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Fire Fighting Drone Using Fire Extinguisher Ball

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ABSTRACT

Drones are a kind of unmanned aerial vehicle (UAV) that is controlled by a radio transmission. Drones like this get about by use of rotary motors. The inexpensive cost and ease of construction make them quite popular. Drones have found extensive application in several industries, such as transportation, military, security, and more. There is a great deal of potential in unmanned aerial vehicles (UAVs), and our study focuses on one practical use of drone technology that might help people. One may convert a drone into a firefighting drone with some clever tweaks. There is a lot of study and a lot of designs in this field. Rapid advancements are being made in drone technology. A giant step in the right way has been the advancement of GPS navigation and the automation of drones. Morphology technology, which allows drones to change their form, is one example of an upcoming drone technology. Our goal is to build a functional morphological fire fighter drone by fusing the concepts of morphological drones with those of firefighting drones. A technique for suppressing wildfires using these swarms of firefighting drones has been developed via research. On a fire front, a swarm of hundreds of drones may mimic the impact of rain by continuously spraying fluids to put out the fire. The self-coordinating system that can carry out the intended firefighting actions is the main point of emphasis.

According to studies, this swarm of drones' capacity to coordinate itself can work in physically changing contexts, generate accurate forecasts, and verify that the swarm's number of drones can scale as predicted. In an ideal world, with enough time and drones, every wildfire could be put out. Nevertheless, because to the limitations of existing technology, there is a cap on the number of drones that may be part of a swarm. Since these autonomous swarms of firefighting drones can organize themselves, human first responders will be superfluous in putting out wildfires.

Keywords- Fire Fighting Drone, Fire Extinguisher Ball, Servo motor

I.INTRODUCTION

Putting out fires now requires a combination of human firefighters and heavy machinery, both of which are labor-intensive and potentially fatal. Firefighters risk their lives to rescue victims, but finding them requires clearing a passage and searching for them by hand, which is a waste of life-saving time. Because it can be controlled remotely, without endangering human life, a firefighting drone (FFD) is an excellent choice in this situation. There are now a lot of innovations happening with firefighter drones.

Designing with the fact that FFD would be functioning in situations with high temperatures in mind is essential. The system's efficiency may be enhanced by using morphing technology to the FFD. The system's incorporation will allow FFD to access previously inaccessible areas, and its functioning will be more manageable inside enclosed buildings.

It is becoming more impossible for human first-responders to effectively handle increasingly risky, complex, and massive fire emergencies. To prevent further significant damage and to safeguard the first responders, unmanned fire fighting equipment might be used as a technological solution. The potential for autonomous firefighting equipment to improve response times and streamline operations in the event of a fire is another perk. In this respect, drone technology is being viewed more and more as a viable option. Depending on the circumstances, firefighting drones might be used for a variety of tasks, including detecting danger, monitoring for risk, and putting out fires. The use of thermal imaging and real-time cameras by drones to detect possible hazard is now the subject of study.

But why haven't fire departments adopted most of these measures yet? When a new issue arises, what obstacles can prevent a possible solution from being implemented? Perhaps the last step in introducing these new technology is to deal with regulation. On the other hand, is there an ethical issue with using drones to combat fires? Could they endanger people? Each of these aspects needs careful consideration in light of the specifics of each business case. Business cases and possible uses for drone technology are being sought after by drone technology businesses in this sector.

One such area is the use of drones in firefighting, an area with a long way to go in terms of commercialization and technological advancement.

In order to better understand the potential of fire fighting drones, this study will provide a comprehensive assessment of the current state of the area and suggest ways to improve it. There is a lack of a comprehensive review and recommendations for future improvements in the existing literature that explains various concepts and designs for firefighting drones. In this case study, we take a look at many types of drones that can fight fires: swarms of drones, individual drones with cameras, drones with fire extinguishing balls, and drones with Ifex's impulse fire fighting cannon.

The selected study design is to evaluate the various business cases using a scanning tool and selected literature theories. Insights for future development and readiness indicators for the various business cases are provided by this. The selected theories provide the groundwork for managing new-product development and outlining the steps needed for success. A literature review, based on a market overview and theoretical framework, forms the basis of this thesis. The methods section details the research process, while the results section presents and discusses the findings. The conclusion section concludes the thesis. This is followed by an explanation of the article's shortcomings and suggestions for further study.

