Design and Implementation of Drone Technology for Medical Supplement Delivery Services in Rural Regions

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Abstract - *More than 60% of the world's rural population lives in the Asia-Pacific region. Of these, more than 90% reside in low- and middle-income countries (LMICs). Asia-Pacific LMICs rural populations are more impoverished and have poorer access to medical care, placing them at greater risk of poor health outcomes. The first step in preventing poor health problems is to provide the appropriate care at the proper time. Timely emergency response can save lives and significantly accelerate recovery. Nowadays, drone are being used for various purposes, such as geographical surveys, rescue missions, inspection of industrial facilities, traffic monitoring, and delivery of cargo and goods. However, there is no commercially available technology that rectifies the issue of medical emergencies till now. As a result, we are designing of drone (air ambulance), which can transport medicinal products such as blood, vaccines, medicines, and also capable of providing telemedicine services in the Asia- Pacific rural region.*

***Key Words*: Asia-Pacific, Healthcare, Air Ambulance, Delivery drone, Telemedicine, Rural Region**

1. INTRODUCTION

The modern healthcare system represents some of the greatest achievements of the human intellect to improve the quality of people's lives. Despite this, many people in Asia-low-Pacific's and middle-income countries, rural populations, and underdeveloped regions continue to lack access to basic healthcare. Due to geographical challenge during emergencies reaching nearby primary health care center is difficult. Even the primary health care center having the problem of the shortage of medial supplements, technology and professional care takes. Thus, the accessibility of medical facilities to the people living in moderately populated and scarcely populated regions is low. Therefore we are implementing the drone delivery service to reduce the gap of the medical facilities in rural region where road transportation is challenging and difficult. The design process is majorly broken into three phases:

- Conceptual design
- Preliminary design
- Detail design

At first we are design our 3D model of the Medical Supplement Delivery drone (air ambulance) by using 3D modeling software and fabricate to meet certain requirements and criteria specified by user. To fabricate the drone we implement additive manufacturing technology, to rectify the complexity of the complex part such as propeller blade, winglets, landing gear, frame, cargo-box camera mount, etc. The drone functions are developing with the integration of software, mechanical and electronic parts.

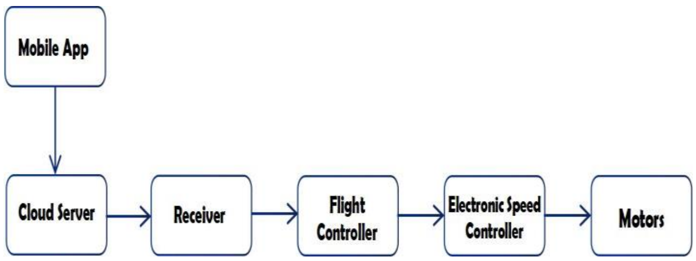

Fig-1: Block Diagram of Drone system

The motivation for the idea of using an air ambulance, which is capable of providing telemedicine and medical supplement delivery services, is to save the lives of people in the Asia-Pacific rural regions where road transport is either unavailable or takes a longer route. Potential applications of Air Ambulance in healthcare are broad based. They include:

- Prehospital Emergency Care through telemedicine
- Medical supplement delivery and
- Surveillance

In addition, they are being used in the identification of mosquito habitats and drowning victims at beaches as a public health surveillance modality. Medicines are typically lightweight but are extremely valuable in terms of their impact on the health of global populations, thus making these items a potential focus for the development of air based delivery solutions.

2. LITERATURE REVIEW

Drones, also known as unmanned aircraft vehicles, can fly long distances over dangerous terrains to deliver medication, vaccines, blood and diagnostic kits. Drones can help to ramp up national healthcare systems, and connect hospitals and laboratories with patients, improving outcomes and reducing waiting times, especially in remote communities. In order for healthcare supply chains to switch to drones, they must be cost-effective and user-friendly.Using drones to deliver healthcare is getting better over time. In the beginning, small test studies have demonstrated that when the government, humanitarian aid organizations, and drone system partners work together, they can improve healthcare access in remote, rural, and local communities all around the world.

