

Design And Implementation of Medical Supplies Delivery with Solar Powered Drone

Arshini Gubbala¹, Pullela Abhinaya², Kanoor Rohan Venkat³, Polisetty Naveen Kumar⁴, Logisa VarahaNarasimha⁵

¹Assistant Professor, Department of ECM, Vignan's Institute of Information Technology (A), Visakhapatnam.

^{2, 3, 4, 5}Dept. of ECM, Vignan's IIT (A), Visakhapatnam.

Abstract: Now-a-days, the benefits of drone technology have generated interest in its possible uses in a number of sectors, including medical. The proposed solar-powered drone delivery system designed specifically for the efficient distribution of medical supplies in remote or disaster-affected areas. The system addresses the challenges associated with traditional delivery methods, such as transportation delays, infrastructure limitations, and high operational costs. By harnessing solar energy, the drones can operate autonomously for extended periods, reducing the reliance on conventional fuel sources and minimizing environmental impact. The integration of real-time monitoring and navigation systems ensures safe and accurate deliveries, while remote control capabilities enable seamless adaptation to changing circumstances. The implementation of this innovative solution has the potential to enhance access to critical medical resources, improve response times during emergencies, and ultimately, save lives. The system explores the technical specifications, operational considerations, and potential benefits of deploying solar-powered drones for medical supply delivery, highlighting the transformative impact of technology on healthcare logistics.

Index Terms: Solar drone, Medical Delivery, Solar Delivery, Medical Drone.

Introduction:

By integrating these two critical aspects, we can optimize the performance of drone fleets, ensuring timely deliveries while maximizing operational uptime. This introduction delves into the intricacies of joint routing and charging strategies, highlighting their significance in the context of logistics drone deployment [2]. The integration of drones into the logistics and transportation sector has shown promising potential for revolutionizing last-mile delivery operations. optimizing the energy efficiency of

drone delivery remains a critical challenge, particularly in urban environments where congestion and limited battery capacity pose significant constraints [6]. Through advanced algorithms and machine learning techniques, drones can adapt their routes dynamically, ensuring timely and reliable parcel delivery over long distances. This innovative approach not only enhances operational efficiency but also opens up new possibilities for last-mile delivery in remote areas, ultimately reshaping the future of logistics [7]. An innovative method for controlling drone deployment to reduce overall delivery time is presented using a simulation-based process model in the realm of logistics optimization. This innovative approach holds immense potential to revolutionize last-mile delivery services, unlocking unprecedented levels of speed and agility in the drone logistics landscape [9]. The integration of synchronized truck and drone routing represents a pioneering advancement poised to revolutionize the industry [3]. The last centimeter personal drone delivery field deployment involves the final segment of the delivery process, where the drone lands and delivers the package directly to the user [12]. Innovative system leverages the strengths of both modes of transportation to enhance efficiency and delivery capabilities. By intelligently routing trucks to strategic locations and deploying drones for last-mile deliveries, this system minimizes delivery times and maximizes resource utilization [10]. The method involved meticulous planning based on various factors such as geographic terrain, population density, delivery demand, and flight range limitations. This approach maximizes the network's reach while minimizing energy consumption and operational costs, ultimately enhancing the scalability and viability of drone delivery services in diverse environments [5]. We envision a truck-assisted drone-based delivery system where a truck carries, up to a suitably selected DP, the drone along with a mobile pod that stores all the packages to be delivered by the drone. This reduces the distance traversed for each delivery and allows multiple deliveries with the same battery [1]. When simply the truck delivers, the suggested model may considerably enhance the outcomes. Furthermore, a

GRASP metaheuristic to tackle larger-scale cases [4]. presented the MFP, which investigates the viability of using a drone to transport items from a depot to a specific client on a budget that includes restricted energy batteries [8]. Leveraging advanced algorithms and real-time data analytics, CBDNs optimize charging schedules, minimizing downtime and maximizing operational efficiency for drone fleets [11].