Thirdly, fire extinguisher balls might be dropped from drones equipped with a payload drop mechanism. One possible use of the kind of drones discussed in the first business case is a system that uses them to search for potential fire hazards and relays that information to a firefighting drone. These fire-extinguishing balls are carried by the firefighting drone, which flies autonomously to the designated waypoints and releases them. Firefighting drones may not be able to effectively assist with building fires, according to experiments, unless there are open doors and windows. On the other hand, they work well on small grass fires, such as a wildfire that is getting close to a structure, a fence, or a firefighting team.

There is still a lot of space for thought since this idea is in its early stages. The first two use cases we presented are compatible with the payload drop mechanism drones. The idea might be combined with a swarm of drones, namely a swarm of fire-extinguishing balls drones, or with a scouting drone, which is a drone with sensor systems. Additionally, the drones might have a first-person view camera attached for remote control and range from 2 to 4 fire-extinguishing balls at once.

II. LITERATURE REVIEW

The fire department in the Netherlands now only utilizes drones with thermal imaging and real-time cameras to identify and monitor possible threat, therefore the present condition of the fire fighting drone industry is quite premature. Because of this, drone technology businesses have a lot of space to grow and fill with innovative firefighting solutions. We utilized a mix of academic and field research to identify possible business cases for firefighting drone applications. The ideas for innovation and their use cases were chosen for the literature review according to how often they were cited in the area of scientific journals. Secondly, the scientific articles' respective dates of publication were considered.

Prior to beginning to write a research paper, it is essential to do a thorough literature review of relevant publications. The following are a few examples of the research articles that were considered:

As an adjunct to conventional firefighting techniques, Burchan et al. (2019) [1] showed how drones may help put out wildfires by delivering fire extinguisher balls. A hexacopter carrying 15 kg of payload and 5 kilogram of balls was the suggested solution. Scouting unmanned aircraft systems (UAS) for spot fires and assessing the danger of wildfires approaching the structure are part of the process. Additionally, it communicates with the firefighting UAS to provide them with relevant data that will aid in situation management. On the other hand, class A and B flames were not effectively put out by these balls.

A UAV was created by Abdulla Al-Kaff et al. (2019) [2] specifically for the important purpose of forest fire monitoring. The device's built-in algorithms allow it to autonomously take off and land, plot its course, and monitor fires, among other possible uses. To alert the Emergency Response Team (ERT) of the fire's progress, this design incorporates thermal cameras, temperature sensors, and communication modules.

Rather of risking the lives of firefighters, Manuj et al. (2019) [3] suggested using semi-autonomous drones for firefighting missions. This article details how to upgrade the current hexacopter so that it can land automatically, collect and store GPS data, and achieve steady flying. Firefighting equipment, including a fire extinguisher, was installed in the system. The findings of the two models that were developed and evaluated in a sequential fashion are favorable to the study.

III. OBJECTIVES

- Preparing a Morphological Firefighter Drone (MFFD): A Technical Study
- Enhance the technology of firefighting drones to prevent loss of life.
- Used for putting out fires in hostile and uninviting environments.
- Getting the fire extinguisher ball to a spot that isn't easy to reach using standard means.(confined spaces, inside)
- Using a first-person view (FPV) camera, to survey the surrounding area and capture footage in real-time.
- In addition, guiding the UAV through tight spaces and determining the precise location to release the fire extinguisher balls
- A better means of preventing and putting out flames is the goal of this design project.
- A human operator is not required for the operation of the unmanned aerial vehicles (UAVs) used in this mission.
- The drone-mounted fire extinguisher ball's dropping mechanism requires a novel design.
- In the event of a fire, the controller may assess the situation, coordinate the extinguishing effort, and provide a hand with vehicle movement.

