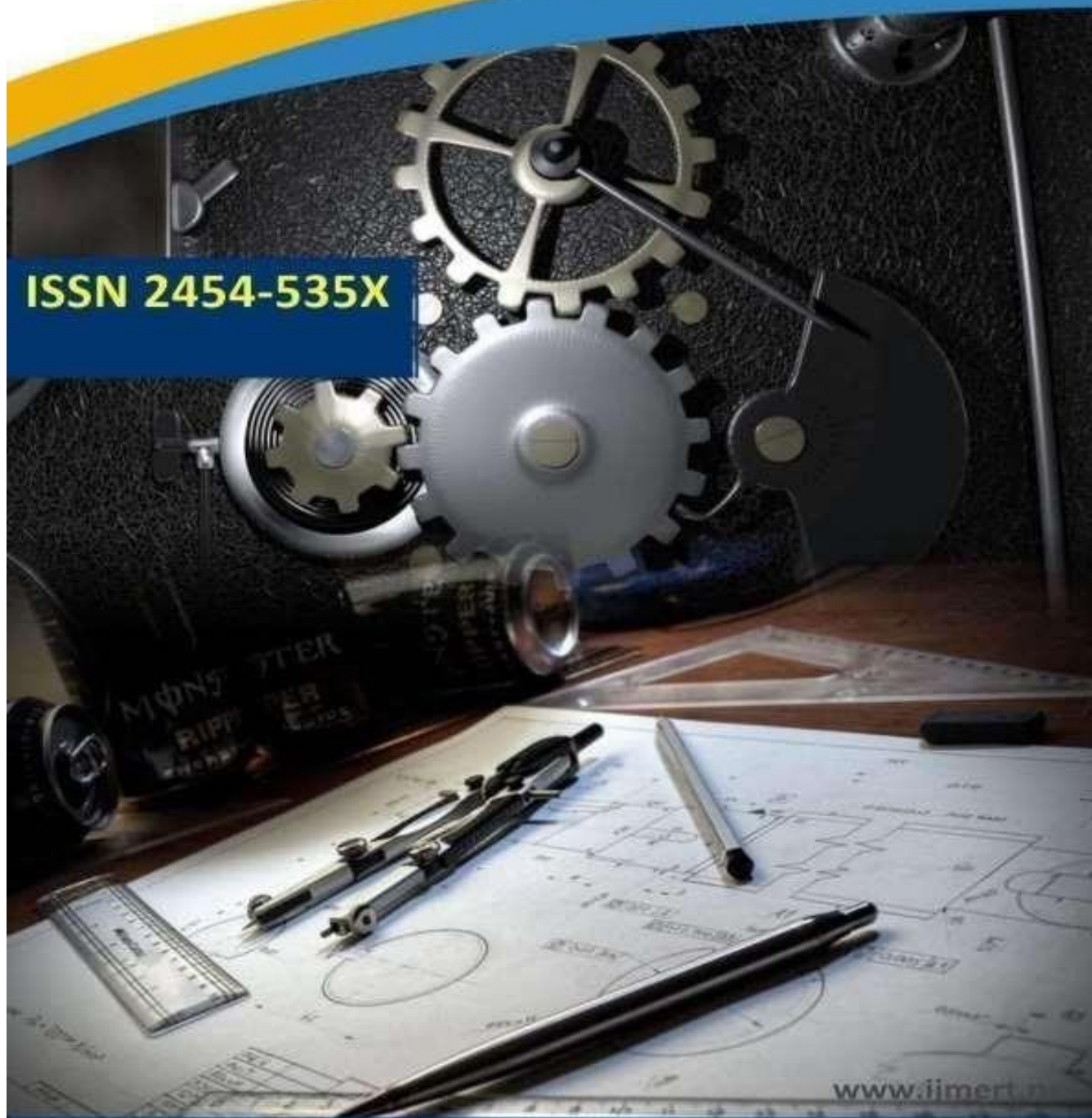




International Journal of Mechanical Engineering Research and Technology

ISSN 2454-535X



www.ijmert.in

Email ID: info.ijmert@gmail.com or editor@ijmert.net



EMERGENCY MEDICAL SUPPLY AUTOMATIC DRONE EVALUATION: A COMPLETE REVIEW

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Received on: 21 Oct 2024 Revised on: 20 Nov 2024 Accepted Date: 25 Dec 2024
Published on: 30 Jan 2025

ABSTRACT

A revolutionary step forward in disaster response and healthcare logistics would be an autonomous drone system that could transport medical supplies in an emergency. The autonomous drone uses cutting-edge technology like AI, GPS navigation, and superior obstacle recognition to deliver life-saving supplies precisely when they need them. Blood products, vaccinations, medicines, and other life-saving equipment can be swiftly delivered to locations that are inaccessible, devastated, or otherwise damaged by natural disasters, where conventional means may encounter long delays. The resilience of the drone's construction guarantees its dependability in a wide range of environments, including those with extreme weather. The technology decreases operational hazards in high-stakes situations and shortens reaction times by reducing the requirement for human involvement. Revolutionizing humanitarian relief and emergency medical response on a worldwide scale, this invention fills critical gaps in healthcare delivery during crises and offers a scalable, cost-effective, and life-saving solution. The following terms are used interchangeably: autonomous drone, healthcare logistics, medical supplies, artificial intelligence, geographic information system navigation, obstacle detection, environmental conditions, operational risks, healthcare delivery, humanitarian aid, and remote areas.