System Under Study:

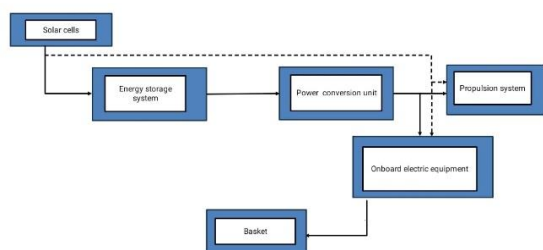


fig.1 block diagram of medical supplies delivery with solar powered drone

Fig. 1 illustrates the block diagram of medical supplies delivery with solar-powered drones where each component plays a crucial role in ensuring the seamless operation and successful transportation of essential healthcare items to remote or underserved areas. High-efficiency solar cells integrated into the drone's design capture sunlight, powering onboard systems and reducing reliance on conventional energy sources. Complemented by advanced energy storage systems, such as lithium-ion batteries, excess solar energy is stored for use during low-light conditions or night time flights. A sophisticated power conversion unit optimizes energy efficiency and voltage regulation, facilitating the transfer of energy between solar cells, batteries, and onboard electronics. The propulsion system, consisting of electric motors and propellers, provides thrust for stable flight, while cargo baskets securely transport medical supplies, protecting them from environmental factors. Onboard electric equipment, through the integration of various interconnected components, solar-powered drones promise to revolutionize healthcare logistics, enabling timely and efficient delivery of life-saving medical supplies to communities in need, irrespective of geographical constraints or infrastructure limitations.

Literature Survey:

The literature survey reveal that several research studies focused on developing devices based on public transport usage, optimal path algorithm which reduced the travelling cost and delivery time,

operational cost. Francesco Betti Sorbelli et al., [1] the study proposes a novel evaluation framework considering both grid layouts and compares the performance of drone delivery systems in pure Euclidean versus mixed grids. The findings emphasize the importance of accounting for urban layout complexities in optimizing drone delivery routes, offering valuable insights for enhancing efficiency in real-world logistics. Muhammad Yeasir Arafat et al, the study proposes a joint strategy that integrates routing decisions with charging considerations to enhance efficiency of drone-based logistics operations. By optimizing both routing and charging simultaneously, the proposed approach aims to minimize energy consumption and maximize delivery performance [2] Dyutimoy Nirupam Das et al, proposed a coordinated approach to efficiently manage delivery operations by integrating both ground vehicles and drones. This synchronization allows for dynamic task assignments, considering factors such as delivery urgency, distance, and traffic conditions [3].

Javier Gómez-Lagos et al., [4], the study proposes a coordinated strategy to leverage both ground vehicles and drones for efficient delivery operations. By dynamically assigning tasks to trucks and drones based on factors such as distance, delivery urgency, and traffic conditions, the approach aims to improve delivery speed and reduce costs. Hailong Huang et al, the proposed model focuses on addressing the critical issue of energy management in drone logistics by strategically locating charging stations. By employing advanced optimization techniques, the proposed method aims to decide where charging stations should be placed to get the most coverage, minimize energy consumption, and improve the operational efficiency of drone delivery networks [5]. Hailong Huang et al[6], introduced a novel approach to optimize drone delivery routes by leveraging existing public transportation networks. The study proposes a round trip routing strategy that minimizes energy consumption while maximizing delivery efficiency. By integrating drones into the existing public transportation infrastructure, the proposed method aims to reduce the overall environmental impact and operational costs of drone delivery systems. Hailong Huang et al[7], developed a optimization of drone routing within time-dependent networks to facilitate cost-effective and long-range parcel delivery. The study addresses the challenge of efficient route planning for drones by considering dynamic factors such as varying traffic conditions and time-sensitive delivery requirements. Francesco Betti Sorbelli et al[8], focused on developing strategies to ensure the efficient and reliable delivery of goods by drones, even when faced with unpredictable wind patterns that can significantly impact energy consumption and flight stability. By incorporating energy constraints and wind variability into the optimization framework, the

proposed approach aims to mitigate the risk of energy depletion and maximize delivery performance .David Swanson et al, developing a simulation-based process model that can effectively optimize the deployment of drones for parcel delivery operations. By leveraging simulation techniques, the proposed model allows for the dynamic allocation of drones to delivery tasks in real-time, considering factors such as distance, traffic conditions, and delivery urgency[9]. Desheng Wang et al[10], routing and scheduling strategies to efficiently coordinate both independent drones and drones carried by trucks for parcel delivery. By leveraging hybrid delivery approaches, the proposed methodology aims to maximize delivery efficiency while minimizing costs and resource utilization. Jinyong Kim et al, this model addressing the challenge of limited battery life in drone networks by leveraging cloud-based resources for efficient navigation and charging. The proposed CBDN system aims to extend drone flight time and enhance operational efficiency by dynamically routing drones to charging stations based on real-time battery levels and workload distribution [11]. Przemyslaw Mariusz Kornatowski et al., [12], the practical implementation and user experience of drone delivery services at a very local scale, emphasizing the final segment of the delivery process— the last centi-meter.

