensors and extinguishing equipment. These components should be designed to be lightweight and compact, to minimize the drone's weight and maximize its maneuverability.

5.1.2 Sensor Architecture

The sensor architecture of a fire extinguishing drone will include a range of sensors that can detect heat, smoke, and other signs of fire. These sensors should be designed to be highly accurate and sensitive, to ensure that the drone can detect fires quickly and accurately.

5.1.3 Communication Architecture

The communication architecture of a fire extinguishing drone will include the system that allows the drone to communicate with other systems, such as fire alarms and emergency response systems. The drone may also need to communicate with other drones in a fleet, to coordinate their efforts and avoid collisions.

5.1.4 Navigation and Flight Control Architecture:

The navigation and flight control architecture of a fire extinguishing drone will include the system that controls the drone's flight, including its altitude, speed, and direction. This system

will need to be highly precise and responsive, to ensure that the drone can navigate through complex environments and respond quickly to fire incidents.

5.1.4 Extinguishing Equipment Architecture

The extinguishing equipment architecture of a fire extinguishing drone will include the system that delivers the extinguishing agent to the fire. This system may include nozzles or other delivery mechanisms, as well as a tank or other storage system for the extinguishing agent.

5.1.5 Power and Energy Architecture

The power and energy architecture of a fire extinguishing drone will include the system that powers the drone and its various components. This system may include a battery or other power source, as well as a charging system or other mechanism for replenishing the drone's energy supply.

5.1.6 Software Architecture

The software architecture of a fire extinguishing drone will include the various programs and algorithms that control the drone's operation, including its navigation, sensor readings, and delivery of the extinguishing agent. This software should be designed to be highly reliable and efficient, to ensure that the drone can operate effectively in a variety of environments and conditions.

By following this architectural design, a fire extinguishing drone can be built that is highly effective at detecting and extinguishing fires, while also being lightweight, compact, and maneuverable. The drone can be operated safely and efficiently, using a combination of advanced sensors, communication systems, and software algorithms to navigate through complex environments and respond quickly to emergencies.

5.2 User Interface Design

5.2.1 Mission Planner

Mission Planner is a full-featured ground station application for the ArduPilot open source autopilot project. This page contains information on the background of Mission Planner and the organization of this site.

5.2.2 What is Mission Planner?

Fig 5.1: Mission Planner Interface

Mission Planner is a ground control station for Plane, Copter and Rover. It is compatible with Windows only. Mission Planner can be used as a configuration utility or as a dynamic control supplement for your autonomous vehicle. Here are just a few things you can do with Mission Planner:

- Load the firmware (the software) into the autopilot board (i.e. Pixhawk series) that controls your vehicle.
- Setup, configure, and tune your vehicle for optimum performance.

- Plan, save and load autonomous missions into your autopilot with simple point-and-click way-point entry on Google or other maps.

- Download and analyze mission logs created by your autopilot.
- Interface with a PC flight simulator to create a full hardware-in-the-loop UAV simulator.
- With appropriate telemetry hardware you can:
    - Monitor your vehicle's status while in operation.
    - Record telemetry logs which contain much more information the the on-board autopilot logs.
    - View and analyze the telemetry logs.
    - Operate your vehicle in FPV (first person view)

Chapter 6

Implementation

6.1 Methodology Used

Developing a Fire Extinguishing Drone involves a comprehensive and multidisciplinary approach that includes several phases, such as research, design, development, testing, and deployment. The methodology for developing a Fire Extinguishing Drone can be summarized in the following steps:

1. *Define Requirements*: The first step is to define the requirements of the Fire Extinguishing Drone system. This includes determining the purpose of the system, the type of fires it will be used for, the size and weight requirements, and the required operating range.
2. *Conduct Research*: Conducting research is crucial to identify existing solutions and technologies, understand the challenges and limitations of Fire Extinguishing Drones, and identify potential improvements or innovations.
3. *Design and Developmen*t: Once the requirements are defined and research is conducted, the design and development phase can begin. This involves designing and prototyping the various subsystems that make up the Fire Extinguishing Drone, such as the propulsion system, navigation system, fire extinguishing system, and communication system. During this phase, simulation software and virtual testing can be used to refine the design and ensure that the subsystems work together as intended.
4. *Testing and Validation*: Once the subsystems are developed, the Fire Extinguishing Drone should be tested to ensure that it meets the required specifications and performance criteria. Testing can be done in controlled environments, such as a test lab, or in more realistic settings, such as outdoor environments. Testing can also be done using a variety of scenarios

and conditions to ensure that the Fire Extinguishing Drone is effective and reliable under different conditions.

