Increasing role of drones within commercial airspace

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ABSTRACT

Drones started to be very popular and visible in the last two decades. Those more and more sophisticated, cheaper in production and exploitation technologically advances air and land based platforms are entering new domains of people's life very progressively. At the present it is not so easy to fully predict to what purposes drones could be used in the future. We are usually consider them as unmanned platforms to be used by armed forces or national security related services to enhance their capabilities to create safe and secure environment. Nowadays we see new solutions and applications everyday. It is assessed that drones utilization is an opportunity to be exploited for both civilian purposes and their growing presence in airspace is unstoppable process. The variety of application will grow extremely quickly as of new technological discoveries and innovative approach of designers. The growing density in the air is causing the urgent need to enhance legal coverage to avoid incidents as those are a danger now and that aspect will be more serious in the future. The paper is composed of two major parts. The first is focusing on current and future applications of drones and the second one is discussing dangers toward using unmanned aerial vehicles requiring legal solutions national and globally. The purpose of the paper to present drones applications as an advantage but also a risk for national and private security along with requirements for formalizing their utilization within legal frameworks..

KEYWORDS: drones, unmanned aerial vehicles, airspace, security of air traffic

1. Introduction

Drones started to be very popular and visible in the last two decades as of military applications during conventional and unconventional armed conflicts. They were used to attack military and non-military targets with high precisions and to deliver up-to-date-intelligence. That type of flying platforms was immediately recognized as an option to be adopted by private persons and commercial organizations. As the outcome drones are currently under very dynamic development in many countries. Those more and more sophisticated, cheaper in production and exploitation technologically advances air and land based platforms are entering new domains of people's life very progressively. Their presence is definitely an advantage for societies but there are many restrains

as people and companies are using them based on law regulations, which are often behind required level of safety causing threat connected with drones as those could be used not so wisely but also for illegal activities. The latter aspect is important as criminal organizations are very effective in adopting new technologies for their purposes.

Safety is the real concern asking for developing proper regulations. Such the domains as privacy, crimes, illegal tracking, human rights are under danger as of using new technologies against them. As explained by Ciara Bracken-Roche "privacy, human rights, and civil liberties questions are sharply raised by the new kinds of surveillance made possible by these remotely operated aerial craft"[1]. On the other hand drones or unmanned aerial vehicles (UAVs) could be used for societal benefit in many

applications for commercial use and to extend safety of ordinary people when used by law enforcement organizations, to observe potential natural hazards (weather, floods, avalanches, heavy rains etc.), to support daily services or even to fight crimes enhancing public security. It is real issue as according to Maryann Lawlor it is possible that "autonomous, networked and integrated robots may be the norm rather the exception by 2025" [2]. The FAA estimates that there will be "as many as 7,500 small commercial UAS…in use by 2018, although that number may change upon the release of the proposed rules on small UASs" [3]. They could be used "in performing the three Ds: dull, dirty and dangerous work, thereby protecting human pilots from fatigue and various environmental hazards" [4]. More and more functions and tasks are to be operated by unmanned systems and this a reality to which there is a need to adopt by preparing societies and legal aspects allowing avoiding their undesirable use. This is an effect of assumption that people are still the weakest security component of using UAVs. US Department of Defense assessed that some 70% of manned aircraft catastrophes [5] are caused by human errors and further autonomy will not eliminate it as still a human will be controlling them.

At the present it is not so easy to fully predict to what purposes drones could be used in the future. The society is usually considering them as unmanned platforms to be used by armed forces or national security related services to enhance their capabilities to create safe and secure environment. Is it to be continued in the future? The answer is given every day as we can observe them for new applications. We could say, with high degree of certainty, that in next one or two decades those devices will be even more ordinary element of people's daily life. However, it should not be forgotten that drones are not only supporting security as those are also real threat for overall security systems, including personal security.

The purpose of the paper to present drones applications as an advantage but also a risk for national and private security along with requirements for formalizing their utilization within legal frameworks. It is assessed that drones utilization is an opportunity to be exploited for both civilian purposes and their growing presence in airspace is unstoppable process. The variety of application will grow extremely quickly as of new technological discoveries and innovative approach of designers. The growing density in the air is causing the urgent need to enhance legal coverage to avoid incidents as those are a danger now and that aspect will be more serious in the future. The paper is composed of two major parts. The first is focusing on current and future applications of drones and the second one is discussing dangers toward using unmanned aerial vehicles requiring legal solutions national and globally.