I. INTRODUCTION

It is sometimes a question of life or death when medical supplies are not delivered promptly in emergency circumstances. Nevertheless, conventional modes of transportation encounter other obstacles, including infrastructure damage, traffic jams, and the inaccessibility of faraway or disaster-stricken areas. Transmitting vital medical supplies like blood, vaccinations, medications, and diagnostic instruments has never been easier than with the advent of autonomous drones, which provide a dependable, quick, and effective way to circumvent these obstacles. To guarantee safe operation in unexpected and dynamic situations, these drones are outfitted with state-of-the-art technology including sophisticated obstacle detection systems, GPS navigation for accurate routing, and artificial intelligence for autonomous decision-making. They may bring goods straight to regions that are normally inaccessible by conventional vehicles because to their tiny design and ability to avoid ground-level limitations. Emergency medical treatments are made more efficient and successful with the help of autonomous drones since they drastically cut down on response times and logistical hurdles. The healthcare system will be more robust and responsive as a result of this innovative strategy, which not only meets the urgent healthcare requirements of impacted communities but also establishes a new benchmark for disaster preparation and humanitarian relief. Autonomous drones not only solve logistical problems, but they can also be quickly and easily adapted to deal with a wide range of situations, whether they be caused by man-made conflicts or natural catastrophes like hurricanes, floods, or earthquakes. Their autonomous capabilities lessen the need for human pilots, freeing up resources for more pressing response areas. In addition, medical supplies may be delivered to numerous places at once using drone fleets, which is particularly important during large-scale catastrophes with significant demand. Drones like this may help save more lives in dangerous situations by coordinating with other emergency response systems and using real-time data to prioritize delivery according to urgency. One major perk of autonomous drones is that they can fly in dangerous environments where human rescue workers may be in danger. Drones can safely carry medical supplies without putting healthcare professionals in harm's way, whether they're flying over rivers, hazardous places, or difficult terrains. Their compact design and little impact on the environment also make them a greener alternative to more conventional transportation options, helping to achieve worldwide targets for reduced carbon emissions. Improvements in healthcare infrastructure and technology adoption are also encouraged by the installation of autonomous drone systems. To enhance delivery precision and efficiency, it promotes the creation of real-time tracking systems, optimum payload designs, and analytics driven by artificial intelligence. The use of these drones also improves communication and coordination among public and commercial entities working to fortify healthcare delivery systems. This collaboration improves regular medical supply chains and guarantees preparedness for crises, which is especially helpful in underprivileged regions. Improved cargo capacity, longer flight times, and the ability to connect with Internet of Things (IoT) devices to keep track of medical supplies in transit are all qualities that autonomous drones are projected to have as technology advances. This new method has the potential to revolutionize global disaster response by helping healthcare systems deal with the increasing complexity of emergency medical logistics and guaranteeing that all people have equal access to vital supplies.

**Fig.1.** Drone Carrying Supplements***A. Uses and Applications***

Drones equipped with medical supplies may change the way people respond to emergencies and get treatment. Drones like this are godsend for emergency response teams because they can swiftly deliver critical supplies like blood, vaccinations, and medications to places where roads are too dangerous or infrastructure is too destroyed. Drones improve health outcomes and fill gaps in healthcare access by ensuring the timely delivery of vital medical supplies in distant or rural places with inadequate healthcare facilities. Autonomous drones are great for disaster assistance, but they are also essential for regular medical procedures. By streamlining the process of transporting blood or tissue specimens to central labs, they allow for quicker diagnosis and less wait time for patients. Drones may also transport life-saving tools like portable ventilators and defibrillators to disaster zones, allowing first responders to treat patients faster. Public health efforts, including vaccination drives, may greatly benefit from the use of drones since they can transport temperature-sensitive vaccines to hard-to-reach places while still meeting cold chain standards. They also help provide medical supplies and personal protective equipment (PPE) to healthcare workers quickly in the event of an infectious disease epidemic or pandemic, reducing the likelihood of exposure and maximizing reaction times. Moreover, drones may improve urban medical supply chains by reducing traffic and delivering vital supplies to clinics and hospitals during times of high demand. Additionally, they are finding their way into telemedicine systems, which will allow patients in remote areas to get their drugs following virtual consultations. In addition to facilitating rapid medical supplies, these drones aid humanitarian efforts by distributing healthcare resources fairly in times of need. The use of autonomous drones in healthcare systems has the potential to revolutionize medical logistics by increasing efficiency, speed, and reach. This, in turn, might lead to a more adaptable and robust healthcare infrastructure on a worldwide scale.