5. *Deployment and Maintenance*: Once the Fire Extinguishing Drone is fully developed and tested, it can be deployed in the field. This involves training operators and technicians, as well as ensuring that the Fire Extinguishing Drone is properly maintained and serviced to ensure continued effectiveness and safety.

6.2 Working of the project

Fire extinguisher drones are unmanned aerial vehicles (UAVs) that are equipped with fire suppression systems to extinguish fires in hard-to-reach areas. These drones typically work by using a combination of thermal imaging sensors and fire suppression technology.

The thermal imaging sensors are used to detect the location and intensity of the fire. Once the drone has identified the fire, it uses its fire suppression system to extinguish the flames. The fire suppression system can consist of a variety of methods, including water, foam, or chemical extinguishers.

The drone typically has a ball filled with the extinguishing agent, which is released using a claw mechanism when the drone reaches the location of the fire. The drone can be directed to target specific areas of the fire or to create a blanket of extinguishing agent to cover a wider area.

Fire extinguisher drones are controlled remotely by a human operator who can monitor the drone's movements and adjust its trajectory as needed to reach the fire. These drones are particularly useful for fighting fires in areas that are difficult or dangerous for humans to access, such as tall buildings, forests, or oil rigs.

In addition to thermal imaging sensors and fire suppression technology, fire extinguisher drones may also be equipped with GPS and other navigation systems to help them locate the

fire and navigate to the location quickly and efficiently. They may also have obstacle avoidance systems to prevent collisions with buildings, trees, or other obstacles while in flight.

The fire suppression system used by the drone will depend on the type of fire it is intended to extinguish. For example, a water-based extinguisher system may be effective for fires involving paper or wood, while a chemical-based system may be needed for fires involving electrical equipment or fuel.

Fire extinguisher drones can be used in a variety of settings, including in firefighting operations, industrial facilities, and construction sites. They can be particularly useful for quickly extinguishing small fires before they have a chance to spread and become more dangerous. Additionally, they can help firefighters gain a better understanding of the location and behavior of the fire, which can aid in developing a more effective strategy for extinguishing it.

Fig 6.2(a): Drone Claw Init Position

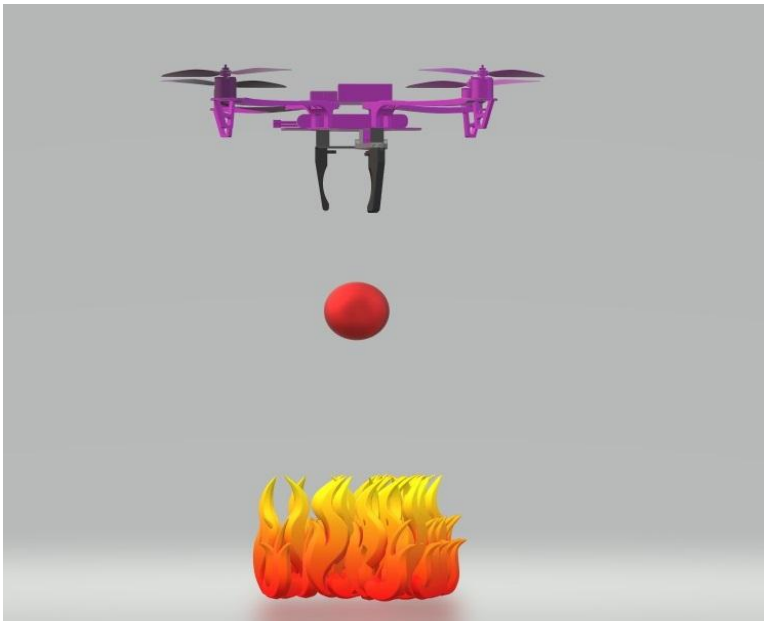


Fig 6.2(b): Drone Claw Open Position

Fig 6.2(c): Drone End Position

Overall, fire extinguisher drones are a valuable tool for firefighters and other emergency responders, as they provide a quick and efficient means of extinguishing fires in hard-to-reach areas, reducing the risk of injury and property damage.