Materials And Methods:

Frame Selection:

Select a light weight and durable frame material such as carbon fibre or aluminium to construct the drone's chassis.

Battery Selection:

An 11.1V 2200mAh LiPo battery is a specific type of rechargeable battery commonly used in various applications, including remote-controlled vehicles, drones, radio-controlled aircraft, and portable electronic device.

Table 1: Specifications of Battery

Specifications	Description
Capacity	2200mah
Nominal Voltage	11.1v
Configuration	3S1P
Discharge Rate	40C
Max Burst discharge rate	80C

Motor Driver:

One kind of synchronous electric motor that runs on direct current (DC) power is the brushless DC (BLDC) motor. It's called "brushless" because it operates without brushes and commutators, which are common components in traditional brushed motors.

Features:

- Voltage Range: 24V to 72V
- Maximum Continuous Current: 50A
- Peak Current: 100A

Transreceiver for drone control:

The Flysky FS-i6 is a popular transmitter used in radio-controlled (RC) hobbyist applications, particularly in the realm of RC aircraft, drones, cars, and boats.

Table 2: Specifications of controller

Specification	Description
RF range	2.4055 – 2.475 GHz
Bandwidth	500KHz
RF Power	Less than 20dBm
Channels	6

Mathematical Parameters:

Energy consumption per distance:

$$E_c = E \cdot D / S \quad \text{eq(1)}$$

Equation (1) gives the energy consumed by the drone per unit distance(E_c) depends on the distance to be covered(D), solar power available(E), and energy efficiency(S)

Maximum payload capacity:

$$P = E / S \quad \dots\dots\dots\text{eq(2)}$$

Equation (2) determines the maximum payload capacity (P) the drone can carry based on the available

solar power (E) and energy consumption per distance(S).

Flight time:

$$T=V/D \dots\dots\dots \text{eq(3)}$$

eq(3) the time taken by the drone to complete the delivery (T) is calculated by dividing the distance (D) by the cruise speed(V).

Solar power generation Equation:

$$E_s= \eta_s \times I \times A_s \dots\dots\dots \text{eq(4)}$$

Equation (4) The energy generated by solar panels depends on factors such as panel efficiency (η_s), sunlight intensity (I), and the area of solar panels (A_s).

Implementation:

The implementation of a medical supplies delivery system utilizing solar-powered drones encompasses a multifaceted approach, weaving together technological innovation, logistical planning, regulatory compliance, community engagement, and ongoing evaluation. At its core lies a meticulous process beginning with a thorough assessment of healthcare needs in underserved regions, identifying gaps in infrastructure and access to essential supplies. This initial phase serves as the foundation for crafting a comprehensive strategy that addresses specific challenges while aligning with overarching goals of improving healthcare equity and outcomes.

Technology selection and design are pivotal, requiring collaboration between drone manufacturers, aerospace engineers, and healthcare experts to tailor drones to meet the unique demands of medical supply delivery. This involves not only outfitting drones with solar panels for sustainable power but also designing payload compartments capable of preserving the integrity of temperature-sensitive medications and vaccines during transit. Rigorous testing under various environmental conditions ensures reliability and performance, while adherence to aviation regulations and safety standards secures necessary permits and approvals for operation.

Infrastructure setup involves establishing ground control stations equipped with state-of-the-art communication systems, enabling real-time monitoring and remote piloting of drones. This infrastructure forms the backbone of the delivery network, facilitating seamless coordination between operators, healthcare

providers, and local authorities. Moreover, robust cybersecurity measures safeguard sensitive data and protect against potential threats, ensuring the integrity and security of the system. Training and capacity-building initiatives are crucial for empowering personnel with the skills and knowledge required to operate and maintain the drone delivery system effectively. This includes training drone operators in flight operations, maintenance technicians in equipment upkeep, and healthcare workers in supply chain management practices. Additionally, community engagement efforts foster acceptance and support for the technology, addressing concerns and misconceptions while highlighting its potential to improve healthcare access and outcomes.