IV. CONCEPT OF QUADCOPTER

An unmanned aerial vehicle (UAV) is a quadcopter. A unmanned aerial vehicle (UAV) is a flying machine that has the capability to fly itself or is intended to do so in the future. Drones are another name for these autonomous flying machines that a human operator may control from anywhere in the globe over the Internet. This often results in significant deployment and maintenance costs, especially for industrial applications. Our quadcopter can quickly and accurately detect fires, put them out, and rescue people in the event of an emergency. Whether in a cross or plus configuration, our quadcopter is equipped with four trust propellers. One major advantage is that you won't need a landing pad to get the quadcopter in and out of the air and landing it upright. The quadcopter may float quite steadily because of this as well. However, even with heavy loads or severe winds, the quadcopter's steadiness keeps it from crashing. The propeller maintains a consistent pitch and roller angle, allowing the quadcopter to float at a steady height. There are two sets of fixed propellers used by quadcopters. One set spins in a clockwise direction (CW), while the other set spins counterclockwise. In a clockwise direction, the propellers on the left and right spin, while those on the front and back spin counterclockwise. In this configuration, the need for a threshold rotor with same rpm for the two propellers is bypassed.

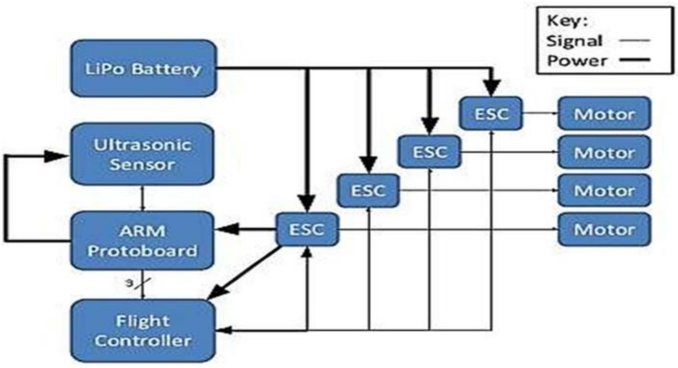


Fig 1: - Design of Quadcopter.

Mechanism of Quadcopter Movement:-

The quadcopter is a little aircraft characterized by its cross-frame design and four rotor rotors. The objective is to track the vehicle's motion using rotors that have a fixed pitch. None of these four rotors affect the speeds. The vehicle's autonomous attitude of pitch, roll, and yaw makes it easy to manage.

Motion system for take-off and landing:-

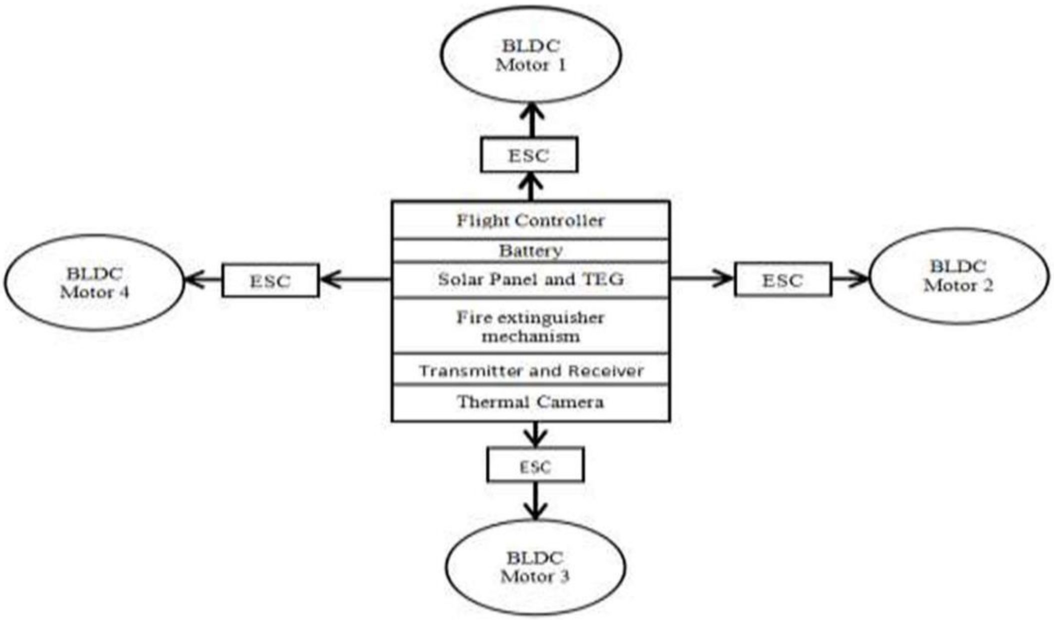
A quadcopter's start off motion involves rising from the ground to hover, inverting the initial position. The vertical motion is altered by controlling the start (landing) motion in tandem with the rise (declining) of four rotors..