Chapter 7

Testing

There are several testing parameters that can be used in fire extinguishing drones to ensure their effectiveness and reliability in responding to emergency situations and moreover testing is essential for fire extinguishing drones. Overall, testing is critical for ensuring that fire extinguishing drones are effective and reliable in responding to critical situations. Here are a few examples:

1. *Performance Testing*: This involves testing the drone's ability to extinguish fires of different sizes and types. The drone should be able to effectively put out fires without causing any harm to the surrounding environment.

2. *Range Testing*: This involves testing the drone's ability to cover a certain distance and stay in flight for a specific amount of time. This is important to ensure that the drone can reach the location of a fire and remain airborne long enough to put it out.

3. *Payload Testing*: This involves testing the amount of firefighting material (such as water or foam) that the drone can carry and how effectively it can be deployed. The drone should be able to release the fire fighting material at the right time and in the right location to be effective.

4. *Communication Testing*: This involves testing the drone's communication system to ensure that it can receive commands and send back real-time information about the fire. This is important for effective coordination between the drone and other emergency responders.

5. *Reliability Testing*: This involves testing the drone's durability and ability to withstand extreme conditions such as high winds, rain, or intense heat. The drone should also be able to operate reliably in different types of environments and terrains.

7.1 Test Cases

Fire extinguishing drone testing is typically done under a variety of conditions to evaluate the drone's performance and ensure its safety and effectiveness. Some of the conditions on which fire extinguishing drone testing is done may include:

7.1.1 Environmental Conditions

Fire extinguishing drones may be tested under different environmental conditions to evaluate their ability to operate effectively in various weather conditions, such as wind, rain, and snow. Testing may also be done in different types of environments, such as urban or rural areas.

7.1.2 Fire Condition

Fire extinguishing drones may be tested under different fire conditions to evaluate their ability to detect and respond to fires of different sizes and types.

7.1.3 Operational Conditions

Fire extinguishing drones may be tested under different operational conditions, such as different altitudes, speeds, and flight patterns, to evaluate their performance and safety.

7.1.4 Equipment and Sensor Conditions

Fire extinguishing drones may be tested under different equipment and sensor conditions, such as different types of cameras and sensors, to evaluate their effectiveness in detecting and responding to fires.

7.1.5 Communication and Control Conditions

Fire extinguishing drones may be tested under different communication and control conditions, such as different types of communication systems and control software, to ensure that they can be operated safely and effectively.

7.1.6 Claw mechanizing conditions

The claw mechanism in a drone is a critical component that allows the drone to pick up and transport objects. Testing the claw mechanism is essential to ensure its reliability and effectiveness in real-world scenarios.

Testing under these conditions helps to identify any weaknesses or issues with the drone's design or operation and allows developers and operators to optimize its performance and safety and it becomes a crucial step in the development and deployment of fire extinguishing drones, allowing developers to ensure the safety, effectiveness, and reliability of these UAVs in firefighting operations.

7.2 Type of Testing used

Testing is an essential process in the development and deployment of fire extinguishing drones. The purpose of testing is to ensure that the drone is safe, reliable, and effective in detecting and responding to fires. Testing helps to identify any weaknesses or issues with the drone's design or operation, allowing developers and operators to make any necessary improvements to ensure the drone performs its intended function.

One reason for testing fire extinguishing drones is to evaluate their functionality. This includes testing the drone's ability to detect fires, navigate to them, and extinguish them. By testing the drone's features and functionalities, developers can identify any potential issues or limitations and work to improve the drone's design. Functional testing ensures that the drone performs as intended and meets the specified requirements.

Another reason for testing is to evaluate the drone's performance under different conditions. This includes testing the drone's ability to operate in various weather conditions, such as high winds, heavy rain, or extreme temperatures. Performance testing helps to ensure that the drone can operate effectively in different environments.

Safety testing is also important in fire extinguishing drone testing. This includes testing the drone's ability to avoid obstacles, maintain stable flight, and avoid collisions with other objects or aircraft. Safety testing ensures that the drone can operate safely and minimizes the risk of accidents or damage.

Endurance testing is also important to ensure that the drone can operate for extended periods of time without failure. This includes testing the drone's battery life and its ability to maintain stable flight and operate its functions for an extended period.

