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# Sustainable Usage of Freight Drones in City Centers, Proposition of Regulations for Safe Usage of Drones

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**Abstract:** This article concentrates on the regulations for the sustainable usage of drones in the central area of cities. This paper does not present the development of freight drones. Here, we do not concentrate on the construction, maneuvering, and steering of one drone or groups of drones, although these aspects are very important for the development of drones. However, the most important usage aspect of drones is the safety conditions. Here, we present a review of the current regulations and also propose beginning a discussion about the technical regulations of the usage of freight drones in this time and after the end of this pandemic for the sustainable usage of them in cities. The regulations are very scattered in the area of the usage of drones. This paper proposes a uniform base of regulations for the usage of drones in city centers.

**Keywords:** freight drones; regulation; safety; urban area; safety usage; pandemic; time

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## 1. The Freight Drone

The typical structure of a drone is composed of a light frame, electric or gasoline drivers, and propellers. This structure is based on the classic structure of observation drone equipment in cameras (Figure 1) and navigation systems. The construction of drones with jet engines is very random and very expensive. They are used by government agencies—the army, police, security forces, and fire brigades. However, all types of usage are either based on tests or they are random, depending on the situation. For uncommon usage of drones, we do not need regulations, but if we think of using drones as couriers, we should have laws for the usage of them in city centers.



**Figure 1.** Structure of a drone [1].

## 2. Usage of Drones in City Centers

Today, many people are strongly fascinated by the usage of drones. The usage of drones is very important for the safety of the air traffic of passenger airplanes. The region of a city called the center corresponds to the area where many high buildings, agencies, and companies are. There is a focus on the engine of the city economy which produces the source of taxies for a city. The users of this region expect to have fast and free access to some products: food, medication, small electronic products, clothes, shoes, etc. Users of these regions and another area of cities, the sleeping settlements, expect that their orders to obtain products are not connected with safety conditions.

A city center is composed of structures of buildings and streets. The height of buildings is not limited as in the XIX century, where the height was limited to the maximum height of fire ladders. Today, the visions of the designs of architecture are limited by the protection of the landscape in cities [2,3].

On these streets, there are moving cars and walking pedestrians. Streets have some regulations about their width, with elements such as the road, pavement, green fields, streetlights, and traffic signs. The same should apply to freight drones.

## 3. Review of the Regulations about the Usage of Drones

Here, a review is presented on several regulations in some countries:

In Austria, since 1 January 2014, drones have been under strict laws regarding flying. The law distinguishes four different zones for drones: open nature spaces, spaces with few buildings such as farm buildings, areas with a few buildings such as houses, and areas with many buildings such as cities. Each area has different legal requirements [4].

In Belgium, drones are categorized into two classes: class 1: RPAS (système d'aéronef télépiloté) weighing above 5 kg and having operations not falling under class 2, and class 2: RPAS weighing less than 5 kg. For each class, there are different regulations:

For class 1, above 5 kg: maximum flight height of 300 ft AGL (above ground level), no flight in controlled airspace, flight over urban areas with DGTA (la Direction générale Transport aérien du Service Public Fédéral Mobilité et Transports) approval, and flight over people or animals with prior DGTA approval.

For class 2, less than 5 kg: the operator has to be a minimum of 16 years old, no flight above 150 ft (45 m), no flights in controlled airspace, no flights above urban areas or in a radius of 50 m, and no flight above people and animals [5].

In Canada, drones may not fly closer than 9 km from any airports, heliports, or aerodromes, they may not fly higher than 90 m above the ground, and they must be no closer than 150 m from people, animals, buildings, structures, or vehicles. Additionally, drones do not fly in populated areas or near large groups of people, including sporting events, concerts, festivals, and firework shows; near moving vehicles, highways, bridges, busy streets, or anywhere they could endanger or distract drivers; or within restricted and controlled airspace, including near or over military bases, prisons, and forest fires [6,7].

In Ireland, drones should never be operated if they will be a hazard to another aircraft in flight, be closer than 5 km from an aerodrome, be operated negligently or recklessly to endanger the life or property of others, be flown over 400 ft (120 m) above ground level, be flown over urban areas, be flown in civil or military-controlled airspace, or be flown in restricted areas (military installations, prisons, etc.), unless the person operating the drone has permission from the landowner for take-off and landing [8].

In the Netherlands, it is prohibited to use any drone for flying due to the presence of traffic, connected buildings, or crowds of people; a protected nature area on which a prohibition has been imposed based on nature protection legislation or a temporary restriction or prohibition, published with a NOTAM (notice to airmen); or contiguous development of city areas: any area such as a city, village, or hamlet that is used to a significant extent for housing, commercial activities, or recreation (congested area) [9].