B. Advantages for Business

Numerous sectors stand to gain greatly from the deployment of autonomous drones for the delivery of life-saving medical supplies in times of crisis. These sectors include healthcare, logistics, and disaster response. Drones improve delivery speed and efficiency, cutting reaction times in urgent circumstances in half, particularly in places with damaged infrastructure or difficult terrain. Eliminating the need for human drivers and fuel-intensive vehicles not only improves patient outcomes but also decreases operating expenses. Medical supplies may be transported to hard-to-reach areas with the help of autonomous drones, which can improve healthcare professionals' safety by reducing their exposure to potentially dangerous situations. Drones also help the environment since they are a low-carbon, energy-efficient alternative to more conventional forms of transportation. Integrating them into telemedicine services may increase access to healthcare in impoverished regions, and their scalability and adaptability make them ideal for large-scale situations requiring several simultaneous delivery. Drones improve inventory management



and guarantee the timely availability of vital commodities by reducing bottlenecks in supply chains.

Finally, companies may put themselves at the forefront of innovation and crisis response by integrating autonomous drones into healthcare logistics. This provides greater efficiency, cost-effectiveness, and dependability.

C. Positive Impact on Society

The use of autonomous drones to transport medical supplies during emergencies has the potential to greatly improve healthcare accessibility and public safety, leading to many societal advantages. When conventional transportation routes are inaccessible due to factors like infrastructure destruction, difficult terrain, or sheer remoteness, medical supplies like vaccinations, meds, and blood products may be swiftly delivered to underserved, distant, or disaster-stricken regions by use of drones. Drones save lives in emergencies by lowering reaction times, which improves health outcomes and allows for the timely delivery of life-saving therapies. Furthermore, drones aid in filling healthcare shortages in low-income or rural areas where medical supplies are sometimes late in arriving owing to logistical issues. Drones improve public health and promote health equality by quickly and efficiently transporting vital medical supplies, ensuring that at-risk people get treatment when they need it. Drones also improve healthcare professionals' safety by reducing their exposure to potentially dangerous places including war zones, polluted regions, and catastrophe sites. This helps keep first responders safe and makes sure people who need medical treatment can get it without endangering those on the front lines. Autonomous drones also help the environment by cutting down on the pollution that comes from using conventional delivery methods like planes and trucks. Their electric battery-powered, energy-efficient design promotes a greener method of healthcare delivery by reducing the negative effects of medical logistics on the environment. By enhancing catastrophe preparation and response capacities, drones can help communities feel more resilient. A more adaptable and efficient healthcare system is possible as a result of the innovation and supply chain management that these technologies may spur when they gain traction in the market. Individuals, communities, and the world at large all stand to gain from autonomous drones' incorporation into medical logistics in the long term, since these tools will guarantee that vital healthcare resources are accessible in a timely, fair, and sustainable manner.

part two. Looking back via time
ACES OF THE UAV ERA (1920S)

While creating "radioplane" targets for aerial combat training in the 1920s, the first idea of UAVs was born. The first unmanned aerial vehicles (UAVs) were RC planes that served mainly as military training tools. Despite not being fully autonomous, these advancements paved the way for drones to come. Despite its primitive state, the technology showed promise for remote-controlled flying. This was the first foray into unmanned aerial vehicle (UAV) research.

the years of the 1940s

The military improved unmanned aerial vehicle (UAV) technology for use in WWII for the purpose of reconnaissance and surveillance. Target practice and flights too risky for human pilots were handled by UAVs. Despite their lack of autonomy and remote control, these UAVs played a crucial role in information collection and mission execution, ensuring that troops were not put in harm's way. New developments in control systems set the stage for autonomous flying to take off in the future. During this time, there was a noticeable increase in the variety of UAV missions.

REMOTE CONTROL DEVELOPMENTS IN THE 1960S
Improved UAV technology, including more advanced remote control systems, was



introduced in the 1960s. Drones were able to carry out reconnaissance, early mapping, and surveillance missions because of these innovations. The military's employment of UAVs for espionage and information collection increased throughout the Cold War. Better flying stability and more precise navigation systems were two examples of how the possibilities of the technology were expanding. Still, most missions need human control of UAVs, since they were not yet fully autonomous.

Urban UAV Application in the 1980s

The 1980s saw a transition in UAV technology toward more civic uses, including research, weather observation, and environmental monitoring. Drones had few non-military use until the advent of global positioning systems (GPS) made them more precise. Drones were costly and had limited capabilities, even though they had early civilian uses. Nonetheless, they were useful in environmental studies and scientific research because to their capacity to collect data from inaccessible or hazardous regions. The framework was established for wider use of UAVs in the next decades.

The 1990s saw the rise of GPS integration. T

Unmanned Aerial Vehicles (UAVs) became much more autonomous and dependable with the incorporation of GPS technology in the 1990s. Drones may now fly along predefined paths with no human intervention thanks to this innovation. Now that UAVs have GPS navigation, they can map locations, collect data, and conduct surveillance much more precisely and effectively. During this time, drone technology reached a turning point, thanks to GPS devices that allowed for the accuracy required for autonomous flights. Unmanned Aerial Vehicles (UAVs) improved in adaptability, opening up new uses for them beyond the military.

GROWTH INTO BUSINESS USES (2000S)

Unmanned Aerial Vehicles (UAVs) first appeared in the commercial market in the early 2000s, with applications soon spreading to mapping, photography, and agricultural monitoring, among others. Drones were formerly off-limits to companies and enthusiasts, but as technology improved, they became more affordable. Thanks to improvements in battery life and downsizing, drones became more accessible as their price and dependability rose. Drone research also increased during this time, with people becoming more interested in employing UAVs for healthcare delivery and logistics. Drones' growing marketability heralded its introduction to hitherto untapped sectors.

