# Versatile Autonomous Delivery Drone System

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*Abstract*—**In today's modern world, time is the precious resource that the human race cannot have enough of. Optimizing various aspects of daily routines of households as well as institutes and organizations is the biggest motivation in the scene of today's innovative world. One of the most crucial and most common aspects that takes place at the heart of all industrial processes is cargo transportation and distribution/delivery. However, unfortunately, the current modes of transportation and delivery are slow, costly, harmful to the environment, prone to casualties and errors and are extremely cumbersome. Through this project, we aim to design and develop a complete cargo delivery system using the modern drone technology which provides other organizations services to fulfill their transportation and distribution requirements via a faster, reliable, safe and low cost-per-kilometer-rate solution. The idea is to develop an elaborate delivery drones system which is compliant with the NPNT (No Permission No Take-off) standards set by India's DGCA (Directorate General of Civil Aviation). These services can be purchased and used by organizations of all industrial sectors to deliver their goods at an intra-city scale. The NPNT-compliant drones are a much more trusted alternative in the world of India's drone technology over China imported drones which do not follow DGCA's NPNT standards.**

***Keywords— delivery drones, autonomous, IAM, NPNT, DGCA, automation.***

## I. Introduction

Today, we rely on pickup trucks or motorcycles for distributing and delivering goods to households, companies or other institutes. These vehicles are driven by humans. Which means that if the vehicle were to meet with an accident, it puts the life of driver person in danger. Additionally, this conventional method of goods transportation uses the medium of roadways which are clogged with heavy traffic in an average metropolitan city. This roadway traffic consequently delays the delivery process significantly. In case of residential deliveries, this puts a negative impact on customer satisfaction. But in case of live donor organ transportation or donor blood transportation, it can cost a human life. Due to the existing system being driven manually by people, there are always chances of anomaly, irregularity or other journalistic conflict causing significant time in remedying. Lack of strong computer aided algorithms always makes for an inefficient and problematic system. Understandably, since the speed and rate of deliveries and distribution operations in the conventional on road methods of today is low, the number of total deliveries and distribution that are completed overall in a day are less than what they could have been if there had been a much faster mode of delivery and distribution. This causes a significant loss for industries like e-commerce and food which use the system of deliveries to make their products reach their customers. We aim to overhaul the delivery system to create a new mode of cargo transportation which is fast, operationally cheap, automated and safe by making use of the growing modern technology of electronic vertical take-off and landing unmanned aerial vehicles (eVTOL UAV), also known as drones. These problems faced by customers and companies due to the conventional slow and accident prone delivery systems inspire to innovate and create this new mode of cargo transportation which operates in the traffic free medium, air. The powers of drone technology has many applications in the modern world. Their operational precision and speed is what motivates us to design this system which would make for a hassle free, automated and precise delivery system.

## II. Problem Statement

The current systems of urban home delivery or goods transportation involve some inefficient and highly accident prone methods like the usage of human driven motorcycles and pickup trucks. These options not only turn out to be points of failure for the industries, they also pose a threat to human life because of the high probability of road accidents in crowded metropolitan cities.

This is a clear problem for industry operators as well as common consumers due to the apparent threat to human lives and customer experience and general Quality of Life (QoL).


Fig. 1 Current methods of urban home delivery.

## III. Literature Survey

Most studies in residential delivery optimization solutions and inter-infrastructure cargo transportation mainly include the usage of algorithms for optimizing routing in order to achieve minimum delivery time or incorporating other conventional modes of transportation in the goods delivery picture. The study done by M. Grazia Speranza in the paper titled "Trends in transportation and logistics (August 2016)" [1] provides a short review of the trends in transportation and logistics with evolving technologies. It provides an insight towards the notion of using the latest emerging technologies in the field of transportation and delivery systems. This paper helps towards the consideration of incorporating the modern eco friendly and robust drone technology in the ecosystem of urban freight transport. Next, the paper published by Laijun Zhao et al. titled "Path optimization model for intra-city express delivery in combination with subway system and ground transportation (February 2019)"[2] presents a study showing the use of path optimization algorithms in order to optimize the delivery time by the road transportation methods. The team also presents a delivery model which hypothesizes the possibility and effects of combining subway systems in the process of delivery systems. Furthermore, I-Lin Wang's paper titled "Distribution of small packages in metropolitan area by motorcycle courier services (January 2008)"[3] analyzes the usage of motorcycles in the process of urban residential small package distribution. The author sheds light on the improvements in delivery time and the increased reach of the delivery process as well as the possibilities of undesirable accidents with said approach. Finally Johan Visser provides an exhaustive study of urban freight transport and residential delivery and modern advancements in the same by e-commerce websites with the considerations of alternative vehicle use in his paper titled "Home Delivery and Impacts on Urban Freight Transport: A Review (June 2013)"[4].

