

Urban Framework Integration for Drone Delivery Services in Mixed Use Area

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Abstract— *Fast-moving consumer content (FMCC) has the highest share of the market after e-commerce in India. Thereby, last mile delivery services (LMDS) are also increasing supporting the FMCC in the market through human services. But, human powered delivery faces many obstacles in urban context like traffic, pollution and physical distancing. These are urging towards a reform in LMDS strategies. Thus, this study is aimed to analyze alternate delivery services in the cities. The paper is aimed to explore the emerging drone industry for commercial activities in mixed use areas. The study is to devise frameworks and guidelines to accommodate drone delivery services(DDS) as a green technological approach. The research majorly focuses on integrating DDS with architecture and urban design framework. The focus of the study is the examine drone infrastructure in a qualitative manner with supporting literature studies of Amazon air, zomatao etc. The study includes the policy level support of various projects, their stakeholders, infrastructure and their technologies. The paper concludes with a framework at Urban and architectural level including the revisions in the policy. The main agenda of the research is to propose a DDS friendly neighborhoods through architectural and design frameworks.*

Index Terms— *Unmanned aerial vehicle, Drone, Drone rules 2021, Amazon Air, Drone Frameworks.*

I. INTRODUCTION

Digital Transformation and Fast moving Consumer Content (FMCC) have changed the traditional retail and commercial market in the world. Human supported last mile delivery services (LMDS) are bridging the gaps between the traditional and contemporary economic system. But, human induced services faces many obstacles in urban context especially due to the current pandemic situation (covid-19). Issues like congestion, emission, delivery costs, digital transformation and the need for physical distancing are urging towards a reform in LMDS strategies.

Drones also known as Remotely Piloted vehicle (RPV); Remotely Piloted aircraft (RPA), Unmanned aerial vehicle (UAV) or Unmanned aerial system (UAS)[3] are the new emerging technology worldwide. Their usage is widely accepted in defense; infrastructure development; agricultural surveys; urban planning; emergency services and various other fields. Due to their characteristics like maneuverability, versatility and efficiency, drone technology has the potential to overcome human impacts and limitations [13].

Thus, exploring drone technology in rapid development (or redevelopment) there is a need to examine drone supporting Infrastructure and Policies. The following paper is aimed to develop a framework for drone delivery services in urban areas. The focus of the study is the examine drone infrastructure in a qualitative manner with supporting literature studies of Amazon air, zomatao etc. The study includes the policy level support of various projects, their stakeholders, infrastructure and their technologies. The paper is focused on the delivery of goods in mixed landuse specific to India but with universally acceptable approach. Thus, the

Drone policy of India, 2021 is also analyzed and compared with literature studies. The paper concludes with a framework at Urban and architectural level including the revisions in the policy. The paper is only based on theoretical proposals and lacks any experimental examination. Thus, there is a scope for the application of the frameworks for specific locations.

II. DRONE RULES AND REGULATION IN INDIA

Quoted by Indian Union minister “India to become a drone hub by 2030” [14], the government is promoting innovative and adaptive drone ecosystem in India. Several policies and rules like the Drone (Amendment) rules (2022); National UTM policy Framework (2021); PLI Scheme for drones (2021) and Certification schemes for drones (2021) are established for the way forward.

As shown in Figure 1, DGCA (Directorate General of Civil Aviation) under Ministry of Civil aviation are responsible for all the aviation activities and polices of drones in India. The drone rules, 2021 (Amended 2022) [3] has classified UAV into following categories based on the maximum all-up weight including payload:

- 1) **Nano** unmanned aircraft system: weighing less than or equal to 250 grams;
- 2) **Micro** unmanned aircraft system: weighing more than 250 grams, but less than or equal to 2 kg
- 3) **Small** unmanned aircraft system: weighing more than 2 kg, but less than or equal to 25 kg;
- 4) **Medium** unmanned aircraft system: weighing more than 25 kg, but less than or equal to 150 kg; and
- 5) **Large** unmanned aircraft system: weighing more than 150 kg.