Civilian UAV Use Opens Doors to FAA (2006S)

Commercial use of unmanned aerial vehicles (UAVs) by civilians was authorized by the US Federal Aviation Administration (FAA) in 2006. This change in regulation was a watershed moment since it made civilian use of drones official. Businesses were able to take advantage of the decision to investigate drone uses in a wide range of sectors, including logistics and the media and entertainment industries. In response to the increasing demand for commercial UAVs, it also sparked innovation in the drone business, leading to the rise of new enterprises. Because of this modification, UAVs are now more practical for usage in fields including agriculture, photography, and rescue operations.

FIRST-EVER RWANDA MEDICAL DRONE DELIVERY (2013S)

The first medical drone delivery service in Rwanda was started in 2013 by the logistics business Zipline. Blood and medical supplies were delivered to faraway places by drones since conventional distribution methods were severely hindered by a lack of infrastructure. Because it proved that drones could swiftly transport life-saving supplies despite geographical obstacles, this was a watershed moment in the use of UAVs for healthcare. Drones have the ability to completely alter the dynamics of medical supply chains and emergency response, as shown by the success of this endeavor. It paved the way for similar



drone initiatives in hospitals throughout the globe. Zipline's Reach in Rwanda Grows in the 2016s. With the expansion of its activities in 2016, Zipline began delivering vaccinations, medications, and other essential healthcare supplies to rural areas of Rwanda. The expansion further cemented Zipline's position as a game-changer in the medical logistics industry, allowing for lightning-fast, on-demand delivery even to the most remote locations. This breakthrough ensured that rural people have access to life-saving resources by reducing the lack of key medical supplies. Furthermore, it demonstrated that healthcare delivery in underdeveloped nations might be greatly enhanced with the use of drones. Other nations with comparable infrastructure issues followed Zipline's lead and adopted comparable initiatives.

2017 World Health Organization and United Nations Drone Study. The use of drones for the delivery of emergency medical supplies was the subject of a research launched in 2017 by the WHO and the UN. In particular, the research looked at the viability of deploying UAVs for medical logistics in areas that are difficult to access or have been devastated by violence. According to the study's findings, drones have the potential to drastically improve emergency healthcare delivery by reaching previously inaccessible areas more quickly and lowering response times. Additional funding for healthcare solutions using drones was encouraged by this project, which educated the world on the pros and cons of using drones in this field. Launch of Medical Drone Trials by Matternet and UPS (2018S). The first testing of Matternet and UPS delivering medical goods using drones in US cities took place in 2018. Medical package transportation between healthcare institutions, with an emphasis on lowering delivery times and improving supply chain efficiency, was the primary goal of the experiments. These experiments proved that drones may enhance urban healthcare logistics by reducing the impact of traffic and urban sprawl. Expanding on earlier achievements in rural regions, this endeavor represented a major milestone in the integration of drones into regular medical delivery in industrialized nations. A nationwide drone delivery network has been launched by Ghana in the 2019S. The first global network for the delivery of medical supplies by drone was established in Ghana in 2019. The goal of this program was to ensure that underprivileged and rural sections of the nation have access to lifesaving medical commodities including blood and vaccinations. Zipline spearheaded the initiative, which marked a watershed moment in the integration of drones into national healthcare systems, particularly in underserved areas. This demonstrated that drones might be integrated into national healthcare logistics systems rather than only used for specific initiatives. Drones have become an integral part of global health after Ghana's success prompted other countries to investigate comparable schemes. DRONES IN THE RESPONSE TO COVID-19 (2020S).

Drones have the potential to revolutionize healthcare logistics in times of global emergency, as the COVID-19 pandemic demonstrated. To reduce the risk of human infection, testing kits, COVID-19 vaccinations, and personal protective equipment (PPE) were delivered to outlying areas using drones. Drones were quickly embraced by countries such as Ghana, the US, and the UK to aid in their response to the outbreak. During this time, medical deliveries using drones became more common, and their ability to bolster healthcare systems during emergencies was shown. The pandemic highlighted the adaptability of drones in handling international health crises. Germany's Medical Drone Services with Wingcopter (2021s). Wingcopter and the German government formed a partnership in 2021 to roll out medical drone services nationwide. Reduced delivery times and the rapid distribution of vital



medical supplies were achieved via the use of drones to transport vaccinations, medications, and diagnostic samples between hospitals. This program helped with the COVID-19 vaccine drive and made city healthcare supply chains more efficient. Additionally, it was a major milestone in the integration of drones into the healthcare infrastructure of Europe. Medical drone services may be easily scaled up in industrialized nations, as shown by Wingcopter's success in Germany. UPCOMING EVENTS (UP TO AND INCLUDING 2025) Improvements in autonomous drones' cargo capacity, flying range, and AI are anticipated in the near future. Drone deliveries will be even more efficient thanks to these advancements, which will make them dependable and able to handle bigger medical supply loads. It is widely expected that drones will become more important in the delivery of regular and emergency healthcare in the future, bolstering health systems in both urban and rural areas. Medical drone logistics has the potential to transform healthcare throughout the world by improving infrastructure and responding to changing rules in a timely manner. This will lead to more equal and rapid access to life-saving supplies.