Static or floating place:-

When the quadcopter is in the air or at rest, its two rotors spin at the same speed in opposite directions. With two rotors spinning in opposing clockwise and clockwise directions, a quadcopter may hover since the sum of its reaction torques is zero.

Our quadcopter has four independent motors and electronic speed controls for its propellers. By adjusting the revolutions per minute (RPM) of each motor, we can self-stabilize the quadcopter by measuring its X, Y, and Z angles using the accelerometer. The stability of the quadcopter platform is provided by the counter-turning motors, which apply a net moment of zero to the center of the aircraft. The use of drones has grown in recent years across many security systems. The design and execution of a tiny X-shaped quadcopter are the major topics of this study. This idea may be used to control the quadcopter's lace, pitch, and roll by adjusting the on-motor speed in relation to the voltage applied to the motor. A fine balancing act between all four engine functions is needed to modify the transient forces exerted on the quadcopter, while varying the speeds of the individual engines allows for temporary and rolling control. The use of drones has grown in recent years across many security systems. Generally speaking, the article discusses the idea and execution of a small X-shaped quadcopter.

V. SYSTEM ARCHITECTURE



Technical Control of Aircraft

Learning the lingo of each design is the first order of business. There are three basic movements that make up the flying mechanism; all of them need constant and standardized control (0 degree). The following are listed:

Throttle: The throttle is used to regulate the drone's vertical movement.

Roll: A roll is a wing-up, wing-down motion that occurs side by side.

Pitch: The front and rear end movements make up pitch. Consequently, it causes the leading edge to be elevated over the trailing edge, or vice versa. It determines whether the quad moves forward or not.

Yaw: The quad's yaw is the angle at which it is turning. In quadcopter X, each of the four rotors—brushless engines—is situated in the four corners of the 'X' construction and, while spinning in the middle, generates a specific amount of power and torque. For points 1 and 3, the direction of rotation is clockwise, and for points 2 and 4, it is also clockwise. A four-rotor propeller is not universal.

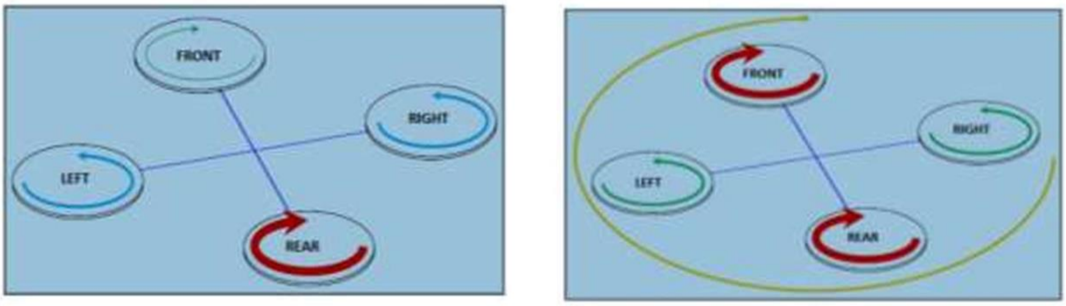


Fig 2:- Illustration of Throttle, Pitch, Roll and Yaw.

There are two pusher propellers and two puller tips on the four-propeller set. This net torque could be 0 if the whole propeller spins in the same direction.

Grip, yaw, pitch, and roll were the typical dynamic characteristics used for airplane orientation. Moving vertically increases or decreases the combined speed of the four propellers. The propeller rotational speed determines all conceivable quadcopter movements, as shown in Figure 3.