Field testing is also an essential part of fire extinguishing drone testing. This involves testing the drone in a real-world environment to evaluate its performance and effectiveness in detecting and responding to fires. Field testing helps to ensure that the drone can operate effectively in the actual scenarios it was designed for.

The entire testing of its operationality is critical to the development and deployment of fire extinguishing drones. It ensures that the drone is safe, reliable, and effective in fighting fires, ultimately saving lives and protecting property. Here are some basic examples of types of testing that may be implemented in order to understand the overall functionality of the model:

1. Hardware testing: This type of testing would involve putting the physical components of the drone, such as the motors, sensors, and extinguisher system through practises. The drone would be put through a series of tests to ensure that all of its components are working correctly.

2. Flight testing: Flight testing would involve flying the drone and testing its flight characteristics, such as stability and responsiveness. The drone would also be tested in different rugged and harsh environmental conditions, such as wind or

   rain, to ensure that it can operate effectively in different scenarios and thereby making it more accustomed to the sense of flight testing.

3. Extinguisher testing: This type of testing is covered in the future aspects as it would involve testing the effectiveness of the drone's extinguisher system. The drone would be flown to a controlled location and the extinguisher system would be activated to test its range, accuracy, and effectiveness at putting out fires.

4. Software testing: The software running the drone would also need to be thoroughly tested to ensure that it is functioning correctly. This would involve testing the communication between the drone and its remote control, as well as the software that controls the drone's flight and extinguisher system.

5. Safety testing: Finally, the drone would need to undergo safety testing to ensure that it is safe to operate. This would involve testing the drone's emergency stop system, as well as ensuring that it meets all relevant safety regulations and standards.

Chapter 8

Result, Analysis and Discussions

Flight Control and Navigation System: Fire extinguishing drones must have reliable flight control and navigation systems to operate safely and effectively. These systems typically include sensors, GPS, and other technologies that enable the drone to navigate the environment and adjust its flight path as necessary.

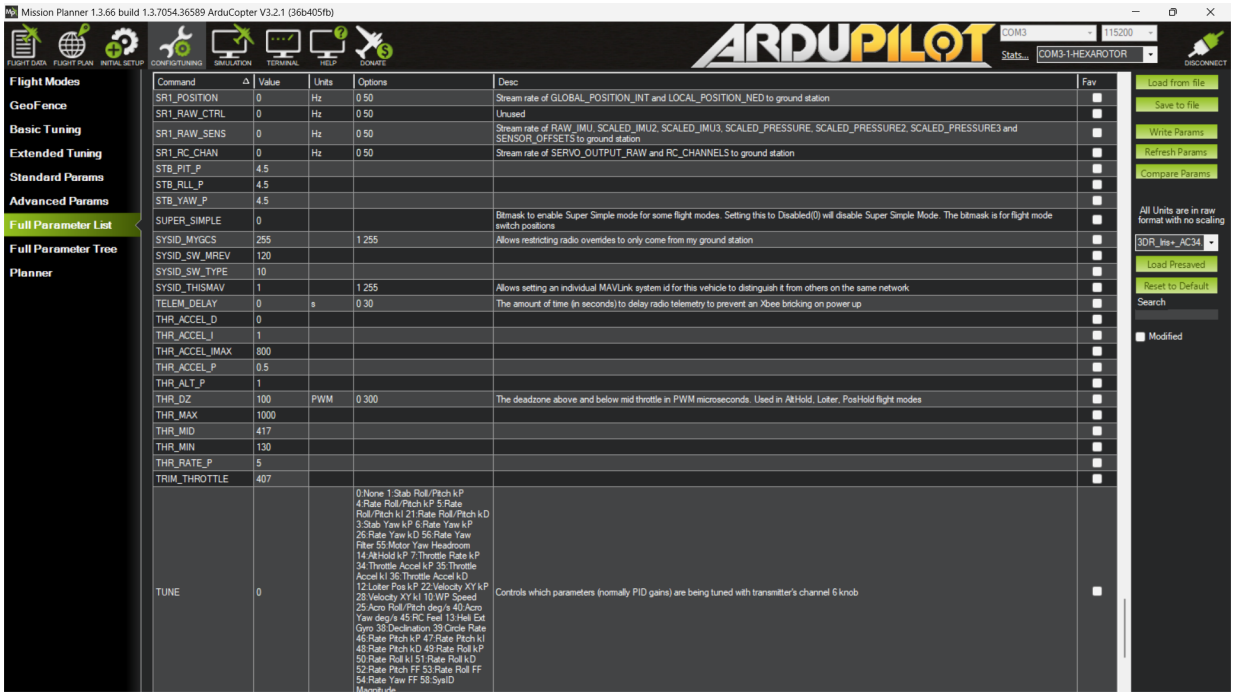


Fig 8(a): Mission Planner Full Parameter List

Power and Propulsion System: The power and propulsion system of a fire extinguishing drone is responsible for providing the energy necessary for flight and operating the drone's various systems and components. The system must be reliable and capable of