II. METHODOLOGY AND MATERIALS REQUIRED

A. Product Shipping

The journey begins when medical supplies, such as blood, vaccines, medications, or medical equipment, are prepared for delivery at a designated distribution center or healthcare facility. These items are carefully packaged according to specific medical and safety protocols to ensure their protection throughout the transport process. For example, temperature-sensitive items, like vaccines or blood products, are placed in insulated containers with built-in refrigeration or temperature monitoring systems to maintain their integrity. The supplies are then loaded onto the autonomous drone, which is equipped with secure storage compartments designed to accommodate the different types of medical items. The packaging ensures that they remain safe, sterile, and in the optimal condition required for use upon arrival. At this stage, the drone is also programmed with specific delivery instructions, which may include the flight route, destination coordinates, and any special considerations such as restricted airspace, flight altitudes, or hazardous weather conditions. With the load secured and all systems checked, the drone is ready for takeoff.

B. Autonomous Flight

Once airborne, the autonomous drone enters the flight phase, during which it operates without human intervention. Using a combination of GPS technology, onboard sensors, and machine learning algorithms, the drone autonomously navigates its route to the destination. During this phase, the drone constantly gathers data from its environment, including weather conditions, air traffic, and potential obstacles such as tall buildings or power lines. The drone's flight system can autonomously adjust its altitude, speed, and course to avoid these obstacles and ensure a safe, efficient journey. For example, if it encounters unexpected weather such as strong winds or rain, the system adjusts its path to navigate around the weather or compensate for the conditions. The drone also tracks its battery life and ensures that it has sufficient power for both the journey to the delivery point and the return trip. In addition to these safety features, the autonomous flight system continuously monitors and adjusts the drone's stability, handling, and performance to ensure optimal flight efficiency throughout the mission.

C. Delivering the Product

When the drone reaches its destination, it begins the process of delivering the medical supplies. This phase involves precise landing or delivery mechanisms designed to ensure that the supplies are dropped off safely. Depending on the location and available space, the drone may either land on a flat surface, such as a rooftop, a designated landing pad, or an open area near the target. In situations where landing is not feasible, the drone may utilize an alternative delivery method, such as a winch system or a parachute mechanism to lower the supplies to the ground in a controlled manner. In either case, the delivery system is carefully calibrated to ensure that medical supplies reach the correct location and remain secure during the process. The drone might be programmed to communicate with a recipient, such as a healthcare worker or emergency responder, through a secure communication channel. This ensures that the person receiving the supplies is ready to retrieve them, allowing for a smooth handoff. For example, in an urban environment, the drone may deliver supplies directly to a hospital rooftop, where staff can immediately retrieve and begin utilizing them in response to an emergency situation.

D. Return Phase

After the successful delivery of medical supplies, the drone enters the return phase, which ensures that it can safely return to its base or recharge station. At this point, the drone autonomously navigates back along the best route to the starting point, taking into account its current battery levels, flight conditions, and any changes in the environment during the initial journey. If the drone encounters any issues—such as a drop in battery power or a technical malfunction—its onboard systems are programmed to take corrective action, such as rerouting or notifying a ground operator. Upon reaching the base, the drone either lands automatically or docks with a recharging station. During this process, the drone undergoes maintenance, such as battery recharging, system diagnostics, and reloading of any required medical supplies. This return phase is essential not only for preparing the drone for the next mission but also for ensuring that the drone fleet can remain operational in a continuous cycle of deliveries. Efficient return and maintenance processes are crucial to maintaining the overall speed and reliability of autonomous medical delivery systems, particularly in emergency response situations where rapid deployment is critical. Overall, each of these four steps is interdependent, ensuring that medical supplies are delivered quickly, efficiently, and safely to those in need, even in the most challenging environments. The combination of advanced technology, real-time decision-making, and secure communication ensures that drones can support critical healthcare systems, especially in times of crisis.

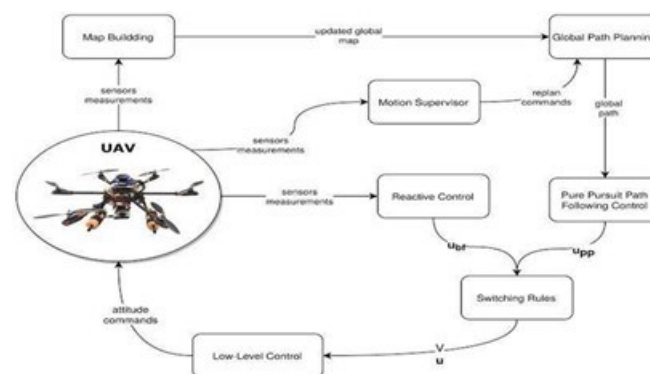


Fig.2. Map Building Methodology of Autonomous Drone



III. MATERIALS REQUIRED:

A. Drone Hardware

Frame and Structure: Lightweight and durable materials such as carbon fiber or high-strength plastic to provide a sturdy yet lightweight frame for the drone. These materials ensure that the drone can carry the payload (medical supplies) while maintaining flight efficiency.