Motion Design:

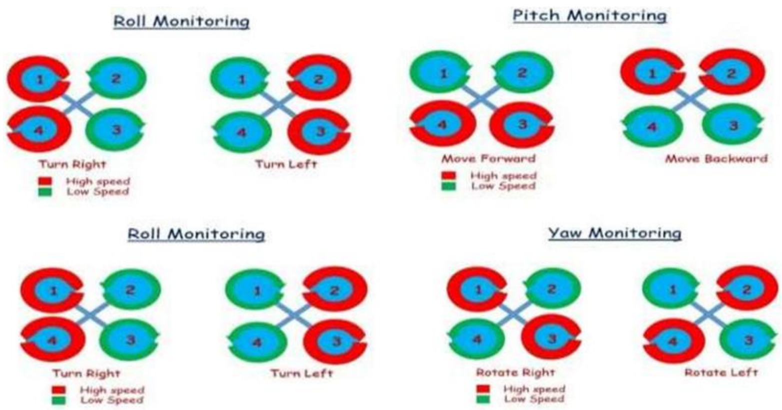
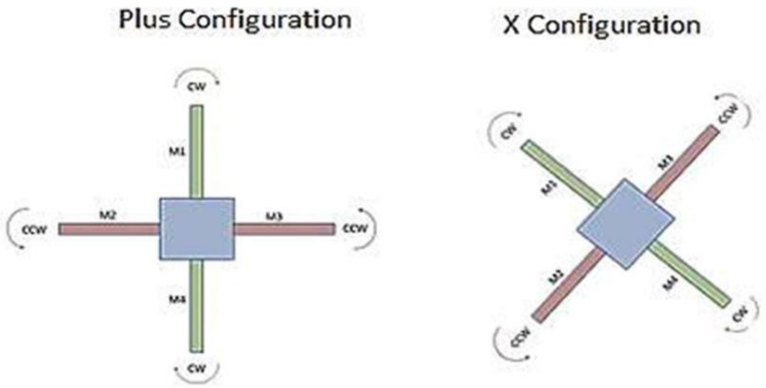


Fig. 3:- Forward Motion , Backward Motion ,Left Motion & Right Motion

Raising or lowering the speed of the rear rotor controls the forward or backward motion. The quadcopter's pitch angle may be adjusted by reducing or raising the speed of the rear rotors at the same time. In the image below, you can see the quadcopter's forward and backward movements.

Controlling Left and Right Movement—The quadcopter's logout angle may be adjusted to regulate its left and right movement. The yaw rotor's speed may be regulated by raising (dismissing) the rotor angle counterclockwise while the clockwise speed is decreased. The right and left steps of the quadcopter are shown in Figure 6.

Configurations and Calibrations: Before we go into the various quadcopter modes, let's talk about the balancing control strategies. Both the (+) and (X) configurations are possible for quadcopters to fly in. The location of the quad's front end is the only distinguishing feature among these variants. The distinction is shown



in the following figure.

Fig. 4:- Quadcopter Configuration “X& Plus”.

Plus (+) Configuration Control In this configuration the control as follows:Pitch Control :-
M1 = M1 + RX(Elevator);M4 = M4 - RX(Elevator);
Roll Control M2 = M2 + RX(Aileron);M3 = M3 - RX(Aileron);
It is very easy to use and is available in any quadcopter program. There are of course somechecks here and there to prevent engine stoppage or saturation. But the principle of flight is still as above. There is also a scaling factor used to evaluate the stick sensitivity, and a dividingfactor that restricts the value range.
X Configuration Control Pitch Control:-
M1 = M1 + RX (Elevator) /2;M3 = M3 + RX (Elevator) /2;M4 = M4 - RX(Elevator) /2; M2 = M2 - RX(Elevator) /2;
Roll Control:-

M1 = M1 + RX (Aileron)/2; M2 = M2 + RX (Aileron) /2; M3 = M3 - RX (Aileron) /2; M4 = M4 - RX(Aileron) /2;
As we see it, we believe only that M1 & M3 act as a single virtual engine together on the front, and that M2 & M4 operate together as a virtual motor on the back. It's the same logic, besides that. In the PLUS form, the same criteria and element are also applied here.
The prototype of the developing project is shown below:

Fig 5 Real prototype of project

Stabilization System: The stabilizing system will be shown next. Basically, you just speed up the right motor and slow down the left one by the same amount if the quad is falling to the right, and vice versa. Also, if the quadcopter is tumbling off the front arm, you need to increase the speed of the M1 motor and decrease the speed of the M4 motor. Below is the rule's textual form.