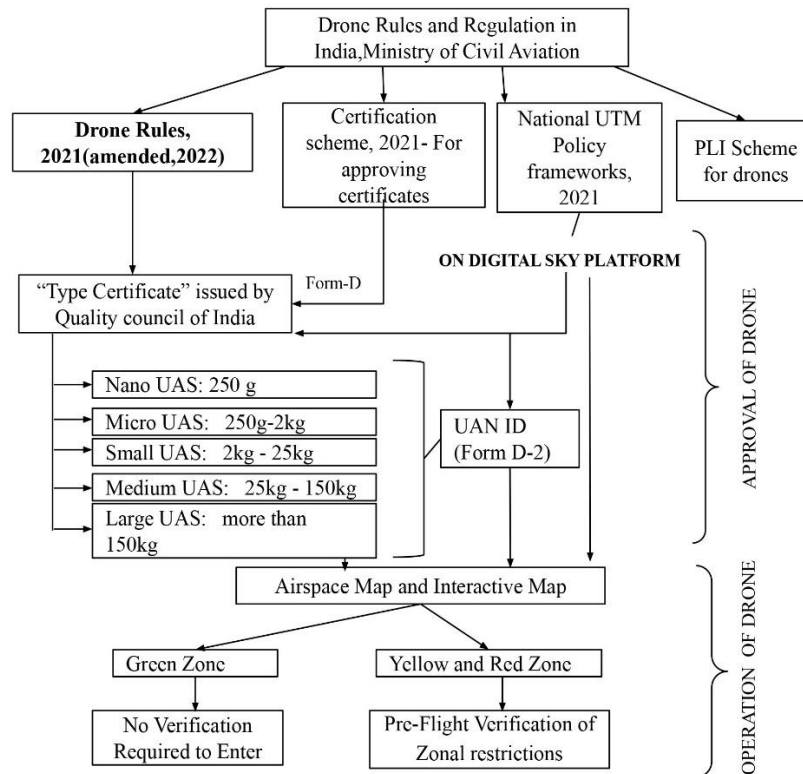


Figure 1 Shows the Approval and operation of Drones in India, Source: Author

The mentioned categories are used for issuing “Type Certificates” for the drone on ‘Digital sky’ platform (through Form-D). And are approved by Quality council of India under Certification scheme (2021) with the requirements as; “No permission-No take-off” hardware and firmware; real time tracking and Geo-fencing capability [3]. The approval process only monitors the real-time information and effectiveness of drones. No data is collected regarding the purpose, need or location for flying the drones. Though the

location criterion is controlled by ‘Digital Sky’ block.

After approval, each drone is enabled with Unique Identification Number (UIN). It helps in the management of UTM ecosystem in India [6] (pg.10) which is machine readable Application Programming Interface (API) enabled and interactive in nature. This Operation of unmanned aircraft system is provided on ‘Digital sky’ block where the airspace of India is segregated into three types : Green Zone, Yellow Zone and Red zone as shown in Table 1.

Table 1 Features of the Drone Airspace Maps,

| Parameters | Green Zone | Yellow zone | Red Zone |
|---|---|--|--------------------|
| Airspace | Upto 400’ not designated as yellow or green zone | 400’ above green zone | ‘No drone zone’ |
| Airspace from the perimeter of operational airport | Upto 200’ above the area located between 8-12 km from perimeter | Above 200 feet in the area located between 8-12 km from the perimeter and above ground in the area located between 5-8 km from the perimeter | - |
| Permission for Drone operations | No permission for all-up weight upto 500 kg | Air traffic control authority – AAI, IAF, Navy, HAL etc. | Central Government |

Source: [2] The drone airspace is subject to change

The Indian airspace for Drones (UTM airspace) upto 1000 feet above ground level, i.e Very Low Level (VLL) airspace consists of these zones. The parameters for their classification is given in Table 1 which includes Airspace distance, Airspace from operational airport and any other restrictions by government. These zones help in flight planning, Synchronization (based on surveillance, weather, terrain, communication), Deconfliction and UAS health

monitoring. Any change in zones should be verified first from the concerned authority. Any flight in the Red and Yellow zone would need a pre-flight verification of zonal restrictions. Whereas green zone doesn’t require any verification. Figure 1

Though, location control is done through zones in Indian airspace. The parameters are very generic. The parameters lack the sensitivity towards Human-drone conflicts (Social

impact assessment)) and Nature-Drone conflicts (Environmental impact assessment) while approving drones and delineating the zones.

A. Stakeholders Involvement

The commercial clearance to fly drones required applications and interactions with multiple agencies as given in Table 2.

