RISK MANAGEMENT REGARDING THE USE OF UAV IN THE MODERN AIR SPACE

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Summary: *Aviation is the domain with one of the greatest technical developments. Thus the emergence and development at the consumer level of commercial UAVs has put the entire aerospace industry and national security system in front of a fulfilled fact. These unmanned human onboard systems and the continuous development of hardware and software systems are currently creating one of the biggest challenges: integration in airspace.*

The article reviews the risks, threats and concepts of illegal use of the drones.

Key words: *UAV, air space, risk management, NOTAM*

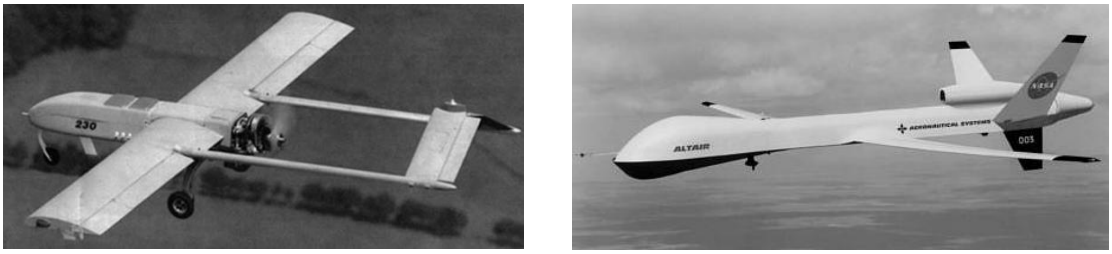
Acronyms and symbols

RPAS	*- remotely piloted aerial system*	*NOTAM*	*- Notice To Air Man*
UAV	*- unmanned aerial vehicle*	*SAR*	*- synthetic aperture radar*
E/VLOS	*- extended/ visual line of site*	*ATC*	*- air traffic control*
BVLOS	*- behind visual line of site*	*ADSB*	*-Automatic Dependent Surveillance, Broadcast*
NBC	*- nuclear, biological and chemical*	*IED*	*- Improvised Explosive Device*

1. INTRODUCTION

1.1. Theoretical landmarks on UAV.

Technological advances in aeronautics, particularly through system miniaturization, have led to a new system-level approach, generating innovative solutions for the technical and management part. According to the references, the UAV field at national [1, 4] and international level, [5, 6, 7, 8] for both civil and military [2, 3] offers a number of modern technical solutions, see Figure 1.



(a) (b)

FIG. 1 The UAVs, a. AAI RQ- 7 Shadow 200, b. Altair (NASA) [8]

1.2. Air space classification

The use of UAVs in airspace involves aviation safety issues and optimal air traffic management, so it is necessary for UAV operators to know the classification of airspace and the existing restrictions. Depending on the altitude and the distance from the airport, airspace is spread over several areas as shown in Figure 2.

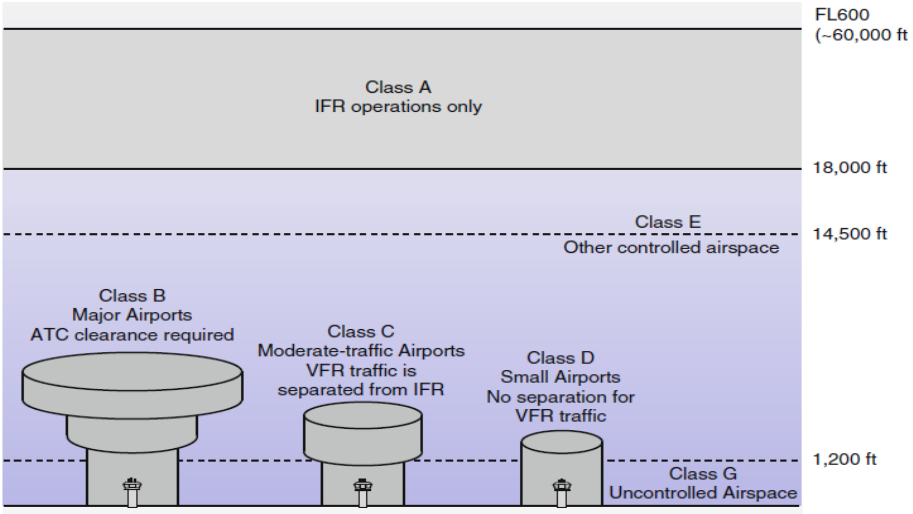


FIG. 2. Air space classification

2. RISKS AND POSSIBLE THREATS IN USING UAV'S

The field of aviation is one of the greatest technical developments. Thus the emergence and development at the consumer level of commercial UAVs has put the entire aerospace industry and national security system in front of a fulfilled fact.

