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Performance of unmanned aerial vehicles according to rules for operating and risks of flight

European Aviation Safety Agency is proposing changes to the existing aviation rules, taking into consideration the latest developments of drones. This is an alleged concept for the creation of common European safety rules for operating drones regardless of their weight. The analysis, systematization, and coding of drone types according to existing classifications were presented.

The main advantage of using unmanned aircraft systems (UAV) is that the operating is attributed to reduced risk and increased economic efficiency, compared with classical means of air transport. The goal of ICAO – International Civil Aviation Organization, is providing of the fundamental international regulatory framework through SARs – Standards and Recommended Practices, with the support of Procedures for Air Navigation Services (PANS) [1]. The definition of drones (UAV) is wide, since it includes all remotely piloted & autonomous aircraft: from small consumer devices used for recreation to large aircraft, used over very long distances for security and other critical operations. Therefore, the drone industry is diverse, innovative and international. It has huge potential for growth with the consequent possibility to create jobs. At the same time, it is required to ensure a safe, secure and environmentally friendly development, and to respect the citizens' concerns for safety, privacy and data protection. In recent years, UAV's became very popular worldwide. Now UAV's are used to perform many tasks that were previously difficult to solve. The use of the UAVs is effective both in intelligence and in civil aviation purposes, dealing with consequences of emergencies & natural disasters, and agriculture, aerial photography, communications retransmission, etc. Furthermore, additional useful properties e.g. faster coverage of big area fragment of urban and minimal risk in the movement of UAVs in town as in "smart-city" should be mentioned. All in all, the disadvantages of UAVs that include the limited capacity due to the small size of UAV can be satisfied with the group flight usage [2; 3].

The purpose of the research is analysis, systematization, classifications, and coding of UAVs in accordance with classic target tasks, tactical and technical characteristics of UAVs including cargo capacity, flight range, construction, ways of take-off and landing; the number of UAVs in the flight, etc. EASA (European Aviation Safety Agency) is proposing changes to the existing aviation rules, taking into consideration the latest developments of drones, for the creation of common European safety rules for operating drones notwithstanding their weight. Taking into account the above, EASA's suggestion contains 33 proposals, regarding different criteria that may help to reorganize the system of rules for drones' flights in Europe [3]. EASA mainly offers to divide drones into three categories with regard to their weight. These three categories are based on the risk the operation is posing to third

parties (persons and property) and are: «open category» (low-risk); «specific category» (medium-risk); «certified category» (high-risk). For comparison, common consolidated classification of UAVs of unmanned aerial complex by main features is as follows and presented in Table 1.

Class	Level of application	Combat radius	Drones categories of NATO members
Class 1 < 150kg	Micro; tactical; take-off weight < 2 kg	< 5 km	micro
	Mini; (tactical battle-fields); 2 kg ≤ take-off weight ≤ 5 kg	> 5 km	mini
	Small; (tactical) take-off weight> 15 kg	> 25 km	small
Class 2 150-600kg	Tactical; (operational and tactical)	> 50 km	tactical
Class 3 > 600kg	operational	> 200 km	MALE (medium altitude long endurance)
	strategic	> 200 km	HALE (high altitude long endurance)

Table 1 The classes of UAVs to according carrying

The purpose of risk usage for differentiation of drone operations is e.g. that an unmanned aircraft over the open sea is less of a risk than a smaller one, operated over spectators in a stadium. It is considered that the Member States designate which of their authorities (or other organizations) will be responsible for the enforcement of the rules [1 -4]. Let's briefly look through the mentioned categories and give them a short description (Table 2).

«Open category» (low risk): Safety in the category is ensured through a minimal set of rules, operational limitations, industry standards, and the requirement to have certain functionalities. Mainly the police carry out the enforcement. «Open category» drones are subdivided into 3 categories according to the weight.

Category	Description	Weight
CAT A0	«Toys» and «mini drones»	<1kg
CAT A1	«Very small drones»	<4kg
CAT A2	«Small drones»	<25kg

Table 2 The categories of drones

The main requirements for this category are the following:

- Only flights in direct visual line of sight of the pilot are permitted.
- Only UAVs with a maximum take-off mass > 25 kg are authorized.
- No operation of drones in 'no-drone zones' is allowed (see Fig.1).
- Drones operating in 'limited-drone zones' are obliged to comply with the applicable limitations (see Fig.1).
- The pilot is responsible for safe separation from any other airspace users and has to give right of way to any other airspace users.
- A drone in the 'open' category must not operate at an altitude exceeding 150 m above the ground or water.

– The pilot is responsible for the safe operation and safe distance from uninvolved people & property on the ground and from other airspace users and must never fly the drone above crowds (> 12 persons).

«Specific category» (medium risk): In this category, an authority (NAA) shall conduct authorisation following risk assessment performed by the operator. A manual of operations lists the measures taken to minimise/mitigate the risks. The 'Specific category' e.g. includes all operations, which exceed the restrictions of the «Open category». Key factors of the safety risk assessment here are the next: area of operation: population density, areas with special protection; airspace: class of airspace, segregation, ATC procedures; design of the drone: functions provided, redundancy and safety features; type of drone operation: operational procedures; pilot competence; organizational factors of the operator.