In Poland, the usage of drones is prohibited near or close to airports. There is the regulation that drones may be used without a regulation only in air zones labeled G. In the

area of airports, the usage of drones is allowed after establishing an agreement with the manager of the zone one intends to fly in. For the area of cities, this regulation states that drones should be used only if the controller of the drone can see it directly. Today, there is an opinion that all users of drones, regardless of the usage, must have a license, similar to the driver's license for cars on the road, and all drones must be registered in the Civil Aviation Authority of Poland [10,11].

A comparison of the regulations for freight drones is presented in Table 1.

**Table 1.** Comparison of regulations for freight drones.

| Type of Region | Austria | Belgium | Canada | Ireland | Netherlands | Poland |
|---|---|---|---|---|---|---|
| nature space | prohibited | | | | prohibited | |
| farm | prohibited | | | | | |
| settlement | prohibited | prohibited | min. 150 m | min. 120 m | prohibited | |
| aerodrome | prohibited | prohibited | min. 9 km | min. 5 km | | prohibited |
| group of people | | prohibited | min. 150 m | | prohibited | |

We can see that the regulations for the usage of drones depend on the area of usage. This means that a uniform base of regulations for the usage of drones needs to be created, which may be applied to the special regions of usage.

Another case is UTM (unmanned aircraft/aerial system traffic management) systems, which are currently active in the world, that can guarantee safe usage and also efficient and predictable integration into the airspace of each country. Below are some examples.

In the United States, there is the NASA-UTM system, which has the main goal to create a system that can integrate drones safely and efficiently into air traffic that is already flying in low-altitude airspace. UTM is based on the digital sharing of each user's planned flight details. The multi-year UTM project developed by NASA is a continued long-standing relationship with the FAA (Federal Aviation Administration). The last tests (from May to August 2019) were based on incorporating more localized weather predictions into flight planning, using cell phone networks to enhance drone traffic communications, and relying on cameras, radar, and other ways of "seeing" to ensure drones can maneuver around buildings and land when needed—all while communicating with other drones and users of the UTM system [12].

In the European Union, there is a regulation process for the usage of freight drones. It is represented by two main regulations. The first, Commission Delegated Regulation (EU) 2019/945, defines the requirements applicable to unmanned aircraft systems [13]. The second, Commission Implementing Regulation (EU) 2019/947, defines the rules and procedures for the operation of unmanned aircraft [14].

In China, there is the UOMS (Civil UAS Operation Management System) which is an integrated system serving as a Chinese solution of offering air traffic services to UAS with cooperation with the General Aviation Flight Service (a system that communicates with current ATM systems), for clouds of drones. Each drone cloud must coordinate with drones to enable real-time flight management. It must also assist government authorities with drone management and support interconnection and interworking between drones. This regulation categorizes drones into two classes: the first class of drones weighs over 7 kg, and the second class is Beyond Visual Line of Sight (BVLOS) drones of less than 7 kg, which must be connected with the drone cloud in real time. This system will emit sound alarms when drones fly into an electric fence [15]. This system was tested in 2017 in the central zone and industrial parks in Nanjing [16].

In Japan, there is the JUTM (Japan Unmanned System Traffic & Radio Management Consortium). More precisely, it is related to the Study Group for Control Systems for the Safe Operation of Drones. This organization has conducted research and disseminated information on the necessary measures for the social implementation of drones and other unmanned vehicles, and the type of social infrastructure that needs to be developed. It is composed of 13 members of different areas of interest such as science, technology, production, and management [17].

The main problem of the usage of drones is BVLOS (Beyond Visual Line of Sight). If the operator loses visual contact with the drone, this creates the risk of an accident.

For longer distance flights, is possible to use GPS, which is now used by the US Army for control of the MQ-9 Reaper drone. However, in the center of cities, there is a problem with radio reflections from the construction of buildings. Therefore, the idea of interconnection and interworking between drones is now being tested in China, but this is an aspect of steering technology.

This article is concentrated on the regulations for the sustainable usage of drones in the central area of cities.

Therefore, if we think about the usage of drones for carrying pizza, medication, or small packages, we need to analyze the safety problems connected with the usage of them.

## 4. The Safety Problems of Freight Transport in Urban Areas by Drones

Drones, as a technical object, have some features which can wear out. The typical problems are engine failure, miscalculations of the trajectory by software, collisions with buildings and other drones, and falling. Of course, there is still ongoing development in the construction of drones. There is extended use of composites for determining the structure of drones, the permanent magnets for electric engines, and new piston solutions for gasoline engines. Some independence can be found in the development of the steering mechanism of drones. Moreover, there is extended use of optic orientation systems connected with satellite geopositioning systems.

These components are used to obtain structures of drones that will have the longest time of flight, the highest payload, the highest speed, and the highest level of flight. For users in city centers, flying freight drones may generate the main safety problems, which are as follows:

1. Rapidly falling in a random place;
2. The large mass of the drone falling down from the sky with high speed;
3. The noise above the street at a high building level from the drone engine;
4. The lights above the street at a high building level from the positioning lights of the drone;
5. The unregulated minimal and maximal levels of flying drones;
6. The unregulated speed of drones;
7. The unregulated ways of flying drones.