The Indian Council of Medical Research (ICMR) released guidelines for drone use in the healthcare sector to ensure access to medicines, vaccines and other paraphernalia to all, especially in the geographically difficult terrains in the country. The move was based on an October 2021 pilot project conducted in Manipur and Nagaland, where COVID-19 vaccines, vaccines for routine immunisation programmes such as measles, mumps and rubella, antenatal care medicines, multi-vitamins, syringes and gloves were delivered. The guidelines were released on June 2 during the Bharat Drone Mahotsav 2022 in Delhi. It was based on field experience, which included an indegenious drone transporting COVID-19 vaccines in 12-15 minutes over an aerial distance of 15 kilometres from Manipur's Bishnupur district hospital to a primary health centre. Extensive qualitative research has been conducted on the advantages and risks associated with employing an Unmanned Aircraft System (UAS) for the delivery and distribution of various medical goods in well- established healthcare systems during routine operations. To accurately quantify these risks and benefits, it is essential to integrate knowledge from multiple research domains, including healthcare logistics and drone optimization. In the field of using delivery drones for medical services, there have been only a few research studies conducted and the results indicate that the drone services are mainly limited to delivering in city areas. There is still a lot to explore and understand about using drones for medical delivery in other regions. By comparative study it is seen that, existing technologies are not able to solve the traumatic situation of people living in rural region because of the territorial challenge, conventional manufacturing process, limitation of range and endurance, rules and regulations of the government, etc.

3. OBJECTIVE

The medicine delivery service plays a vital role in saving human lives during medical emergencies, and the delivery of medical supplements can be possible even in rural region can be possible. The Integrated Telemedicine service in an air vehicle guarantees that patients receive the appropriate care at the appropriate time. To save time spent on medicine distribution and emergency medical services in remote areas, it is economically more beneficial to the masses if such projects are performed and regulated by the government, as the need to create profits is significantly reduced. We use additive manufacturing technology to develop air ambulance parts such as propeller blades, winglets, landing gear, frames, camera mounts, and delivery boxes to reduce the complexity of complex part development, mass customization, and improved performance.

4. OUR DESIGN PHILOSOPHY

Drone design is the conceptual process of developing a flying machine on paper or on a modelling software to meet certain requirements and criteria specified. We can understand from the name itself that design requires practical experience rather than just a book. However, because theory and experimentation are intertwined, we should examine the available literature before starting on a comprehensive design approach.