Table 2 Stakeholders Involved in Drone Rules, India;

| No. | Stakeholder | Responsibility |
|-----|--|--|
| 1 | Directorate General of Civil Aviation | Import clearance; Issuance of UIN; Issuance & Renewal of UAOP; Suspension / Cancellation of UIN & UAOP in case of violations of regulations. |
| 2 | Directorate General of Foreign Trade | Import license |
| 3 | Ministry of Home Affairs | Security clearance |
| 4 | Ministry of Defense | Permission for aerial survey/imageries/ videography/ still photography over the restricted/prohibited areas on a case-to-case basis |
| 5 | Indian Air Force | Air Defence Clearance Monitoring of RPA movements in the country |
| 6 | Wireless Planning and Coordination Wing, DoT | Equipment Type Approval (ETA) or License for RPA |
| 7 | Bureau of Civil Aviation Security | Approval of the Security Programme |
| 8 | Airport Authority of India | Flight Plan Approval Monitoring of RPA movements in the country |
| 9 | Local Police Office | Enforcement of violators as per applicable IPCs |

Source: [6]

B. Conclusion:

The Drone rules, 2021 promotes a drone ecosystem in India. But, it is very Machine-centric rather than Human-Centric. The rules focus on drones rather than the purpose of drone which can lead to safety issues in future. The policy also lacks Human-drone and Nature-Drone considerations while delineating the zones. The entire rules are very ambiguous in terms of Quantity.

III. LITERATURE STUDY 1: PRIME AIR

With the challenge of quick, cost-effective and safe customer service, ‘Amazon prime air’ by Amazon has developed drone delivery services in US, case taken, Lockeford, California. The site consists of industrial property, rural communities, and heavily managed agricultural lands. The operation of prime air is governed by the federal aviation administration (FAA) of America. The management system of FAA is Human centric and includes an operation approval in the form of EIA. The EIA assessment considers 1) Biological Resources (including Fish, Wildlife, and Plants); 2) Department of Transportation for any public places; 3) Historical, Architectural, Archaeological, and Cultural Resources; 4) Noise and Noise-Compatible Land Use; 5) Environmental Justice (for minority and low-income population); 6) Visual effects (Change in landuse, landform or visual character of the area) and; 7) Water resources. Other than these, FAA also considers social impact during approval regarding operation

at night, over a human being, from a vehicle etc. The FAA considers Human-Nature-Drone relationship.

A. Description of Proposed Operations

The entire Amazon operation of UAs from central PADDCC (landing and launching zone) is given in Figure 2, considering aircraft of maximum weight (41.5 kg); speed of “52.4 KTS” (27 m/s), altitude of 165 ft, AGL (above ground level) and sound of 67.7 db. The timings of the service from 7:00 am to 10:00 pm is the impact of noise sensitivity in the area.

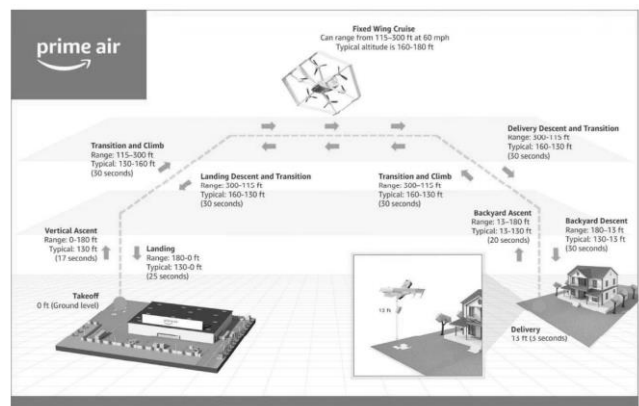


Figure 2 A Graphical Depiction of the Proposed Amazon Prime Air MK27-2 Flight Profile to a Destination; Source: Amazon, August 2022

As mentioned in [1] pg,105. the typical flight operations of Amazon air start with 1. Takeoff and vertical ascent; 2.

Transition and climb outbound; 3. Fixed-wing cruise outbound; 4. Delivery descent and transition; 5. Backyard descent, delivery, and ascent; 6. Transition and climb inbound; 7. Fixed-wing cruise inbound; 8. Landing descent and transition; 9. Vertical descent and landing. These are called PADDC Infrastructure. PADDC is planned to be situated in a Noise sensitive zone as mentioned above. Each PADDC is designed for four landing and launching pads operating in the individual sector respectively.

IV. LITERATURE STUDY 2: DOMINOS PIZZA

Domino's Pizza Enterprises Limited and Flirtey drone delivery system (Sky Drop) has tied up for pizza delivery through drones. To avoid the traffic congestion and reduce the delivery time initiative has been taken. The experiment happened with a test flight in Whangaparaoa, about 20 miles north of Auckland. The test has been carried out by considering the temperature of food and cooperation with the government. Ordering pizza from their phone and drone will deliver it to the doorstep. It will fly at the height of 200 feet and the customer will notify when the delivery is approached. The drone will be lowered down with pizza while keeping a safe distance from the consumer.