providing enough power to operate the drone for an extended period, as firefighting operations may require prolonged flight times.

Fig 8(b): Mission Planner Battery Monitor

Remote Control and Communication System: Fire extinguishing drones are typically operated remotely, either by a human operator or an autonomous control system. The remote control and communication system must be reliable and capable of transmitting and receiving information in real-time, allowing the operator to control the drone effectively.

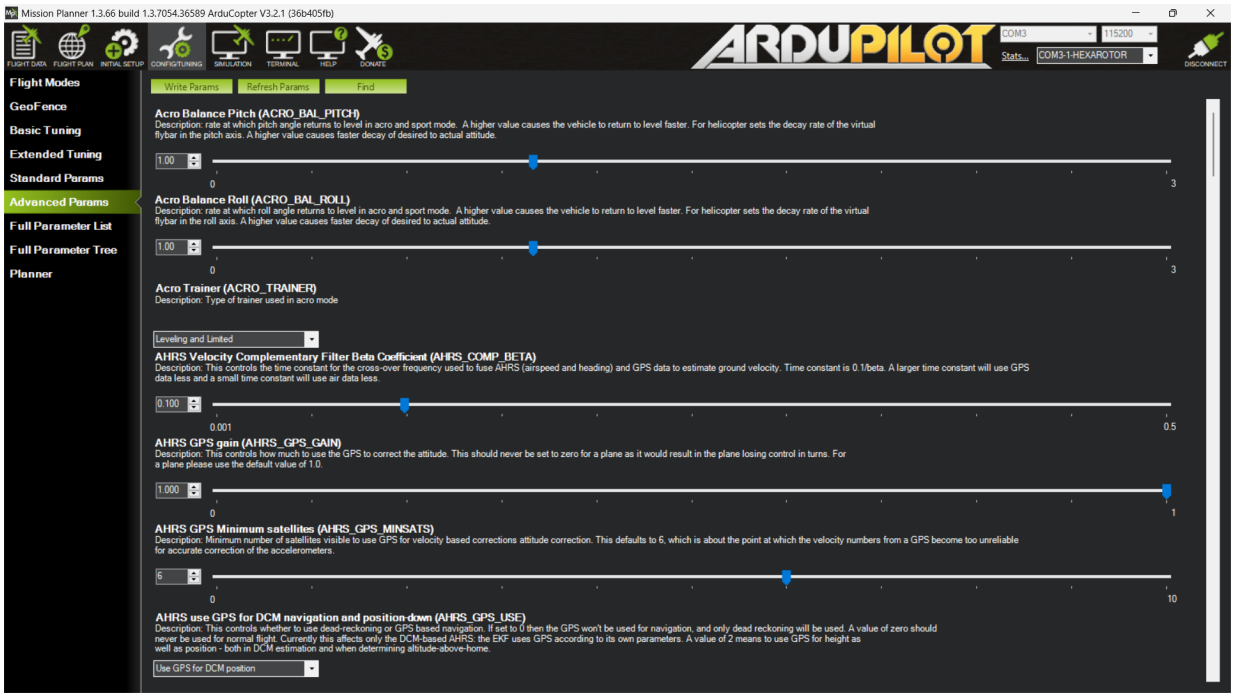


Fig 8(c): Mission Planner Advanced Parameter

Chapter 9

Conclusions and Future Scope

In conclusion, fire extinguishing drones have the potential to be a valuable tool in responding to emergency situations, particularly in situations where access to the fire site is difficult or dangerous. However, to be effective, these drones need to be reliable, efficient, and able to perform their functions in a variety of different environments. Fire extinguishing drones have the potential to revolutionize the way we respond to fires, particularly in hard-to-reach areas or situations where human intervention is difficult or dangerous. Through the use of advanced technologies such as sensors, algorithms, and artificial intelligence, these drones can provide faster and more effective responses to fires, potentially saving lives and minimizing damage to property and the environment. As the technology continues to evolve, there are several areas for future development and improvement in fire extinguishing drones.