*TABLE 1*

SUMMARY OF LITERATURE SURVEY

| Sr. No. | Paper Title | Author | Year |
|---|---|---|---|
| 1 | Trends in transportation and logistics | M. Grazia Speranza | August 2016 |
| 2 | Path optimization model for intra-city express delivery in combination with subway system and ground transportation | Laijun Zhao et al. | February 2019 |
| 3 | Distribution of small packages in metropolitan area by motorcycle courier services | I-Lin Wang | January 2008 |
| 4 | Home Delivery and Impacts on Urban Freight Transport: A Review | Johan Visser | June 2013 |

## IV. Objective and Scope

This autonomous delivery drone system is so designed that the customer organization (e.g. hospital, factory, e-commerce website, restaurants) can purchase the service from our manufacturing company which allows them to purchase a number of NPNT compliant autonomous delivery drones which will be parked in tenanted warehouses for battery recharging. Whenever a service of delivery is requested by the organization, a drone with sufficient battery power and load carrying capacity will take off from the warehouse and reach the nearest drone port to the source hub of the organization. Here an employee of the customer organization will place the cargo within the drone port which will be automatically placed inside the drone. Once the cargo has been loaded, the flight path has been validated and billing has been done, the drone will take off from the source drone port and reach the destination in a very short time with 100% accuracy and avoiding harm to

the mass and all this while emitting zero direct carbon emissions from the machines making the world a bit greener every time. The system can potentially be employed by a range of different industry sectors from healthcare to manufacturing to FMCG goods delivery to food delivery and many others. The possibilities are boundless.

## V. System Architecture

In this paper, the drone based delivery system is hypothesized and visualized in depth. The operation flow, business model, operational requirements and installation requirements are stated in detail in this paper. The entire system architecture consisting of all the components and functional endpoints of the system are listed and explained exhaustively. The proposed system consists of:

### *A. Customer Organization:*

Any organization or independent individual which requires on demand immaculate delivery services approaches us, the manufacturing entity and purchases a number of delivery drones which can be used in the delivery and distribution process of the customer.

### *B. Delivery Requester:*

An individual on behalf of their own self or a sub-unit of one of the customer organizations requests a delivery to take place which will transfer a certain package from one of the endpoints of the organization to another or from the source hub to a household.

### *C. Customer Application:*

Web based and mobile based applications are made available to the customer organization which purchases the delivery drones from the manufacturer. The delivery requester uses this application to place a delivery order manually and feed in the details about the package, source location, destination location and other minor details. The application forwards the request to the management server for business logic, billing system, best available drone selection, delivery time estimation and other essential operations.

### *D. Management Server:*

A headless backend management server placed on the cloud which performs the business logic calculations, billing, drone selection, etc. and accordingly generate the delivery order details, order number, drone number to perform the delivery, closest source drone port, destination drone port and the estimated delivery time. The management server is also responsible for contacting the Directorate General of Civil Aviation (DGCA) server and take permission for performing the delivery by use of the delivery drones. Once all of this process are validated and verified, the delivery is sent ahead to take place.

### *E. Drone Ports:*

Small infrastructure for loading and unloading of packages, charging of battery and temporary parking of the delivery drones.

### *F. DGCA Compliant Delivery Drones:*

Fully autonomous and DGCA No Permission No Takeoff (NPNT) compliant delivery drones are used in this delivery drones system.