V. LITERATURE STUDY 3: ZOMATO INDIA

Zomato India's one of largest food delivery apps also successfully tested drone technology to deliver food to the consumer and collaborated with Tech Eagle for this experiment. The experiments have been conducted through hybrid drone. It covered the distance of 5km within 10 mins of time. Speed limit was 80kmph. The load carried by this drone was 5kg [12].

VI. LITERATURE STUDY 4: CAA, UK

The UAS drone rules in the UK are governed by the 'UK Civil Aviation Authority (CAA)'. Their drone flight rules are very simple yet effective and open for various functions of drones.

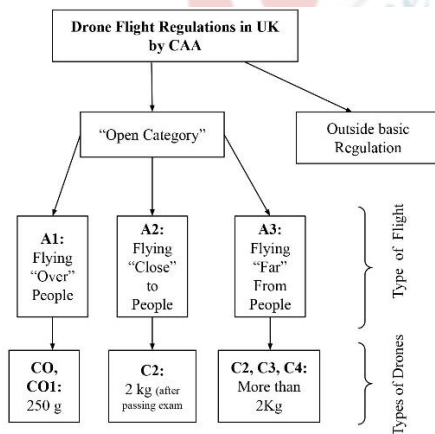


Figure 3: Shows Approval and Flight Regulation, CAA; Source: Author

The categorization and approval process for drone flight is given in Figure 3. The regulations for flying a drone there is based on following norms [7] :

1) pass the online test and hold a Flyer-ID; 2) be responsible; 3) Flight in Visual Line of sight; 4) not fly more than 400ft/120m above the surface and no flight in restricted zone without permission; 5) UAS must weigh less than 25Kg. Fulfillment of these regulations allow drones flight without approval in any given area under the category "Open". These categories are further divided based on flight and type and weight of drones, Figure 3. The rules are also flexible for the drone flights which are outside the basic regulation limit and require an operational authorization from the CAA. The authorization is based on a 'Risk assessment' of flight which includes the proposed operation plan; its process; technical aspects and safety demonstrations. Overall the regulations are comprehensible and efficient with transparency in the approval process. Also, the regulations consider human-drone interaction during approval process consisting of Flying over people, close to people and far from people. Though, the regulations don't include any environmental factors.

VII. MIXED LANDUSE (IN INDIA)

Land Use is the use of land permitted to the people i.e., can be Residential, Commercial, Industrial, Mixed, green, agriculture etc. Among these classification, mixed land use is a type which allows residential, commercial, institutional, Industrial or any other landuse. Typologies of mixed zones in India as per URDPFI Guidelines, 2014: (1) Mixed Industrial use: M1; (2) Mixed Residential use: M2 & (3) Mixed Commercial use: M3. Zone M1 consists of Non-Polluting Industries with 20-30% other land uses. Whereas Zone M2 consists of 60% Residential coexisting with other landuse. While M3 is 60% commercial and Institutional coexisting with other landuse [15].

As per [8] the mixed landuse can be Vertical or Horizontal. The vertical landuse is when a single building shares different uses like Residential, small shops and other activities. Whereas in horizontal landuse, the neighborhood will have various uses of buildings together. The paper considers both vertical and horizontal types of mixed landuse area considering a high/medium density development. There is a need to do on-site analysis of mixed use areas specific to a location for more detailed analysis.

A. Impact of drones on mixed use area

The paper [4] has researched an important issue of spatial privacy in residential and Public areas. The paper talks about the privacy issues people feel like threatened, noise or physical presence of drones in private space. This is seen through a 'Privacy triangle' comprising three domains namely; informational privacy, spatial privacy and uncertainty. The experimental study concludes that drone

flights above or 50 m in height have little effect on social activities while flights at 20 m create spatial privacy within people. Thus uncertainty should be reduced by awareness among people of the drone flight. Other Impacts can be due to noise on the people.

VIII. PROPOSED FRAMEWORK AND REVISIONS IN DRONE RULES, 2021

The paper proposes several frameworks for Urban and Architectural scale, especially for Indian cities, to be implemented for drone delivery services. The proposals are generic to have a universal usage. The paper suggests revisions in Drone Rules, 2021 (India) and provides frameworks for approval, identification of launch, landing and delivery zones at infrastructure level, Figure 4.