Certified category (high-risk): requirements can be compared with those for manned aviation. These operations will most likely involve large drones used for operations by small or large organizations. Oversight is performed by the NAA (issue of licenses & approval of maintenance, trainings, operations, ATM/ANS and aerodromes organizations) and by the Agency (design and approval of foreign organizations). In the «Certified category» drones are treated in a similar way as manned aircraft. They are certified for their airworthiness and with this approach they have operational restrictions close to manned aircraft. Certainly, any idea is never convincing without a particular example. Here is the zonal analysis of German city Bergisch Gladbach on the subject of drones' flight availability (Fig.1). For ensuring safety, environmental protection, and security and privacy, the competent authorities can define *'no-drone zones'* where no operation is permitted without authority approval, and *'limited-drone zones'* where drones have to provide a function to enable easy identification and automatic limitation of the airspace they can enter and should have a limited mass.

Figure 1 Limited-drone zones

The classification of UAVs has been developed according to classic target tasks, tactical and technical characteristics of UAVs such as cargo capacity, flight range, construction, ways of take-off and landing; the number of UAVs in the flight. By the purpose, the UAV classified as agricultural, forest, and town works; surveillance and monitoring for situations such as natural, technical, and social ordinary/emergency situations; organization of search and rescue; organization and controlling of traffic road; organization and improve performance logistics, and communications, urban planning; dynamic management and urban planning. The analy-

sis, systematization, and coding of UAVs according to classifications is carried out (Table 3).

Table 3. Classification of UAV (drones) types

№	Class	Classification	Subclass
1	A	Purposes	Surveillance
			City works
			Other works (agricultural, forest, sea, river, etc.)
			Dynamics management and urban planning
			Relays communications
			Logistic
			SAR (Search & Rescue) operations
			Organization of traffic, controlling traffic road
			Aerial photography
			First aid to people
			Noise and landscape pollution
			Monitoring nature emergency situation
			Monitoring social situations in the city
			Monitoring the technical emergency situation
2	B	Flight endurance	Drones of a short flight (1h)
			Medium-flight Drones (1 – 6h)
			Long flight Drones (> 6h)
			Distant flight Drones (> 30h)
3	C	Weight	Micro Drones (> 1 kg)
			Small Drones (1 – 100 kg)
			Lightweight Drones (100 - 500 kg)
			Medium Drones (500 – 5000 kg)
			Heavy Drones (5000 – 15000) kg.
			Super heavy Drones >15000 kg
4	D	The type of aircraft	Drones-airplane (fixed-wing)
			Drones-helicopters (rotary-wing)
			Drones with flapping wings
5	E	Take-off method	Airfield take off drones
			Non-airfield drones taking off from a catapult
			Non-airfield drones taking off from hands
7	F	The way of landing	Airfield landing drones
			Non-airfield drones landing with the parachute
			Non-airfield drones landing using snares;
8	G	The number of applications	Drones of single applications
			Drones of repeated applications
9	H	Number of UAVs in flight	Drones of single flight
			Drones of group flight
10	I	Schemes of UAV control: group and single	Drone operator - single drone
			Group of operators of drones – group of drones;
			UAV operator – Central Drone Repeater (CDR) – group of drones.
11	J	Drones classification by method of control of UAVs flight	UAV under remote control by an operator
			UAV autonomously by on-board computers
			UAV piloted by an autonomous robot

The air navigation rules of UAV flights and expected risks are using for classification obstructions in towns and between towns. The risk estimations of the obstructions, zones of flights, levels of flight in the city using the Expert Judgment method and fuzzy logic had obtained. The air navigation rules of UAV flights and expected risks are using for classification obstructions in towns and between towns. The risk estimations of the obstructions, zones of flights, levels of flight in the city using the Expert Judgment method and fuzzy logic had obtained. For a definition, minimal cost flights and safety of UAVs movement ways in the towns and between towns use the method of dynamic programming. Grid-analysis - cells are superimposing on a fragment of terrain and performing a risk assessment of Grid cells depending on the types of areas ("Allowed", "Restricted" or "Dangerous"). Figure 2 shows an example of constructing a path of minimum cost, taking into account the presence of "Allowed", "Restricted" and "Dangerous" flight zones.

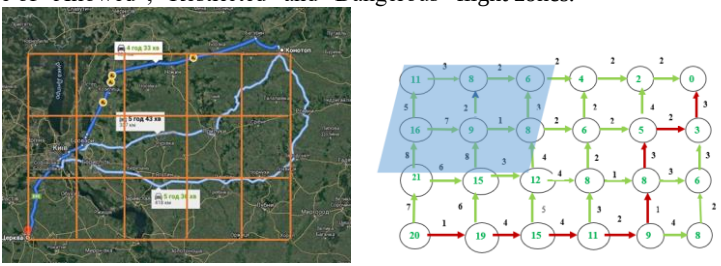

Figure 2. Minimal cost flight of UAV

To sum up, it is obvious that aviation sphere develops rapidly. Drones have already become an essential part of it and it is necessary to consolidate data regarding them to make common rules for their exploitation. Laws establishing regulations and restrictions with reference to UAV in Europe have not been changed since 2008 and it is obligatory to create some kind of classification and set up particular limitations.

References

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