- **Motors and Propellers:** High-efficiency electric motors and durable propellers designed to support vertical takeoff and landing (VTOL) and stable flight in various weather conditions.
- **Battery and Power System:** High-capacity lithium-ion or lithium-polymer batteries with long flight times, optimized for power efficiency. This ensures that drones can travel longer distances and complete deliveries without the need for frequent recharging.
- **Payload Compartment:** A secure, insulated, and possibly temperature-controlled compartment to carry medical supplies. The compartment should be designed to ensure safe transportation of fragile and temperature-sensitive items (e.g., vaccines, blood).
- **Landing Gear:** Robust landing gear or landing pads, designed to protect the drone during takeoff, landing, and emergency landings, while also being capable of handling varying surfaces like rooftops, fields, or helipads.
- **Navigation and Sensors:** GPS receivers, inertial measurement units (IMUs), magnetometers, and altimeters to help the drone navigate accurately and stabilize during flight. LIDAR or radar sensors may be used for obstacle detection and avoidance.

B. Communication Systems

- **Telemetry System:** A communication link (e.g., radio frequency, satellite communication, or cellular networks) to transmit real-time data between the drone and a ground control station. This allows operators to monitor drone status, flight path, and medical supply conditions.
- **Secure Data Transmission:** Encryption protocols and secure communication systems to protect sensitive health data and ensure privacy during the medical supply delivery process.
- **Autonomous Command and Control (C2) System:** A sophisticated software system to provide autonomous flight planning, navigation, and control. It allows the drone to perform missions without human intervention while maintaining a real-time connection to the command center.

C. Autonomous Navigation System

- **Flight Control Software:** Advanced algorithms for autonomous flight, enabling the drone to adjust its path based on real-time conditions such as wind speed, airspace congestion, and potential obstacles.
- **Obstacle Avoidance Sensors:** Ultrasonic sensors, cameras (e.g., infrared or visual), and radar systems for detecting and avoiding obstacles during flight, particularly in urban environments or rugged terrains.
- **Artificial Intelligence (AI) and Machine Learning:** AI algorithms for dynamic decision-making, optimizing flight paths, detecting hazards, and adapting to changing circumstances, such as emergency rerouting based on weather conditions or traffic.



D. Medical Supply Handling Equipment

- **Insulated Medical Containers:** Specialized containers for temperature-sensitive medical supplies like vaccines, blood, and medicines. These containers are equipped with temperature regulation mechanisms, such as cooling systems, to ensure that the supplies remain within the required temperature range.
- **Safety Seals and Packaging:** Secure packaging materials, including tamper-evident seals, to ensure that medical supplies are safely transported without contamination. This ensures that the supplies are intact when they arrive at their destination.
- **Payload Release Mechanism:** For remote drop-off or delivery, the drone may be equipped with a payload release system, such as a winch or drop mechanism that allows the supplies to be safely lowered to the ground at the destination.

E. Infrastructure and Ground Operations

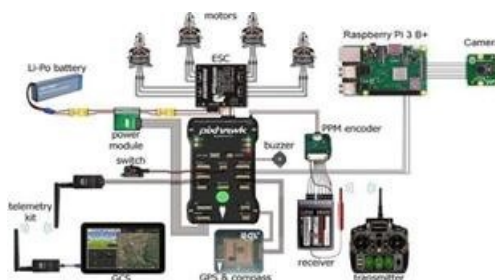
- **Charging Stations and Docking Stations:** Locations where drones can recharge their batteries between missions. These stations are essential for ensuring continuous drone operations. Charging stations may be located at healthcare facilities, emergency hubs, or central distribution centers.
- **Landing Zones:** Pre-designated safe landing zones, such as rooftops, helipads, or open fields, for the drone to deliver medical supplies. These zones should be equipped with beacons or lights to help guide the drone for landing in various weather conditions.
- **Remote Control and Monitoring Stations:** Ground control centers with operators who can monitor the drones' progress and intervene in case of emergencies or system malfunctions. These stations also manage real-time data and ensure the safety of the flight path.
- **Weather Monitoring Systems:** Real-time weather data feeds to help the drone system avoid flight during dangerous weather conditions such as thunderstorms, high winds, or fog. Weather stations can be located near drone operations hubs to provide local weather information.

F. Software and Data Systems

- **Flight Planning and Routing Software:** Software that allows for the automated planning of the optimal flight path, considering factors such as battery life, airspace restrictions, weather conditions, and destination coordinates. The system should also account for no-fly zones and obstacles in real-time.
- **Database for Medical Inventory Management:** A centralized system to track medical supplies, ensuring that the required items are available, properly packaged, and ready for transport. The system can provide live updates on the status of deliveries.
- **Data Logging and Monitoring Software:** Software to log flight data, including temperature and humidity conditions of medical supplies, flight times, battery usage, and route data. This ensures that each delivery meets the required standards and allows for future analysis and improvements.
- **Emergency Response Algorithms:** Software protocols for emergency situations that allow drones to make decisions, such as returning to the base in case of low battery or navigating around unexpected obstacles or airspace restrictions.

G. Regulatory Compliance Materials

- Licensing and Certification: Materials to ensure that all drone operations comply with local aviation regulations, including
- certifications from aviation authorities like the FAA (Federal Aviation Administration) or EASA (European Union Aviation Safety Agency).
- Safety Standards Compliance: Adherence to international safety standards for UAVs, medical delivery, and emergency operations. These materials help guarantee that the drones are designed and operated to meet rigorous safety, privacy, and security requirements.