### *G. IAM Server:*

A high powered robust durable server responsible for performing client validation, identity verification and access management for manufacturers, customer organizations as well as final end cargo receiver

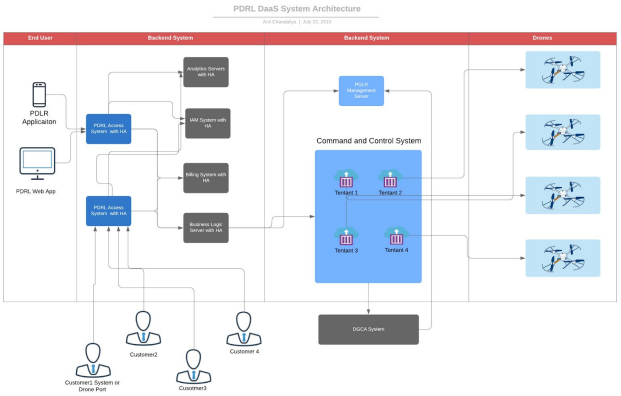


Fig. 2 System Architecture

## VI. Hardware To Be Used

### *A. LiDAR Sensor*

This sensor is capable of sensing distance of surroundings by the use of laser technology to map the environment. This sensor proves to be a very important tool in the process of critical collision detection and avoidance.


Fig.3 360º LiDAR

### *B. GPS:*

Global Position System sensor provide geo-location information of the system accurate to a precision level of 1 meter. This sensor is interfaced through the USART communication which provides a serial

communication between the controller and the sensor for data transmission


Fig.4 GPS sensor

*C. Gyroscope, Accelerometer and Magnetometer sensor (IMU sensor):*

A complete AHRS (Attitude and Heading Reference System) for estimating the position and orientation of the flight device.

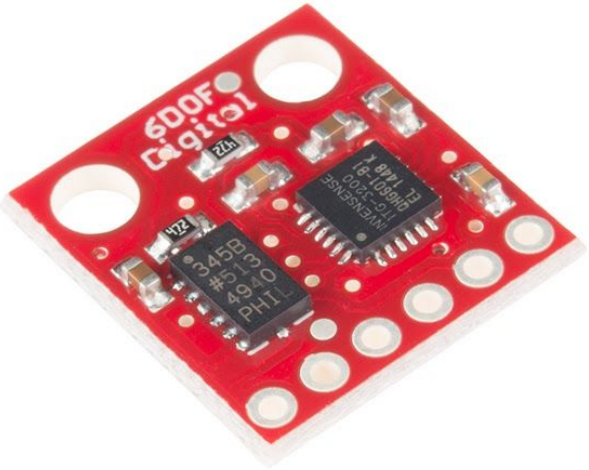


Fig.5 IMU sensor

*D. STM32F7 Microcontroller:*

A combination of STM32F7 microcontrollers are used in the delivery drones for high performance, compact size and various interfaces

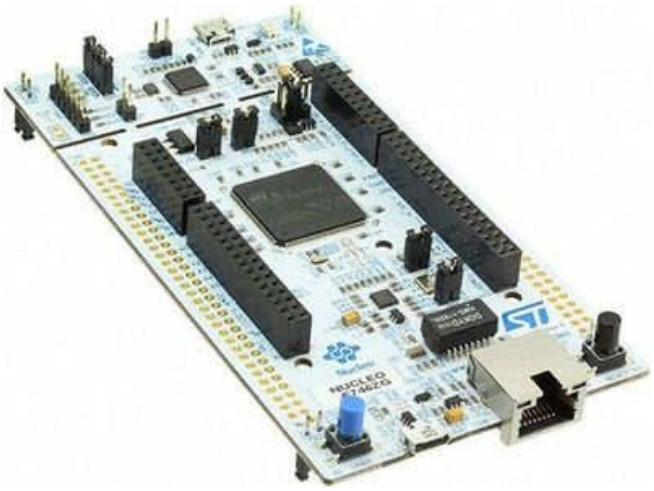

Fig 6 STM32F7 Microcontroller

*E. Nvidia Jetson Nano Single Board Computer :*

For collision detection and avoidance system and other critical high performance tasks are carried out by the Jetson Nano board which is equipped with a GPU on board for parallel computations on a compact embedded system

Fig.7 Nvidia Jetson Nano

Fig. 8 AeroVan Delivery Drone

## VII. Drone Based Metropolitan Delivery Method

Through this system we provide a versatile solution to various industry sectors to implement a new mode of goods transportation which operates at 100% efficiency, is safe, accurate, operationally cheap and eco friendly. The system provides an on demand delivery request based service which is met by high availability for enabling faster operations to businesses thus increasing profit, end user experience and general QoL. The system implements highly secure measures and standards for delivery request verification, identity verification, permission requests etc. to ensure the optimal level of security for all the participants of the system.