Therefore, it is possible to propose some laws and technical solutions for the safe usage of freight drones.

## 5. Propositions for Regulations for Safe Usage of Freight Drones

The regulations should be based on the regulations for the protection of nature, the landscape, settlement areas, air traffic, and fire protection. Here, the roles of all actors involved in the usage of drones in the territory of cities are proposed.

1. Permission of municipal governments
    - 1.1 Municipal governments are able to establish the safety agencies of flying control above cities.
    - 1.2 Municipal governments are able to establish the flying corridors above the roads and buildings where it will be possible to use drones, by establishing the positioning of RIFD (radio-frequency identification) points, on masts or buildings walls. This may help to create a digital map of positioning systems for drones.
    - 1.3 Municipal governments are able to establish the landing places for drones, where it will be possible to load and unload drones (for example, parking stations for packages and letters). In terms of landing, there will be places which realize the safety control of loads and drones.

1.4 Municipal governments are able to build protection nets above some regions in city areas.
1.5 Municipal governments are able to regulate the following:
- The minimum and maximum heights of flying (see Figure 2);
- The minimum and maximum speeds of flying;
- The minimum distance above the road;
- The minimum distance from one drone to another;
- The minimum distance to buildings;
- The maximum level of flying above buildings and roads;
- The types of load which are prohibited to be transported by drones.

2. The construction of drones
2.1 The structure of drones must be composed of fireproof materials.
2.2 The structure of drones must have landing legs or another structure which can protect the drone if it falls down with three levels of acceleration of gravity.
2.3 The structure of drones after rapidly falling must be complete, and all parts must not be able to separate.
2.4 The minimum stock of energy must be able to maintain the flight of the drone for two hours in cities.

3. The moving system
3.1 The propeller elements must be surrounded by permanent outside rings.
3.2 The propeller elements must be permanently fixed.
3.3 The engines must be protected from fire after collisions.

4. Steering system
4.1 The steering system must have an open structure, though it must be protected against being infected by viruses.
4.2 The steering system must be able to maintain the position of the drone in one place in the flying space with 0.3 m precision.
4.3 The steering system must be able to control the speed with 0.1 km/h precision.
4.4 The steering system must be able to control the acceleration with 0.05 $m/s^2$ precision.
4.5 The steering system must include an autonomous anti-collision system for flight in the flying space.
4.6 The steering system must be able to use the positioning RIFD points for orientation in the flying space.
4.7 The steering system must have a panel for remote control that is able to be controlled by the safety agencies of flying control.

5. Control system
5.1 The control system of the drone must be able to realize the route of flying from two places in a space which is regulated by the safety agencies of flying control.
5.2 The control system of the drone must be able to be controlled by the safety agencies of flying control at the time of flying in the flying corridors.
5.3 The entrance to the flying corridors is only near the landing places.
5.4 A change in the level and direction of flying is possible only in designated areas in the flying corridors.
5.5 The control system must realize the safety regulations of flying directed by the safety agencies of flying control, especially the following:
- The minimum and maximum heights of flying;
- The minimum and maximum speeds of flying;
- The minimum distance above the road;
- The minimum distance from one drone to another;
- The minimum distance to buildings;
- The maximum level of flying above buildings and roads.

5.6 The control system must have remote control capability for stopping and landing that can be controlled by the safety agencies of flying control.
5.7 It is prohibited for an unclassified user to use a drone above a city or for a user to use a drone without a classification by the safety agencies of flying control.
5.8 All alien drones will be overridden by any means or destroyed.

6. Users of drones in city centers
6.1 Each user of a drone in a city must be classified by the safety agencies of flying control.
6.2 Each drone must have safety control and a classification assigned by the safety agencies of flying control.
6.3 Each user must respect the regulation set by the safety agencies of flying control.
6.4 Each user of a drone will be punished if they do not respect the law.