2. Drones application for private use and public service

Drones are named in a few ways as: unmanned aerial vehicles or UAVs, unmanned aerial systems or UASs, remotely piloted aerial systems (RPASs) but in essence they are similar as it is about an aircraft operated without a pilot on board. Their advantage is manoeuvrability in airspace, low costs, easy way to operate,

multifunctionality and variety of available payload both in size and sophistication. US Congressional Research Service is recognizing specifically the last element and "a central issue surrounding the use of unmanned aircraft is the airborne sensors, particularly imaging sensors that are mounted to the underbellies of these vehicles to gather data and collect images of the earth below. While these sensors may be utilized for a variety of beneficial applications, they have also raised considerable concerns regarding their potential intrusiveness, despite the aforementioned industry commitments to respect the privacy of individuals" [6]. Among them such payloads as less and more advanced cameras and electro-optical imagers, infrared sensors exploited in night and in poor visibility, synthetic aperture radars to penetrate through rain, fog, smoke and dust or other specialized sensors (chemical, biological, radiological) are recognized. Military applications proved abilities to operate effectively in variety of weather and terrain using mounted sensors and managed by a pilot located far away in safe location. Integration of three basic elements in most UAVs: a ground station (for piloting the vehicle), the payload, including sensor(s), video and still cameras etc., and the platform (flying mechanism) [7] is done in many configurations based on a customer needs. It is an effective approach to ensure required applications and the number of applications is unlimited and it is growing based on researchers innovative approach and user expectations as "drones are versatile, efficient and competitively-priced, a perfect combination reflected in current enthusiasm" [7].

The delivery of goods is an important sector of local and global services and that sector is creating many opportunities. Amazon Company after research recognized the value of drones and in December 2013 "Jeff Bezos, the CEO of Amazon.com (Amazon), announced that the company was testing a new delivery system called Prime Air" [3]. The aim of the Amazon Prime is to deliver packages with weight up to 2.3 kilograms (five pounds) in no more than 30 minutes using small drones (see the figure). The vehicles will be constructed „with multiple redundancies, as well as sophisticated "sense and avoid" technology. Additionally, through our private trial in the UK, we will gather data to continue improving the safety and reliability of our systems and operations" [8]. The Prime Air centres are located in the United States, the United Kingdom, Austria and Israel and tests are ongoing in other countries. The issue is still related to legal regulation not allowing some options e.g. US Federal Aviation Administration (FAA) is prohibiting filming of the delivery. Amazon Prime is „currently permitted to operate during daylight hours when there are low winds and good visibility, but not in rain, snow or icy conditions. Once we've gathered data to improve the safety and reliability of our systems and operations, we will expand the envelope"[8].

Prime Air is important tool and it will be profitable undertaking as some 86% of deliveries are to meet characteristics of the concept [3]. Internet companies as Facebook and Google have already invested into UAVs that "could fly at high altitudes (these being respectively, Ascenta, a UK company, and the US Titan Aerospace)" [7]. They are recognizing their value even to be used as telecommunications relay points enhancing Internet access for populations in remote areas enabling better access to new clients and boosting their profit.

Fig. 1. Amazon.com's drone 'Prime Air' [8]

Privacy and safety of public events is another important solution to be used by police and other security related services as they are allowing monitoring large gatherings like demonstrations, concerts, sport events etc. Another option is to monitor fragile infrastructure during specific periods like religious celebrations, elections. Using them for highways monitoring is allowing recognition of traffic jams and accidents in real time speeding up support and creating warning opportunities for other users. UAVs were used in US to monitor political rallies, in Netherlands to surveillance football fans and their aggressive behaviour, in India to observe sanctuaries often attacked by 'unknown' people. Even the security of the NATO Summit in 2009 and also next summits were supported by drones; Indian security forces supervised game venues and residential zones when running Commonwealth Games in 2010 [4]. Drones are important tool to fight organized crime allowing monitoring selected locations and groups during day and night using specialized sensors. This is especially important in cities as that way of shadowing is very effective as of limitations of road systems and density of buildings. The same is related to difficult terrain conditions allowing criminals to hide and escape having good knowledge about terrain. It is e.g. important toll to monitor national borders and it is used in many countries and services as the United States Border Patrol; it is not only limited to land borders but also for vast sea areas as UAVs could monitor them following pre-planned routes. The same solutions are already applied in Europe in Austria, UK, Germany, Poland and other nations. In South America UAVs as used to discover illegal plantations of marihuana and in Afghanistan to locate opium poppy fields and routes of drug trafficking. Organization of special centres for operating drones and their integration in overall monitoring systems is under way to extend integration of new capabilities in security systems of nations and beyond.