These unmanned human onboard systems and the continuous development of hardware and software systems are currently creating one of the biggest challenges: integration in airspace. The benefits of using UAVs have been demonstrated in a variety of areas: Critical Infrastructure Inspection and Surveillance, Agriculture applications, SAR, law enforcement, and applications that would normally be considered too dangerous to be operated by aircrafts with a human pilot on board.

In addition, the implementation of any technical system, in addition to its benefits, cannot be free of both technical and human risks, so UAV incidents will occur irrespective of the measures taken, requiring a number of regulations and technical solutions to limit the risks [10, 11, 12].

2.1 Collision with an aircraft with human staff on board or UAV

One of the most common problems that may arise in operating the UAVs in the airspace is the possibility of collision with an aircraft carrying personnel on board or the collision between two UAVs. Depending on the impact force, the masses of the aircraft and their structure (fixed wing or rotating wing), this can materialize by destroying one or both aircraft. The fact that a UAV can be in flight in one of three situations: VLOS (visual line of site) is operated in the visual range; EVLOS (extended line of site) where the operator is assisted by an external operator at the limit of the visual range; BVLOS (behind visual line of site) where the UAV is only piloted instrumentally and far exceeds the visual range. These situations call for a set of measures both on the part of the authorities and on the part of the UAV operators as follows: announcement of the flight to the Air Operations Center as well as establishing a link with the traffic unit if the flight takes place in the classroom B, C, D.

In the case of VLOS flights, it is necessary: an observer to monitor airspace visually; the deployment of ADSB (Automatic Dependent Surveillance - Broadcast) systems that connects to the UAV's Fail Safe system which can make decisions to correct the trajectory much faster than the operator response.

In the case of BVLOS flights, it is essential to set up TSA segregated areas whose presence is announced for at least 24 hours via the NOTAM (Notice to Air Man) system.

2.2 Impact on soil with an object on the ground or with people

This event may occur for several reasons, such as: an air collision between a UAV and another aircraft or birds; the release of material or electronic elements; deliberate destruction by anti-aircraft combat means; terrorist attacks.

In the diagram below you can see the components that lead to a ground impact and impact result. The frequency of incidents can be calculated using the following equation:

$$f_F = A_{\exp} \cdot \rho \cdot p \cdot f_{GIA} \cdot f_{shelter} \quad (1)$$

Where:

f_F *– represents the frequency of incidents;*

$A_{\exp}$ *- The area in which the incident occurred;*

ρ *– Population density in the area;*

p $(f_{atality|exposure})$ *– depends on the strength of the human body at impact as well as the resistance of shelters;*

f_{GIA} *– Rate of ground impact;*

$f_{shelter}$ *– are marked with values from 0 to 1 where 0 represents the fact that all persons are housed and 1 represents that no person is housed.*

Following the conducted studies, it has been established that a minimum level of ground impact safety would correspond to a value of 95 KJ. For the kinetic energy limits and the end of flight method, two collapse scenarios, depending on the type of UAV, should be considered as follows:

-for UAVs (fixed wing or multi-copter type) capable of developing a high horizontal travel velocity, the kinetic energy assessment will be performed for the maximum impact velocity (established as $1.4 \times V_{max}$ that can be achieved in flight horizontally);

-for all multi-copter UAVs, the kinetic impact energy will be evaluated for a free fall of 400 ft. Thus, for the above data and the weight of the aircraft, the kinetic energy of the impact can be calculated, see Table 1.