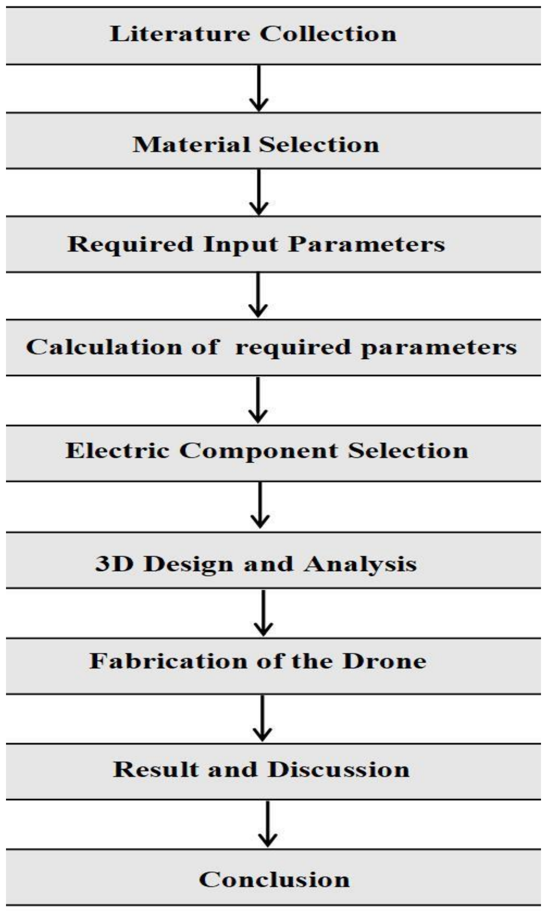

Fig-2: Design Methodology

The 3D model of the air ambulance is created using the solidworks software by using comparative study data of the various model and theoretical calculations. After that CFD wind tunnel simulation is utilized to conduct a transient analysis of physical variables involved with aerodynamic behaviour of the drone. CFD studies are being conducted to improve the efficiency of a wide range of devices. For fabricating the drone using materials such as Carbon fiber reinforced composites (CRFCs), Aluminum alloy, and various thermoplastics such as polyester, nylon, polystyrene etc. These materials are carefully chosen for the design to improve its performance with strong frames while keeping it lightweight through 3D printing or additive manufacturing. After fabricating the model, it can tested in a wind tunnel which is pretty useful for engineers as they can find ways to improve their designs by identifying areas where the lift-to-drag ratio can be increased.

The component which is used to design and develop the delivery drone is listed below:-

- Power Distribution Board
- Flight Controller
- Brushless motor – 5500 rpm / Thrust – 2400 N
- Battery Eliminator Circuit (BEC),
- Lipo Batteries – 84000 mah- 51.8v
- ESC = 30 amp ,
- Receiver: 16-Channel
- Transmitter – Wb37-4920 Mah-7.34
- Gps System - Beitian BN-220
- High Quality LED Display
- High Quality Camera With Gimble Support
- Attitude Sensors, Altitude Sensors, Air Speed Indicator

To select our drone specifications, we reviewed historical data and conducted a comparison analysis. Based on a comparative analysis and theoretical calculations, the air ambulance can successfully meet the parameters listed below.

Table-1: Model Specification

Specification	
Total Weight	18 kg
Take-off Weight	27 kg
Max. Thrust Weight ratio	1.80 (with a take-off weight of 42 kg)
Operating temperature	-10℃ to 40℃
Max. Fly speed	14.8 m/s
Max Service ceiling	3346 m
Pay load capacity	7.5 kg
Endurance	120 min
Range	25 km

4.1 Required Input Parameter

Developing a drone requires careful consideration of a range of input parameters, including:

Design specifications: This includes the overall dimensions of the drone, the shape of the cargo box, the size and shape of the control surfaces, and the positioning of the motor and landing gear.

Power source: The drone will require a power source to drive the motors and other electrical components. This can include batteries, fuel cells, or other energy sources.

Propulsion system: The propulsion system for the drone can include electric motors, propellers, or other systems that can move the aircraft through the air.

Control system: The control system for the drone can include servos, radio transmitters and receivers, and other components that allow the operator to control the movements.

Materials: The materials used to build the drone are also an important input parameter. This can include thermoplastic, fiberglass, carbon fiber, aluminium alloy and other materials that provide the required strength and durability.

Environmental factors: The environment in which the drone will be operated is also an important consideration. This can include factors such as atmospheric density, temperature, air pressure.

Reynolds Number: Reynolds number is a dimensionless quantity that is used to describe the flow of fluids, including liquids and gases. The Reynolds number (Re) is defined as the ratio of inertial forces to viscous forces within a fluid. It is calculated using the following formula:

$$Re = (\rho VL) / \mu$$

Where:
ρ is the density of the fluid
V is the velocity of the fluid
L is a characteristic length of the flow
μ is the dynamic viscosity of the fluid

4.2 Electrical Component Selection

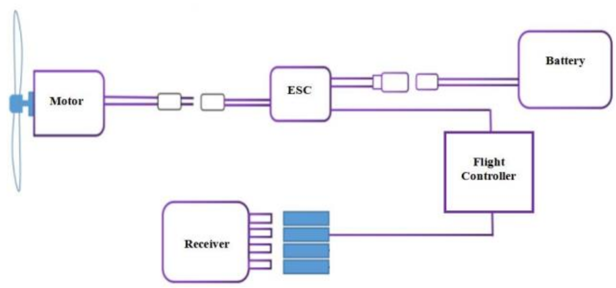

Fig-3:Basic connection of electronic component of drone

An electronic component is a fundamental part used to build electronic circuits. These components are designed with specific electrical properties and functions, making them suitable for various applications. In a drone's electronic setup, you'll find various components like motors, electronic speed controller, flight controller, batteries, transmitters, receivers, camera, sensors, wires, etc. These components are essential for controlling the movement and functionality of the drone.