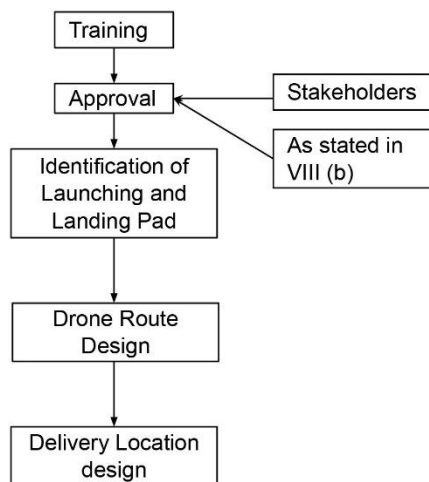


Figure 4 : Shows Proposed Framework,
Source: Author

A. Training

UAV operators training programme based on the type of drones, requirements of platform are very necessary. The important part of the training is the simulation to enhance the skills and operating the vehicle in a smooth manner.

Simulation is one of the way through which real life situations can be dealt in a controlled environment. As discussed in [10], has included UAV's different components, control systems and procedure for pre-flight measure, takeoff and landing with maintenance. The Drone rules, 2021 has measures to apply as a pilot and be trained in Digital Sky Platform. The same can be encouraged especially to work in conditions of mixed use environment.

B. Approval

Experimenting with UAV required designated approvals from different authorities as given in Table 2 for India. The analysis of the literature concludes that Drone rules, 2021 lacks major human centric approvals. The following are proposed framework for various parameters to be considered while 'approving' any Drone flight:

- 1) **Privacy (of public) in case of mixed use zone:** As per the literature the drone flight should be above or **50 m in height** to reduce spatial privacy. The drones in India are monitored by Digital sky, can share the location with public to reduce uncertainty and information Privacy. Also, a monitoring is necessary for the drones for the kind of information they are accessing (privacy of people). The same can be dealt with human resources on drone centres connected with particular UID's.
- 2) **Noise Problem in Mixed use zone:** As per Amazon air study, speed of "52.4 KTS" (27 m/s), altitude of 165 ft, AGL (above ground level) creates sound of 67.7 db which is normal for Humans. This can be kept as a minimum standard especially in mixed use area. The timings of service of drones can be between 7 am-10 pm (though further area specific research needs to be done).
- 3) **Risk Assessment:** As per CAA literature study, the risk assessment should be an integral part of approval process as it states the intention of the project. The risk assessment shall include the proposed operation plan; its process; technical aspects and safety demonstrations.
- 4) **Environmental Impact Assessment:** It is very necessary to evaluate the environmental impact of drone for any area before approval. The types of zoning in Drone airspace map of India (Digital sky) need computed with respect to Biological Resources (including Fish, Wildlife, and Plants); Public spaces; Historical, Architectural, Archaeological, and Cultural Resources; Environmental Justice (for minority and low-income population); Visual effects (Change in landuse, landform or visual character of the area) and Water resources.
- 5) **Theft/Misuse/Drone abuse (of Drones):** The UID already issue the "Type certificate" through Form D-1 on Digital Sky Platform which monitors the Real-time tracking of drones.

C. Identification of Launch and Landing Pad, Drone Route and Delivery location design

The landing and launch pad needs to be identifies based on the noise sensitive areas. As per [9] the drone communicates with the pilot through computers and a Wi-Fi system. Once the drone is approaching the landing it is necessary to connect it with the landing pad. This landing approaches directly the drone to the relative vicinity of the landing pad or it will be guided by the computer towards the landing. For targeting the landing areas some of the parameter is required: Obtain image from drone; apply Gaussian Blur; Threshold Image; Apply dilation; Find largest round contours

Find center x,y cords; Once the image has been received its covered into image with the above mentioned process and different color coding for landing coordinates are done. It helps in calculating the distance from the launching pad to drone area and then safely descending towards landing The

distance of the x,y coordinate every time change once the image will receive for different location. Thus, the landing and launch pad irrespective of their location in mixed use can be operated. The locations can be roof [5], common plaza in group housing or terraces in high rise buildings.

IX. CONCLUSION

The paper facilitates the development of UAV system in Urban mixed use area. Several frameworks based on training, approval and drone flight design are discussed in the paper. The frameworks are derived from the literature studies and drone rules of India. The main focus was on the revision of drones rules based on Risk assessment, social issues and Environmental impact assessments for approval process. The paper is based on Qualitative approach thus a future scope for experimental analysis is open.

X. FUTURE RESEARCH

The authors strongly suggest a location specific analysis for the future based on these frameworks. A need for architectural and urban context analysis is recommended as different countries have different contexts. The authors are looking forward for the same as these frameworks can be a useful tool for development and interactions of the UAV system in India.

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