The current state of fire extinguishing drones is still in its early stages, and there is considerable scope for further development and improvement. Here are some potential future areas of focus for fire extinguishing drone technology:

1. Increased autonomy: Developing fire extinguishing drones with more advanced autonomous capabilities could increase their effectiveness and efficiency in responding to emergency situations.

2. Integration with other emergency response systems: Integrating fire extinguishing drones with other emergency response systems, such as firefighting teams and ground control stations, could improve coordination and response times.
3. Improved firefighting capabilities: Developing new firefighting technologies and materials that can be deployed by fire extinguishing drones could increase their effectiveness in combating different types of fires.
4. Enhanced sensors and data analysis: Improving the sensors and data analysis capabilities of fire extinguishing drones could enable them to provide more accurate and reliable data about the fire and surrounding environment, improving their effectiveness and safety.
5. Regulatory frameworks and safety standards: Developing regulatory frameworks and safety standards for fire extinguishing drones could help ensure that they are safe, effective, and reliable in emergency situations.

Eventually, the future of fire extinguishing drones is promising, and continued development and innovation in this field could lead to significant improvements in emergency response capabilities.

Fire extinguishing drones have a lot of potential for the future, particularly in areas where traditional firefighting methods are difficult or impossible to employ. The future scope of fire extinguishing drones is quite promising. Here are some potential areas of growth and development:

1. Increased automation: Fire extinguishing drones can be designed to operate autonomously, with minimal human input. This can reduce the response time and increase the efficiency of the fire extinguishing operation.
2. Improved navigation and obstacle avoidance: Future fire extinguishing drones can be designed to have better navigation systems and obstacle avoidance capabilities. This can allow them to navigate through complex environments and reach difficult-to-access areas.

3. Enhanced firefighting capabilities: Future fire extinguishing drones can be equipped with more advanced firefighting technologies, such as high-pressure water sprayers or chemical extinguishers. This can increase their effectiveness in extinguishing fires.

4. Integration with other technologies: Fire extinguishing drones can be integrated with other technologies, such as artificial intelligence, sensors, and big data analytics. This can provide firefighters with real-time information about the fire and its behavior, allowing them to respond more effectively.

5. Use in other industries: Fire extinguishing drones can be used in other industries besides firefighting, such as in oil and gas exploration, mining, and construction. They can be used to detect and extinguish fires in hazardous environments, or to monitor and inspect infrastructure for potential fire hazards.

Overall, the future of fire extinguishing drones is likely to involve increased automation, improved navigation and firefighting capabilities, and greater integration with other technologies. Fire extinguishing drones have a lot of potential for the future, and as technology continues to advance, we can expect to see even more innovative uses for these versatile devices. As the demand for faster and more effective fire fighting solutions grows, fire extinguishing drones are likely to play an increasingly important role in the firefighting industry.

Appendix

STATIC THRUST CALCULATION

Calculations of static thrust are needed in order to ensure that the proper propellers and motors have been selected. Static thrust is defined as the amount of thrust produced by a propeller which is located stationary to the earth. This calculation is particularly important for this project because quadrotor helicopters are more likely to perform at low speeds relative to the earth. This low-speed performance ensures that the calculations of static thrust can be applied to a wide range of flight conditions. Also, it is important to note that the final calculations of static thrust are estimates and not actual values.

The first step in calculating static thrust is determining the power transmitted by the motors to the propellers in terms of rpm. Aircraft-world.com has compiled empirical data used to calculate power, and the formula used for their datasheet is given

$$Power = prop\ Const * rpm^{Power\ Factor}$$

Where power is in watts and rpm is in thousands. For example, a 6X4 APC propeller has a propeller constant of 0.015 and a power factor of 3.2. Given a rotational speed of 10,000 rpm, the calculation goes as follows: Power=$0.015X10^{3.2}$=24 W.

The next step is to determine the thrust produced by a propeller. Equation 2 gives thrust based on the Momentum Theory.