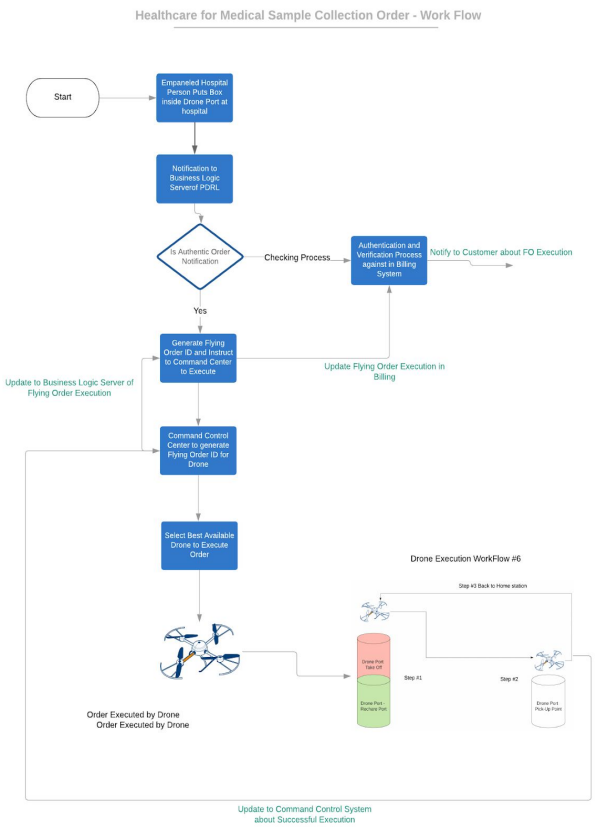


Fig 9. Drone Based Delivery System Flow Diagram

## VIII. Advantages:

The proposed system of small to medium size cargo transport provides a much more efficient, safe and secure solution one of the most common processes of many businesses and industries, delivery/transportation/distribution. It does so by:

• Providing an eco friendly method of transportation by using electricity as the primary source of energy which can be produced by non conventional and renewable energy generation methods

• Delivering much faster delivery time increasing overall business transactions and increasing business profit

• Reducing cost per kilometer of deliveries

• Fully autonomous and robust flight and routing algorithms ensuring accuracy and safety at all conditions

## IX. Limitations:

The limitation of this system is the fact that the system can only function at an intra-city level. Meaning the deliveries and transportation cannot take place from one city to another. However, further research in improving battery capacity or overhauling the energy source to implement a more efficient solution can help overcoming this limitation

## X. Conclusion:

In this paper, we hypothesize and describe a novel delivery and distribution system which can be implemented by various business and non profit organizations to meet their delivery and distribution requirements via a cheap, highly efficient, eco friendly and modern method by use of quadcopter electric Vertical Take Off and Landing drones which are fully compliant with India's DGCA standards namely NPNT in contrast to the chinese manufactured drones populating the current drone business in India. We aim to produce an efficient method for delivery which improves the overall life of the mass and makes trivial things less expensive for the common population.

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## XII. References:

[1]M. Grazia Speranza "Trends in transportation and logistics", 2016, pp 1-10
[2] Laijun Zhao et. al, "Path Optimization Model for Intra-City Express Delivery in Combination with Subway System and Ground Transportation", 2019. Sustainability, pp 1 - 25
[3] I-Lin Wang, "Distribution of small packages in metropolitan area by motorcycle courier services", 2014. National Cheng Kung University, International Journal of Integrated Supply Management
[4] Johan Visser, "Home Delivery and the Impacts on Urban Freight Transport: A Review", Conference Paper in Procedia - Social and Behavioral Sciences, 2013.
[5]https://dgca.gov.in/digigov-portal/
[6]https://jungleworks.com/npnt-compliance/
[7]https://docs.aws.amazon.com/IAM/latest/UserGuide/introduction.html
[8]https://store.cuav.net/index.php?id_product=28&rewrite=cuav-ublox-m8n-gps&controller=product
[9]https://www.seeedstudio.com/RPLIDAR-360-degree-Laser-Scanner-Development-Kit-p-1823.html
[10]https://en.wikipedia.org/wiki/Quadcopter
[11]https://en.wikipedia.org/wiki/Inertial_measurement_unit
[12]https://www.st.com/en/microcontrollers-microprocessors/stm32f7-series.html
[13]https://www.amazon.com/NVIDIA-Jetson-Nano-Developer-Kit/dp/B07PZHBDKT