**Fig.3.** Final Outcome of Project with Parts**Fig.4.** Pixhawk Flight Controller Connection in Autonomous Drone**A. PIXHAWK FLIGHT CONTROLLER**

The Pixhawk flight controller is a highly versatile and open-source hardware platform designed to manage and control the flight of unmanned aerial vehicles (UAVs), including autonomous drones used for medical supply delivery. Developed by the PX4 community and supported by numerous organizations, Pixhawk is renowned for its ability to provide robust flight control, advanced navigation capabilities, and real-time decision-making. It integrates a variety of sensors, including accelerometers, gyroscopes, magnetometers, and barometers, to monitor the drone's orientation, altitude, and movement, ensuring precise flight stabilization. The Pixhawk is compatible with various autopilot software stacks, such as PX4 and ArduPilot, allowing users to customize and configure the system to meet specific operational needs, such as autonomous navigation, obstacle avoidance, and mission planning. In medical delivery scenarios, the Pixhawk flight controller plays a critical role in enabling the drone to autonomously navigate complex environments, avoid obstacles, and adjust its flight path based on real-time data. Its open-source nature ensures continuous improvement and adaptation to new technological advancements, making it a popular choice for developers and researchers in drone applications. Additionally, Pixhawk supports multiple communication protocols, including GPS, telemetry systems, and real-time data streaming, allowing ground control operators to monitor the drone's performance and intervene if necessary.



With its high reliability, precise control, and adaptability, the Pixhawk flight controller is an essential component for deploying autonomous drones in emergency situations, where precision and safety are paramount.

HARDWARE MODULE	SPECIFICATIONS
Quadcopter	1) Well balanced structure & are comparatively light weight, 2) Fast & smaller in size. 3) Enough of space to carry necessary components. 4) Cheap to make & simple structure. 5) 90degree apart configuration ensures efficiency for image capturing. 6) They can lift a larger weight thus higher chance to survive from crash
Flight controller Board: PIXHAWK 2.4.5 PX4	1. It is very popular & powerful open-source drone controller. 2. 32-bit ARM Cortex M4 core with FPU 3. 168 kbps 256 KB RAM 2 MB Flash 4. 32-bit fallback co-processor 5. MPU6000 as main accel and gyro 6. ST Micro 16-bit gyroscope 7. ST Micro 14-bit accelerometer/compass (magnetometer) 8. MEAS barometer.
BLDC:	1) 1000KV BLDC's have significantly higher efficiency and performance. 2) Higher torque to weight ratio, output power & speed range. 3) Increased torque per watt of power input also increased efficiency. 4) Offers 2000-6000 RPM and torque less than 0.20mNm
BLHeli_32	1) An ESC BLHeli_32 is preferred since it is third generation and the latest of firmware. 2) It has 32-bit MCU which has increased processing power. 3) Faster input signals and much lower latencies can be achieved. 4) It also provides reversing of the motor and dynamic braking.
Radio telemetry & GPS	1) 3DR Single TTL MINI Radio Telemetry 433MHz 500mW for Pixhawk consists of Radio Telemetry Base Station, telemetry Transceiver, 5-pin Lead cable for APM FC, 6-pin Lead cable for Pixhawk FC, 2.5dBi Antenna. 2) It allows to link the flight controller & a Raspberry-pi 4 module & other OTG. 3) Pixhawk also supports global navigation satellite systems (GNSS) which includes Micro MSN GPS module for it. 4) It consists for build-in battery backup & 25*25*4 mm ceramic patch antenna. It has 1 second pulse & continues discipline frequency of 100Hz.
Raspberry pi 4 as a companion computer	1) Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz 2) 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE 3) Gigabit Ethernet 4) 2 USB 3.0 ports; 2 USB 2.0 ports. 5) Micro-SD card slot for loading operating system and data storage 6) 5V DC via USB-C connector (minimum 3A*) 7) 5V DC via GPIO header 8) A good quality 2.5A power supply can be used if downstream USB peripherals consume less than 500mA in total. 9) Raspi camera module is used
Li-po battery	1) It is robust and flexible and offers voltage of 11.2V 2) More lightweight as compared to others and have an extremely low profile 3) Lower chance of suffering from leaking electrolyte. 4) Safer in comparison and has less chances of explosion

Table.1. specification of hardware components for construction of autonomous drone

B. AUTONOMOUS OPERATION OF DRONES

Drones may be considered autonomous when they can fly themselves, making decisions, and navigating with the help of internal systems and algorithms rather than a human pilot. Drones are able to plan and carry out missions, make real-time modifications, and react to changing environmental circumstances because of a mix of communication technology, software, and hardware. Drones that can fly themselves rely on sophisticated flight controls, sensors, and AI to function. Drone sensors like GPS, accelerometers, magnetometers, and cameras provide data into the flight controller, which is often a Pixhawk. The drone's location, orientation, height, and environment may be better understood with the aid of these sensors. Drones can typically avoid impediments, adjust to changing weather, and reroute themselves if unforeseen difficulties arise thanks to artificial intelligence algorithms and machine learning methods. Waypoint navigation, in which the drone follows a set of predetermined locations in space, and dynamic mission planning, in which the drone determines and changes its course in real-time, are both capabilities of autonomous drones. As an example, drones have the ability to fly independently over both urban and rural regions, avoid barriers such as buildings and trees, and carry goods to specific places, all while

minimizing the need for human supervision.