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

where, T= thrust (N)
D= propeller diameter (m)
v= velocity of air at the propeller (m/s)
Δv= velocity of air accelerated by propeller (m/s)
ρ= density of air (1.225 kg/m^3)

A commonly used rule is that velocity of the air at the propeller is v=½Δv of the total change in air velocity: Therefore this equation is derived

$$T = \frac{\pi}{8} D^2 \rho (\Delta v)^2$$

The below equation gives the power that is absorbed by the propeller from the motor. The torque can be calculated as:

$$P = \frac{T \Delta v}{2} \Rightarrow \Delta v = \frac{2P}{T}$$

$$T = \left[\frac{\pi}{2} D^2 \rho P^2\right]^{\frac{1}{3}}$$

Newton's Law, F=ma, is used to obtain in terms of mass is given as:

$$m = \frac{\left[\frac{\pi}{2} D^2 \rho P^2\right]^{\frac{1}{3}}}{g}$$

Where g=9.81m/s^2

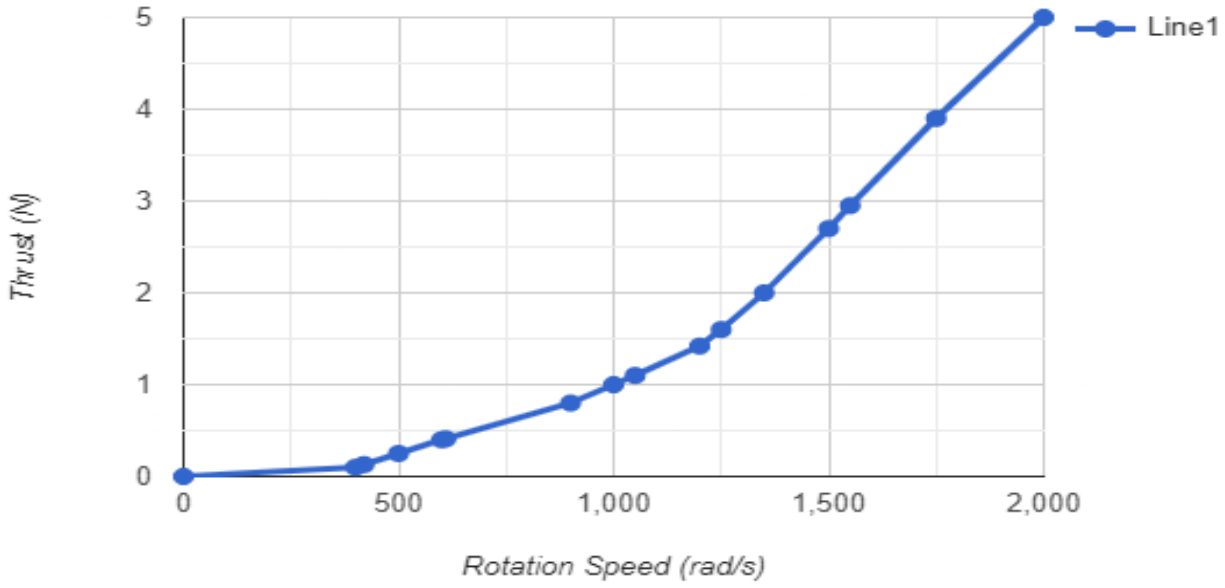
Solving for mass is useful for quadrotor helicopters because it can be directly related to the mass of the aircraft. In particular, a thrust (mass) that equals the mass of the aircraft is needed for hovering.

GRAPHICAL EVALUATION:

Thrust and rotation speed are two important factors that affect the performance of a UAV. The thrust of a UAV refers to the force that is generated by the motors and propellers to lift the

UAV off the ground and keep it in the air. The rotation speed, also known as the "rpm" (revolutions per minute), refers to the speed at which the propellers are spinning. In general, increasing the rotation speed of the propellers will increase the thrust of the UAV, and decreasing the rotation speed will decrease the thrust. However, the relationship between thrust and rotation speed is not necessarily linear and may vary depending on the specific characteristics of the UAV and its propellers.

Sr. No	Thrust (N)	Rotation Speed (rad/s)
1.	0	0
2.	0.1	400
3.	0.13	420
4.	0.25	500
5.	0.4	600
6.	0.41	610
7.	0.8	900
8.	1	1000
9.	1.1	1050
10.	1.42	1200
11.	1.6	1250
12.	2	1350
13.	2.7	1500
14.	2.95	1550
15.	3.9	1750
16.	5	2000



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by

Probir De

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