Continuous monitoring and evaluation mechanisms are integrated throughout the implementation process, enabling stakeholders to track delivery performance, assess impact, and identify areas for improvement. Data-driven insights inform iterative refinements to the system, optimizing efficiency, reliability, and scalability over time. As the system matures, opportunities for scale-up and expansion emerge, paving the way for broader adoption and impact across additional regions and healthcare contexts.

Flowchart:

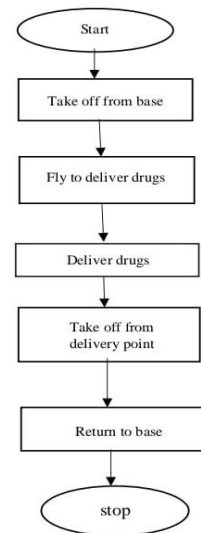


Fig.2 Flow Chart of Proposed System- Medical supplies delivery with solar powered drone

Fig. 2 the operation of medical supplies delivery with solar-powered drones begins with the careful loading of essential supplies into the drone's payload compartment at designated distribution centers or healthcare facilities. These drones, equipped with

specialized designs featuring expansive photovoltaic panels, efficiently convert sunlight into renewable energy to power their propulsion systems, enabling sustained flight over vast distances without reliance on traditional fuel sources. As the drones take flight, they autonomously navigate through advanced GPS, inertial navigation, and sensor technologies, continuously adjusting their flight path to avoid obstacles and adverse weather conditions in real-time. Throughout the delivery process, communication with ground control stations and satellite networks ensures accurate monitoring of the drones' position, flight trajectory, and operational status. Upon arrival at the designated delivery location, the drones initiate their descent with precision, facilitating the secure unloading of medical supplies by trained personnel or awaiting recipients. Following the completion of the delivery mission, the drones may return to their base for recharging and maintenance or be redeployed for subsequent delivery missions, maximizing operational efficiency and impact. This seamless integration of renewable energy, advanced aerial technology, and precision logistics exemplifies the transformative potential of solar-powered drones in overcoming geographical barriers and enhancing healthcare accessibility for remote and underserved communities. As research and development efforts continue to progress, solar-powered drones are poised to revolutionize healthcare delivery models, ultimately improving health outcomes and promoting global health equity on an unprecedented scale.

Result And Discussion:



Fig. 6.1 Front View of Medical Supplies Delivery with Solar Powered Drone

Fig. 6.1 depicts a vast and rugged landscape, with a solar-powered drone gracefully navigating through the azure sky, propelled by gleaming solar panels harnessing renewable energy. Laden with essential medical supplies, the drone's payload compartment represents a beacon of hope for remote communities

awaiting critical healthcare interventions. With state-of-the-art navigation systems, the drone effortlessly traverses challenging terrain, symbolizing the promise of improved healthcare accessibility. Against the backdrop of nature's grandeur, the figure encapsulates the transformative potential of solar-powered drones in revolutionizing healthcare delivery to remote regions, serving as a testament to the convergence of technology and humanitarianism.



Fig.6.2 Top View of Medical Supplies Delivery with Solar Powered Drone

Fig. 6.2 illustrates the process of medical supplies delivery via solar-powered drones orchestrates a symphony of technological sophistication and renewable energy utilization, revolutionizing the landscape of healthcare logistics. Initiated at distribution centers or healthcare facilities, essential medical supplies are meticulously loaded into the drone's payload compartment, which serves as a beacon of hope for remote communities awaiting vital healthcare interventions. Once airborne, the drone's sleek silhouette is embellished by solar panels, eagerly absorbing sunlight to power its onboard systems and propellers, ensuring sustained flight over vast distances without the encumbrance of traditional fuel dependency. Guided by state-of-the-art navigation systems and real-time monitoring, the drone autonomously charts its course through rugged terrain and unpredictable weather, skilfully circumventing obstacles with precision and efficiency. Upon reaching its destination, the drone executes a graceful descent, delivering its payload with pinpoint accuracy to waiting recipients or on-site personnel.