Also, autonomous drones can communicate and interpret data on their own, so they may report back to a ground control station so that humans can keep tabs on the drone's location, speed, and cargo. The objective is to keep humans out of routine operations as much as possible, but they can step in remotely if needed to make sure everyone is safe. Drones may range from partially autonomous systems, where they can do some flying but still need human supervision, to completely autonomous systems, where they can finish whole missions without human intervention. The algorithmic complexity, sensor reliability, and legal context in which the drone operates affect its degree of autonomy. To sum up, unmanned aerial vehicle (UAV) autonomy is a game-changing technology that allows UAVs to gather data, conduct surveillance, and make deliveries with little to no human oversight. Drones can now carry out more complex tasks than ever before because to advancements in technology, sensors, artificial intelligence, and real-time communication. This is particularly true in emergency scenarios when every second counts.

C. PATH PLANNING

Path planning for autonomous drones in medical supply delivery is a crucial aspect that ensures efficient, safe, and timely transportation of critical resources, particularly in emergency situations. The process begins with defining the mission parameters, including the starting point, destination, and any intermediate waypoints, such as hospitals or remote medical facilities. Drones use advanced algorithms to plan the optimal flight path while accounting for various dynamic factors, such as real-time obstacles like buildings, trees, and moving vehicles, as well as adverse weather conditions like high winds or rain. The system continuously adjusts the route using data from sensors such as LIDAR, cameras, and radar to avoid collisions and adapt to changes in the environment. Additionally, battery life is a key consideration in path planning, with algorithms calculating the most energy-efficient routes to conserve power and ensure a safe return. The path planning system also ensures that the drone operates within airspace regulations, avoiding no-fly zones and adhering to local aviation rules. Real-time re-routing capabilities allow the drone to adjust its flight path if new obstacles, weather conditions, or airspace restrictions arise during the mission. In larger operations, path planning can also involve multi-drone coordination to avoid congestion and ensure efficient delivery. Ultimately, the path planning process combines advanced technology, real-time data analysis, and optimization algorithms to ensure that autonomous drones can deliver medical supplies quickly and safely, especially in critical, time- sensitive scenarios.



Fig.5. Comparing The Arial Route to Actual Route Mapping by Autonomimous Drone



Fig.6. Mapping in ARDU Software for Autonomous Drone

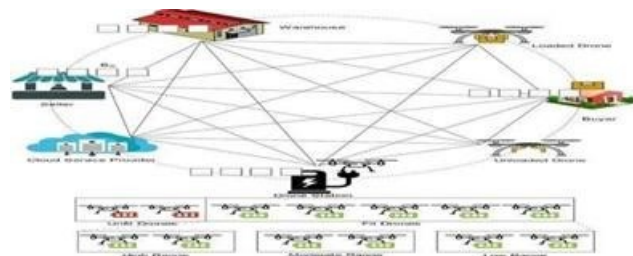


Fig.7. Plan of Drone Delivery Supplements

IV. FUTURE SCOPE

The future scope of autonomous drones for medical supply delivery in emergency situations holds immense potential for transforming healthcare logistics and response times. As drone technology continues to advance, we can expect significant improvements in range, payload capacity, and flight endurance, allowing drones to deliver a broader range of medical supplies over longer distances, even in remote or underserved areas. The integration of artificial intelligence (AI) and machine learning will enable drones to perform more sophisticated decision-making in real time, improving their ability to adapt to dynamic environments, avoid obstacles, and optimize delivery routes. Furthermore, advancements in battery technology, such as the development of longer-lasting and faster-charging power sources, will help drones operate more efficiently and increase their mission capabilities. Autonomous drones could also be integrated with real-time health monitoring systems, enabling the delivery of personalized treatments or critical medical supplies based on patient data. Additionally, regulatory frameworks and airspace management systems are expected to evolve, making it easier for drones to operate in urban environments and larger, more populated areas. With the growing adoption of 5G networks, drones will be able to communicate more efficiently, enhancing their coordination with ground control stations and other drones. This progress, combined with global advancements in automation, could lead to fully autonomous, large-scale drone fleets capable of delivering medical supplies anywhere in the world, significantly reducing response times during health emergencies and saving countless lives.

V. CONCLUSION

To sum up, the use of autonomous drones to transport medical supplies in times of crisis is an innovative step toward better reaction times and a complete overhaul of healthcare logistics. Delivering life-saving medical supplies to underserved or inaccessible regions has never been easier than with these drones, thanks to their enhanced navigational capabilities, obstacle avoidance skills, and real-time route adjustments.



They are able to optimize flight patterns and make intelligent judgments because to the integration of innovative technologies like AI, machine learning, and real-time data processing. These autonomous drones are now a dependable and scalable alternative for emergency medical delivery, and their breadth will only grow as battery technology, payload capacity, and regulatory frameworks continue to progress. At the end of the day, these drones might end up saving lives by making healthcare more accessible and responsive in even the most difficult places, decreasing delivery times, and making sure that life-saving medical supplies go where they need to go when they need to.

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