4.3 Purposed Design of model

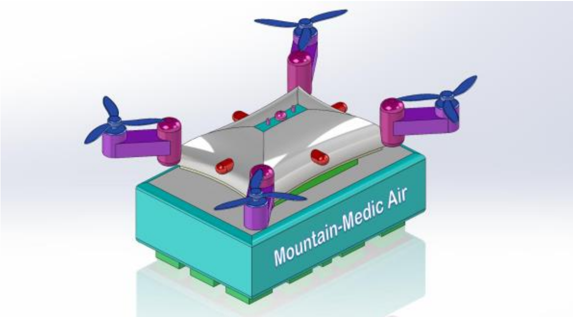

Fig-4: Proposed design model

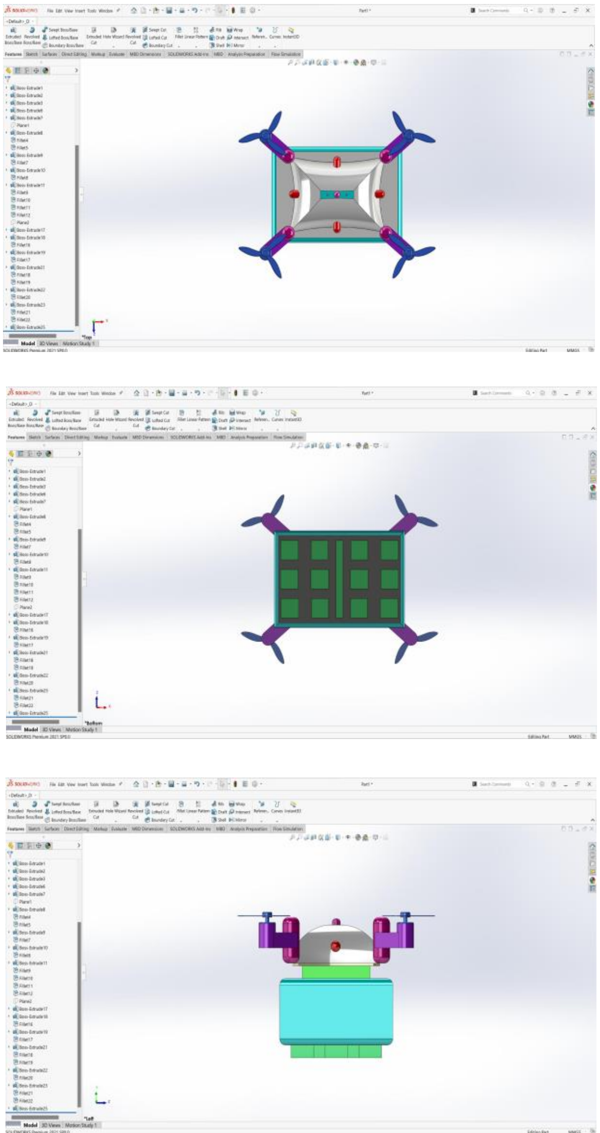

Fig-5:. Three View Diagram of the drone

During this preliminary design stage, minor modifications are made to the configuration arrangement from the conceptual design. In this process, serious structural and control system analysis and design take place. Additionally, significant wind tunnel testing and CFD (Computational Fluid Dynamics) simulations of the entire flow over the aircraft design will be conducted during this phase. At the end of preliminary design, the airplane configuration is fixed.The primary goal of this phase is to prepare the industry ready for the full-scale development of Air Ambulance. In the detail design considers each individual component like the ribs, spars,every rivets, bolts, section of skin, paints etc, takes place. In this design the connection and allocations are made.With the detail design stage, the assessments for aerodynamics, propulsion, structures, and flight control have all been completed. At the end of this design cycle,the drone is ready to be manufacture.