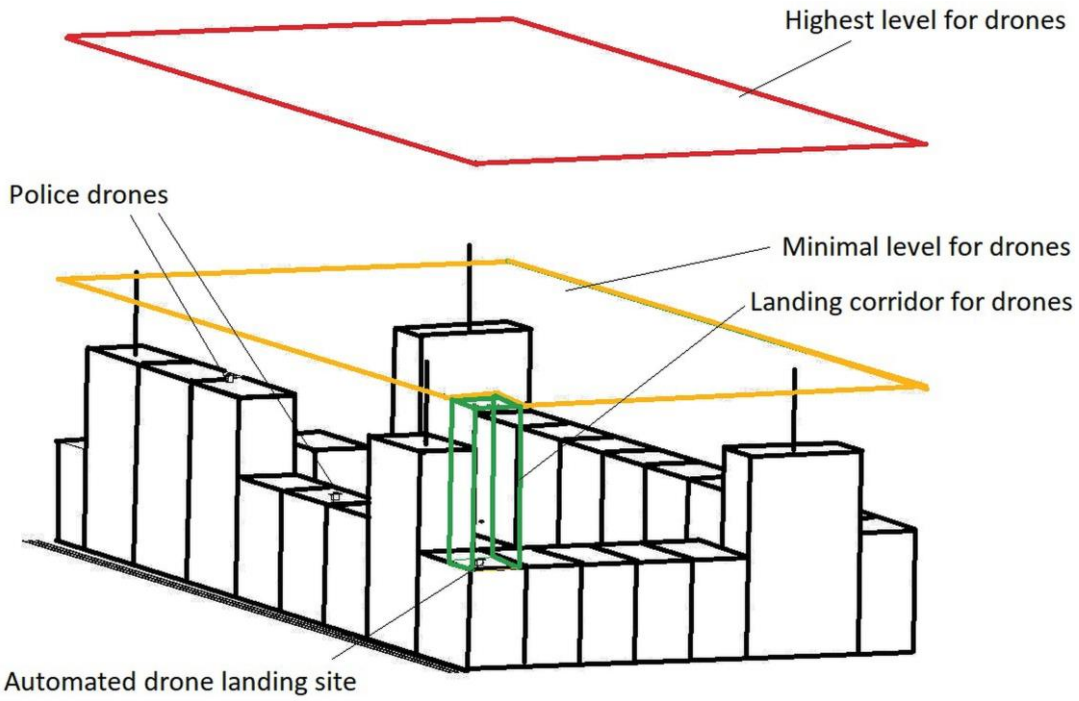



**Figure 2.** Scheme of flying corridors for drones, air control stations, and air control police drones above city streets.

All of those propositions should be discussed by all actors involved in the usage of drones in the territory of cities to create a complete ecosystem that meets the needs of all users. Of course, these propositions should be subject to change depending on whether there are new technical solutions and new aspects concerning the areas where drones can be used. Times are moving on, and therefore the law should be changing with the times.

## 6. Discussion

If there are no regulations on the usage of drones, it is possible that, above our heads, in the sky, we will see mixed clouds of drones flying in many directions and with different heights above the ground.

Therefore, it is possible that if many drones will be flying on the same, parallel, or crossed paths, there will be collisions amongst them. This represents a possible technical failure of drones. As a result, all damaged drones will fall down from the sky to the ground.

If a lighter drone has a mass of half a kilogram, the body of this flying object will fall with an acceleration of about 10 $m/s^2$; if it were to fall from a level of 100 m, it will have a speed of 44.7 m/s. This corresponds to about 160.92 km/h, which is enough to kill a human.

When we are pedestrians on footpaths, we would not expect to be hit by any object falling from the sky.

It is necessary to analyze all aspects of using freight drones in urban centers in order to assess the safety conditions of their usage. The proposed regulations are designed for discussion and, more so, for clarification. Today, there are not enough law tools for this matter; therefore, a preliminary sketch of the laws should be established. I would like to invite other researchers to discuss and, of course, to extend these rules. Now we have the pandemic of the COVID-19 virus affecting the whole world, drones can be used as a model of contact with people who are currently in quarantine in their homes. Face-to-face contact with people who are infected is banned in order to reduce the risk of transmitting the COVID-19 virus. Drones can be used to transport medication and personal gifts to people isolated in their homes. This represents the possibility to improve the psychological conditions of people in isolation.

It is hoped that by the end of the COVID-19 pandemic, regulations for the usage of drones in city centers will be finalized, and regulations for the sustainable usage of them in cities will be established.

## 7. Conclusions

The area of regulations for the safe usage of freight drones is in the early stages of its application. Therefore, it is necessary to observe the types of accidents involving drones in cities and conclude on what can be carried out to prevent these events. For future usage of freight drones, we must develop a technology for the construction of drones but also extend the regulations of their usage. Today, drones are still under development, but in the future, we must have full regulations for them. Without regulations, it is possible to expect accidents on the ground caused by fallen drones, and also many court cases about violating the privacy of people or causing dangerous situations.

For future work, a meeting of actors must be carried out involving those who are interested in the usage of drones from different points of view such as municipal governments, who are the owners of the territories, users, who represent the owners of drones and are interested in using them in the territory of cities, and lawyers, who represent a country's government and have knowledge of the law, in order to create new regulations that respect the laws of other persons and institutions. This meeting may help to create a complete ecosystem that meets all the needs, requirements, and expectations of potential users. Owing to the commitment from all actors involved, it is possible to establish a unified attitude towards the sustainable usage of drones in city centers.

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