Table 1 Kinetic energy

Weight RPA	Max speed - Hconst (Vmax)	Impact speed 1.4 x Vmax	Cinetic energy of impact speed	Weight RPA	Max speed - Hconst (Vmax)	Impact speed 1.4 x Vmax	Cinetic energy of impact speed
Kg	Kts	m/s	KJ	Kg	Kts	m/s	KJ
1	70	50	1	50	70	50	64
2	70	50	3	60	70	50	76
3	70	50	4	70	70	50	89
4	70	50	5	75	70	50	95
5	70	50	6	80	68	49	95
10	70	50	13	90	64	46	95
15	70	50	19	100	60	44	95
20	70	50	25	110	58	42	95
25	70	50	32	120	55	40	95
30	70	50	38	130	53	38	95
40	70	50	51	150	49	36	95

2.3 The possibility of carrying out terrorist and smuggling acts (illicit shipments):

The availability of the general public to the constructive elements of a UAV, as well as some incidents that have taken place lately, jeopardize the use of these systems for committing terrorist attacks. Thus we can list some incidents as follows:

- USA 2011 - 26-year-old Rezwan Ferdaus is arrested for planning an attack on the Pentagon building with a radio commanded model [13];
- In January 2015, a Phantom DJI multi-copter collapses on the white house's lawn. Fortunately, the incident was due to a technical failure known as flyaway, [14]
- USA 2015 - ElMehdi Semlali Fahti is arrested for planning an attack on a school and on a governmental institution, [15]
- September 2013 a Parrot drone succeeds to approach German Chancellor Angela Merkel, [16];

3. CONCEPTS ON ILLEGAL USE OF DRONES

Public disorder: It is manifested by violation of private property, the emergence of UAV's at various public events, and is manifested by a low risk, in most cases being done by "terrible" people or by children.

Airspace interference: The lack of clear and applicable legislation at the moment creates the prerequisites for the use of the drones in different airspaces, thereby endangering air traffic. In recent years, a number of incidents have been reported in which there was an assumption of an air accident between UAVs and onboard aircraft.

Illegal monitoring: One of the most notable threats is the use of UAV's for illegal monitoring in various areas of private or governmental interest. The current capabilities of the hobby platforms (DJI, 3DR) 4k camcorder, zoom, life HD transmission, full autonomous flight have brought this technology from the prohibitive area of information structures to the public area, making it very difficult to identify what the mission is Each system and the information that collects them.

Accident risk: UAV is a real danger to people and goods on the ground. In addition to the human or material damage that can be generated by the impact, there is also the risk of fires due to the Lithium-Polymer batteries used by these flight systems, see Figure 3.

FIG. 3 Damage caused by UAVs

FIG. 4 Taser drone [17]

Contraband and transport of illicit materials: UAVs can be used as a smuggling cargo transportation system. Their use allows criminal groups or terrorist organizations to avoid classical security systems. Often, attempts to place goods with drone in prison are reported.

Non-lethal weapons: While non-lethal weapon use is not associated with criminal activities, it is already used by security structures. The provision of drones with rubber bullets, tear gas, or electro-shock weapons are applications that can be used by the police or the gendarmerie. An example is the Chaotic Moon drones that were equipped with a 80000V Taser type system, see Figure 4, [17].

Dead weapons: With a minimum of effort, these drones can be equipped with a lethal weapon like a gun, a flame thrower. The electronics with which they are equipped allows for the realization of different control systems, and the association with visual recognition software can create a threat to be considered, see figure 5, [18].

FIG. 5 UAV equipped with UZI machine guns, [18].

NBC (Nuclear - Biological - Chemical): Weapons of mass destruction are a real danger in today's geopolitical context. Thus, a UAV equipped for the transport of such substances can become very "effective" at this time for terrorist structures. Failure to be immediately detected as a dangerous system, as well as the distances that can be traversed, creates a security issue at the moment.

IED (Improvised Explosive Device): Terrorist structures have so far shown enough ingenuity in the placement of explosive material. So using a drone for an assault becomes a viable thing and you can ask yourself: when and where this will happen, [20].

Radio electronic attack: A particular case of criminal use of UAVs is to equipment them with electronic devices that can connect to WIFI or GSM systems and collect data. These equipment are called Snoopy can penetrate any radio data system, [19].

4. CONCLUSSIONS

The article addresses a new field of interest, an area that until recently was exclusively the prestige of the specialized military structures for anti-aircraft defense. To deepen the scope of my own research I propose to study a miniaturized airborne robot recovery system that meets current security requirements and addresses the micro UAV category for civilian use. For this I will go through the following steps: analysis of target acquisition methods represented by miniaturized airborne robots both wing-type wing systems and fixed wing systems; analysis and simulation of methods of intercepting aerial targets such as miniaturized aerial robots; the development of an airframe model with a fixed wing interceptor; analysis of the interception phase; the realization of an experimental model (for launching a recovery net and a recovery parachute).