4.4 Additive Manufacturing

Additive manufacturing (AM) is a process that uses a digital design to create three-dimensional solid objects layer by layer. It enables unrivalled flexibility in component design and production in comparison to traditional method of production therefore the difficulties during the manufacturing are easily attained.Using 3D printers for these purposes is called rapid prototyping. Rapid prototyping is the fast fabrication of a physical part, model or assembly using 3D computer aided design (CAD).

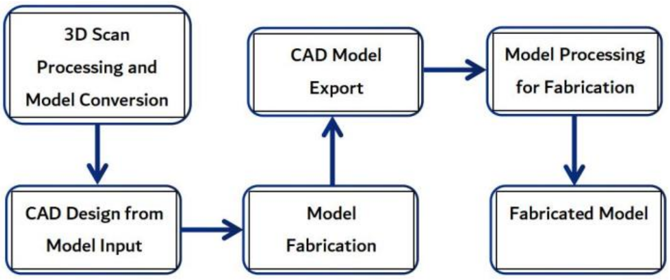

Fig-6: Additive manufacturing fabrication process

The first step is creating a digital design using CAD software. After finishing the 3D modeling, the user-friendly design needs to be converted into a file with machine-readable instructions. This allows the manufacturing machines to accurately and reliably create the designed objects. This process is known as G-Code generation. The exact steps required to create such filewill depend greatly upon the type of machine you will use for the production.

5. Potential Application

By investigating the technical feasibility and potential benefits of drone-based supply chains, this study presents an approach to addressing healthcare accessibility challenges.The primary objective of this application is to improve healthcare access and equity in regions where traditional transportation infrastructure is lacking. Drones have the potential to significantly reduce delivery times, ensuring that patients receive essential medical supplements in a timely manner. In emergency situations, drones can play a crucial role in delivering life-saving medications promptly, thereby contributing to more effective emergency response systems. The drone also offers the opportunity to collect valuable data on health trends and disease prevalence in under served areas. Equipped with sensors, drones can gather information that aids healthcare providers and policymakers in making informed decisions regarding resource allocation and public health strategies. The drone can be integrated with video-conferencing via Google Glass, was designed to deliver an emergency supply medical kit. The proposed application not only addresses logistical challenges but also contributes to data-driven healthcare interventions. By using the capabilities of drones in routing, navigation, and real-time monitoring, this application has the potential to revolutionize the healthcare supply chain, reduce healthcare disparities, and ultimately enhance patient outcomes in areas that have historically struggled with healthcare accessibility.

CONCLUSIONS

The medicine delivery service plays a vital role in saving human lives during medical emergencies, and the delivery of medical supplements can be possible even in rural region can be possible.The Integrated Telemedicine service in drone guarantees that patients receive the appropriate care at the appropriate time. To save time spent on medicine distribution and emergency medical services in remote areas, it is economically more beneficial to the masses if such projects are performed and regulated by the government, as the need to create profits is significantly reduced. We also use additive manufacturing technology to develop drone parts such as propeller blades, winglets, landing gear, frames, camera mounts, and delivery boxes to reduce the complexity of complex part development, mass customization, and improved performance. Looking ahead at the potential of the drone, plans include integrating a GPS system for tracking the drone's location and facilitating its retrieval in case of system or power failures. Furthermore, the addition of multiple Medkit boxes could enable the drone to deliver medical supplies to several locations in a single flight. To extend flight duration's, the incorporation of high-capacity batteries is under consideration for future enhancements. Considering Asian political policies regarding the healthcare system, the dynamic capabilities in aerospace manufacturing sectors and societal needs, the development of air ambulance will benefit the Asian communities as well as global communities.

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