Conclusion:

In conclusion, the integration of solar-powered drones into medical supplies delivery systems heralds a new era of innovation and opportunity in healthcare logistics. Through a combination of renewable energy utilization and cutting-edge technology, these unmanned aerial vehicles have demonstrated their potential to overcome longstanding challenges of

accessibility, affordability, and timeliness in healthcare delivery, particularly for remote and underserved communities. Despite notable progress, however, several avenues for future exploration and development remain open. Research efforts should focus on optimizing drone design and performance, enhancing autonomy and navigation capabilities, and refining logistical protocols to maximize efficiency and scalability. Additionally, collaborative initiatives involving government agencies, healthcare providers, technology developers, and regulatory bodies are essential to address legal and regulatory frameworks, safety standards, and public acceptance issues surrounding drone operations. Looking ahead, the future scope for medical supplies delivery with solar-powered drones holds tremendous promise, with the potential to revolutionize healthcare delivery models, improve health outcomes, and promote global health equity on an unprecedented scale. As we continue to innovate and evolve in this field, it is imperative to remain committed to the overarching goal of leveraging technology for the betterment of humanity, ensuring that no individual is left behind in the pursuit of accessible, affordable, and equitable healthcare for all. In future we would like to increase the capacity of holding the medicines and the distance it can travel to delivery medicines.

References:

- [1] Sorbelli, Francesco Betti, Cristina M. Pinotti, and Giulio Rigoni. "On the evaluation of a drone-based delivery system on a mixed euclidean-manchattan grid." *IEEE Transactions on Intelligent Transportation Systems* 24, no. 1 (2022): 1276-1287.
- [2] Arafat, Muhammad Yeasir, and Sangman Moh. "JRCS: Joint routing and charging strategy for logistics drones." *IEEE Internet of Things Journal* 9, no. 21 (2022): 21751-21764.
- [3] Das, Dyutimoy Nirupam, Rohan Sewani, Junwei Wang, and Manoj Kumar Tiwari. "Synchronized truck and drone routing in package delivery logistics." *IEEE Transactions on Intelligent Transportation Systems* 22, no. 9 (2020): 5772-5782.
- [4] Gómez-Lagos, Javier, Alfredo Candia-Véjar, and Flavio Encina. "A new truck-drone routing problem for parcel delivery services aided by parking lots." *IEEE Access* 9 (2021): 11091-11108.
- [5] Huang, Hailong, and Andrey V. Savkin. "A method of optimized deployment of charging stations for drone delivery." *IEEE Transactions on Transportation Electrification* 6, no. 2 (2020): 510-518.
- [6] Huang, Hailong, Andrey V. Savkin, and Chao Huang. "Round trip routing for energy-efficient drone delivery based on a public transportation network." *IEEE Transactions on Transportation Electrification* 6, no. 3 (2020): 1368-1376.
- [7] Huang, Hailong, Andrey V. Savkin, and Chao Huang. "Drone routing in a time-dependent network: Toward low-cost and large-range parcel delivery." *IEEE Transactions on Industrial Informatics* 17, no. 2 (2020): 1526-1534.
- [8] Sorbelli, Francesco Betti, Federico Corò, Sajal K. Das, and Cristina M. Pinotti. "Energy-constrained delivery of goods with drones under varying wind conditions." *IEEE Transactions on Intelligent Transportation Systems* 22, no. 9 (2020): 6048-6060.
- [9] Swanson, David. "A simulation-based process model for managing drone deployment to minimize total delivery time." *IEEE Engineering Management Review* 47, no. 3 (2019): 154-167.
- [10] Wang, Desheng, Peng Hu, Jingxuan Du, Pan Zhou, Tianping Deng, and Menglan Hu. "Routing and scheduling for hybrid truck-drone collaborative parcel delivery with independent and truck-carried drones." *IEEE Internet of Things Journal* 6, no. 6 (2019): 10483-10495.
- [11] Kim, Jinyong, Seokhwa Kim, Jaehoon Jeong, Hyoungshick Kim, Jung-Soo Park, and Taeho Kim. "CBDN: cloud-based drone navigation for efficient battery charging in drone networks." *IEEE Transactions on Intelligent Transportation Systems* 20, no. 11 (2018): 4174-4191.
- [12] Kornatowski, Przemyslaw Mariusz, Anand Bhaskaran, Gregoire M. Heitz, Stefano Mintchev, and Dario Floreano "Last- centimeter personal drone delivery: Field deployment and user interaction." *IEEE Robotics and Automation Letters* 3, no. 4 (2018): 3813-3820.