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REFERENCES

[1] Prisacariu V., Cîrciu I., Luchian A, *Unmanned aircraft vehicle (UAV) in the Romanian airspace. An overview.* Journal Of Defense Resources Management, vol.4 issue 1(8)/2014, ISSN:2068-9403, eISSN:2247-6466, ISSN-L: 2247-6466, p123-128;

[2] Prisacariu V., *The UAVs in the theatre of operations and the modern airspace system*, RECENT Journal, 3 (39)/2013, Transilvania University of Brasov, Romania, ISSN 1582-0246, p. 169-180;

[3] Prisacariu V., Muraru A., *Unmanned aerial system (UAS) in the context of modern warfare*, Scientific Research And Education In The Air Force-AFASES 2016, Brasov, DOI: 10.19062/2247-3173.2016.18.1.23, ISSN 2247-3173, p. 177-183;

[4] Prisacariu V., Cîrciu I., Cioacă C., Boşcoianu M., Luchian A., *Multi aerial system stabilized in altitude for information management*, REVIEW OF THE AIR FORCE ACADEMY, 3(27)/2014, Braşov, Romania, ISSN 1842-9238; e-ISSN 2069-4733, p 89-94;

[5] Reg Austin, *Unmanned Aircraft Systems UAVs design, development and deployment*, Aerospace Series, ISBN 978-0-470-05819-0, 2010, 365p;

[6] UAS Yearbook, *Unmanned aircraft systems – The Global Perspective 2011/2012*, Blyenburg & Co, june 2011, Paris, ISSN 1967-1709, 216 p., available at www.uvs-info.com;

[7] Suraj G. Gupta, Mangesh M. Ghonge, Dr. P. M. Jawandhiya, *Review of Unmanned Aircraft System (UAS)*, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), Volume 2, Issue 4, April 2013, ISSN: 2278 – 1323, p1646-1658;

[8] http://www.trade.gov/td/otm/assets/aero/UAS2011.pdf, accesed at 12.05.2017;

[9] https://www.unmannedtechshop.co.uk/ping-rx-ads-b-receiver-for-uavs/, accesed at 12.05.2017

[10] EASA, Introduction of a regulatory framework for the operation of unmanned aircraft, Technical opinion, Related A-NPA: 2015-10 —RMT.0230—18.12.2015, 50p, available at https://www.easa.europa.eu/system/files/dfu/Introduction%20of%20a%20regulatory%20framework%20for%20the%20operation%20of%20unmanned%20aircraft.pdf

[11] Global Aerospace, UNMANNED AVIATION RISK MANAGEMENT, ACCIDENT PREVENTION AND INSURANCE, available at http://www.global-aero.com/wp-content/uploads/2015/10/GA135_Whitpaper_ Template_Screen_Version_r9.pdf;

[12] Prisacariu V., Pop S., Cîrciu I., *Recovery system of the multi-helicopter UAV*, REVIEW OF THE AIR FORCE ACADEMY, 1(31)/2016, Braşov, Romania, DOI: 10.19062/1842-9238.2016.14.1.13, ISSN 1842-9238; e-ISSN 2069-4733, p 92-98;

[13] https://www.theguardian.com/world/2011/sep/29/fbi-entrapment-rezwan-ferdaus, accesed at 14.05.2017;

[14] http://www.bbc.com/news/technology-31023750, accesed at 15.05.2017;

[15] https://www.investigativeproject.org/case/662/us-v-fathi , accesed at 15.05.2017;

[16] https://arstechnica.com/information-technology/2013/09/german-chancellors-drone-attack-shows-the-threat-of-weaponized-uavs , accesed at 15.05.2017;

[17] http://pix11.com/2014/03/09/texas-company-creates-a-drone-with-a-80000-volt-stun-gun, accesed at 17.05.2017;

[18]http://www.dailymail.co.uk/sciencetech/article-2134024/FPSRussia-shows-flying-drone-fitted-machine-gun.html, accesed at 17.05.2017;

[19] Mears M.J., *Cooperative Electronic Attack using Unmanned Air Vehicles*, Wright-Patterson Air Force Base, AFRL/VACA, WPAFB, OH 45433-7531, USA, 2006, 10p, available at http://www.dtic.mil/dtic/tr/fulltext/u2/a444985.pdf;

[20] Wallace R.J., Loffi J.M., *Examining Unmanned Aerial System Threats & Defenses: A Conceptual Analysis*, International Journal of Aviation, Aeronautics and Aerospace, vol.2, issue 4., 2005, p34.