M1 = M1 + Pitch Amount * Pitch GainM4 = M4 - Pitch Amount * Pitch Gain M2 = M2 + Roll Amount * Roll Gain M3 = M3 - Roll Amount * Roll Gain
Any software for quadcopters worth its salt will have this one rule. The methods used to determine Pitch Amount and Roll Amount are the primary differentiators among the various firmware techniques. A measure of sensitivity is the gain factor.

Flight Time The UAV shall be measured as follows for optimum flight time:

$$\textbf{Maximum Flight Time (min)} = \frac{\textbf{Battery storage Amp rating (mAh)} * 60}{\textit{Current draw of UAV (Amps)}}$$

The 22000 mAh capacity of the battery is impressive. The amp-minute rating of the battery is 60, calculated as (22000/1000). As the transmitter is monitored, the UAV consumes an average of around 30 amps after many flights. Thus, the total flying time for the UAV is 44 minutes, or 1320 divided by 30.

Whereas the required time of flight is determined as follows:

Recommended Flight Time (min) = Maximum Flight Time (min) * Safety Factor

Where, 0.4 to 0.7 is the protection factor. The estimated flight time is therefore between 17.6and 30.8 minutes.

VI. AFO FIRE EXTINGUISHER BALL

Fig 6:- AFO Fire Extinguisher Ball

- The circular fire extinguisher known as a fire extinguisher ball is designed to put out fires.
- Because of its spherical form, it is known as a ball. In the event of a fire, it functions similarly to any other extinguisher.
- Mainly, it weighs 1.5 kg and has a diameter of 150 mm. Its small stature and low weight are results of this.

Working :- Fire extinguisher balls, when tossed into a fire or placed in an area prone to fires, explode and discharge their contents, which are mostly dry chemical powder, when they come into contact with flames. So the fire doesn't start, a cloud of dry chemical powder accumulates surrounding the spot.

Contents :-The fireball contains a chemical powder that is dry. Ammonium sulfate and mono-ammonium phosphate are the main ingredients. It is the former that has an active ingredient. Silicon stearates, which prevent the substance from caking, may or may not be used to moisture-proof them. Anyone may use it to put out fires since the substance is safe and non-toxic. No one is impacted by it.

There is a 5-year shelf life for the fire extinguisher ball. It is completely maintenance and repair free for the first five years. However, before using it, always check that it is in excellent shape. Anybody may operate them; no special training is necessary.

VII. MECHANISM OF EXTINCTION OF FIRE

Fig 7:- Project Prototype

To put out fires, this quadcopter makes use of an AFO fire removal ball. Firefighters vehemently advocated for the use of a larger extinguishing ball and the possibility of firing several balls inside the space in the event of a fire.

To put out a structure fire more quickly, try throwing an AFO ball into the blaze. If the balls were tossed from a greater height, the powder would be more evenly distributed and so more effective. As a result, the job became even better.

"... water damage is destructive compared to that, these balls won't do any harm to the buildings...." is what firefighters said when asked why they weren't using water to put out the fire in this quadcopter. This further simplified the task. Contrary to what firefighters may have reported, this quadcopter does not utilize water to put out fires. Water is destructive, and these balls will not do any damage to structures. A good rule of thumb for determining the amount of water a fire requires every minute is to divide the area by three..

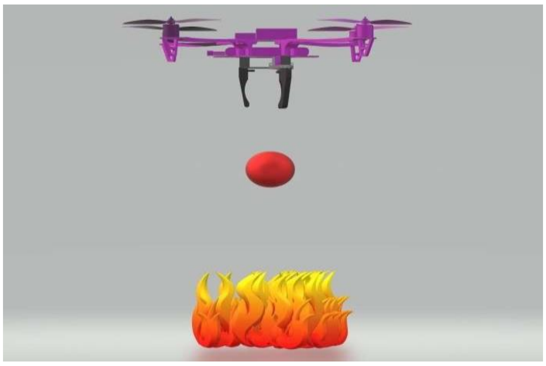


Fig 8 Working of Project

When a fire breaks out in a confined area or when no one can get to the home, our AFO balls may also be tossed out a broken window. Specifically, this quadcopter is equipped with a thermal camera. Upon arrival at the site of the fire, the thermal camera transmits a live thermal picture of the blaze, greatly enhancing the ability to monitor the fire. The individuals in need might get food and medical supplies delivered by our quadcopter.

VIII. PROJECT PORTFOLIO

Rapid Response: Rapid deployment of firefighting drones allows for their prompt aid in life-or-death emergencies..

Aerial Surveillance: By providing a bird's-eye view, firefighters can better gauge the scope of the fire and devise tactics with the use of drones.

Access to Inaccessible Areas: Firefighters face challenges and risks while attempting to enter high buildings, roofs, or other inaccessible sites. Drones provide a safer and more efficient alternative.

Real-time Monitoring: Firefighters may benefit from real-time data on fire behavior, temperature, and smoke levels provided by drones equipped with thermal cameras and sensors.

Fire Suppression: Firefighting equipment, such as water cannons or foam dispensers, is mounted to certain drones, allowing them to put out flames from above.

Safety Enhancement: Firefighters may lessen the likelihood of injuries or deaths by using drones to reduce their exposure to dangerous areas.

Cost-effective: Since drones don't need as many resources or firefighters as conventional firefighting tactics, they may be a more economical choice.

IX. SCOPE OF STUDY

Drones used in firefighting are unmanned aerial vehicles that are controlled from a distance by people. With the constant advancement of cutting-edge technology, companies are using electromechanical sensor technology for firefighting drones. Drones piloted by firefighters are invaluable in situations including hazardous materials, rescue efforts, wildfires, and car accidents. Loss of life, destruction of property, and injury to firefighters may occur as a result of fire incidents. As a result, several nations' governments are pushing for the use of cutting-edge technology, such as firefighting drones. In addition, top drone manufacturers are working on cutting-edge firefighting solutions with enhanced functionality and safety measures. Governments are investing in the future of FFD due to the rising need for drone technology. A wealth of new possibilities for using FFD within buildings, such as apartments, factories, plants, etc., have been opened up by integrating morphology technology with the FFD system. This system may be used for remote sensing and surveying of areas damaged by fires, whether they be buildings, forests, or other structures, by integrating high-definition cameras with heat sensors. A total of five business cases were generated from this procedure. A variety of drones are available for use in firefighting operations, including those with cameras, "sniffer" drones, swarms of drones, fire extinguisher balls, and Ifex's impulse fire fighting cannon. Research into the literature provided the first four, while field testing led to the selection of the Ifex impulse fire fighting rifle.

The business cases will be further evaluated for readiness using the Space53 fast scanning tool. A readiness level assessment will be conducted for each domain of the business case applications on a scale ranging from 1 to 9. Participants in this study will be invited to give their expertise in many disciplines in order to answer the questions posed by this scanning tool.

X. CONCLUSION

With the current state of fire protection in the industrial sector, India is very susceptible to catastrophic disasters. The research and evaluation results show that the industry's safety evaluations of fire risks are lacking. Research shows that many businesses lack the means to adequately address catastrophic fires. Some sectors do not have enough of the necessary equipment, such as smoke alarms, fire resistant doors, suitable emergency exits, and warning devices. In addition, the majority of buildings' elevators and stairwells were insufficient. Building compartments in the cavity using the fire barriers—mounted horizontally and vertically between the covering and the internal wall—can help to prevent the spread of fire.

Unfortunately, the device's efficacy depends on its design, and retrofitting isn't always an option due to factors like the shape and condition of the existing walls. We are still in the process of developing the early fire detection system. However, the practical use of our quadcopter has been questioned, and its power is insufficient to keep an eye on the explosion. If they get themselves into trouble, the fire department can keep an eye on the quadcopter. The quadcopter can reload itself, and they can watch it from anywhere in India to clear the area of fire. To put out the fire as quickly as possible, we believe our quadcopter is in the best position. We are certain that we are heading in the correct way to achieve the aim after doing thorough research and experiments using simulations. Moreover, we take it for granted that our method is accurate and current. Firefighters may save lives and property without harm or loss of life provided they are well-informed about the situation and the controls. The use of software to improve command and control efficiency is also backed up by the statement.

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