Monitoring forests and underpinning fighting fires is important application recognized as one of first roles in the civilian functions. Mounting infrared cameras and optical as payload has allowed early warning and constant overview of situation in all weather conditions and during limited visibility which is often linked with fires. It allowed to safe human effort, resources and money when covering large spaces. It encouraged other services to supervise fragile areas endangered by natural disasters as 'flying eyes' allowed examining "debris and identify victims of hurricane Katrina" [7]. Such capabilities are enabling delivery of basic first aid kits, medications and other urgently needed staff in many cases allowing savings people's life. This is connected with inability to access endangered humans using other ways. Another example could be

support for tourists stacked somewhere in mountains or remote areas when temporarily isolating from other ways of supplies. The UAVs support is not only related to humans as it is important aspect of monitoring wildlife, coordination of anti-hunting activities especially to safe endangered animals. Huge parks and wildlife reserves are usually vast areas requiring close supervision to deny poaching and drones are very suitable for that purpose being quiet and reliable platforms.

Alternative option is to monitor and inspect important and fragile infrastructure like power plants, pipelines, railways, dams, electric grids, bridges, airports and others. Among them nuclear power plants are very important as those could a matter of attack by terrorist looking for effective ways to harm modern democracies. In the case of any catastrophe drones equipped with specialized radiological sensors could be sent to hotspot limiting risks for crews. In general, close focus on critical infrastructure is supporting their security and in the case of any damages or dangers is enabling quick reaction toward specific spots denying the need to find it losing time. Environmental protection is another application e.g. by supporting control of growing smog in major cities during unfavourable weather conditions as it is happening in major cities like Lima, Phoenix, Beijing but also in Europe e.g. Naples, Rome, Brussels. Chemical, biological, or radiological sensors may be used to collect air samples in such environments being hazardous for humans allowing warning citizens on time. The US National Atmospheric and Oceanic Administration (NOAA), which is concentrated on predicting changes in climate, weather, oceans, and coasts as of their importance for economy, is investing into Unmanned Aircraft Systems (UASs). The vision related to them is as follow: "UAS will revolutionize NOAA observing strategies comparable to the introduction of satellite and radar assets decades earlier" [9] as of better understanding global environment and increasing predictability of impact of human activities. It has equipped its UAVs with variety of advanced sensors to collect and analyse different type of samples or to monitor any changes, to research atmosphere research to predict natural disasters etc. Such the approach has global context as it is allowing following the global warming status and changes especially in such remote areas as Arctic "to measure water and ice temperatures; ocean salinity; albedo (that is, the reflectivity of the ice) and more" [10]. UAVs are equipped with heat-sensitive, near-infrared cameras, radar altimeters, and could drop "microbuoys" to water to measure salinity and send out data. What is important UAVs could be complemented by underwater drones deployed beneath the ice in the Arctic Ocean to monitor ice melting and understand to assess when sea routes will be more open for trade.

Search and Rescue are of great importance as time is critical to save life especially in bad weather conditions or for peoples who suffered injuries. That aspect of drones' utilization is of great attention as "some civilian applications of SAR include maritime search and rescue in adverse conditions, fire line tracking in smoke, iceberg detection and tracking, and oil spill monitoring. While SAR platforms had only been available for large unmanned aircraft until recently, in 2008, defense contractors demonstrated a 2-pound SAR payload for small UAVs that were made commercially available in 2010" [6]. All the nations and services are recognizing the value

of those new devices as in many cases access to people in need is limited by terrain enhancing time to reach them and not always aircraft or helicopters could land in specific areas. However, UAVs are able to move more freely and even deliver emergency supplies although with some limitations. In that context, it is necessary to mention also big cities, as heavy traffic is another obstacle to deliver urgent supplies like medicaments in short notice. The Transplant Transportation Services Inc. recognized the value of using drones to transport organs for transplantation as "reducing safety risks, increasing operating room utilization through flexible timing, surgeon cooperation and collaboration and significant cost savings are just the beginning of what we all have so much to gain from the use of these machines. Our partners are innovators and leaders in their respective fields. There is no doubt that through working closely with them; the benefits will change transplant, and potentially the entire healthcare industry" [11]. Some years before it was something not to be taken under consideration but it is just reality supporting medical services. Specialized drones for that fragile cargo are already developed and operational.

It is necessary to mention the importance of UAVs for media as this is critical for newspapers, TV stations, and radio operators to deliver up-to-date information on very competitive market. The speed of delivering a 'hot topic' means for them commercial success. This is why UAVs are very useful tool both in crowded cities allowing quick presence in any 'hot spot' and it is referring also to remote areas with limited entry. That type of platforms is useful for war correspondents to motor situation, to provide reports from conflicts zones avoiding direct exposure for danger. UAVs' aerial picture and videos are highly desired materials requiring presenting them in short notice to be ahead of other media providers and are used by worldwide news providers as BBC, CNN, and many others.

The competition among drones' users of airspace and rivalry among them in getting information is an issue as they want them very quickly to present as first provider. It is encouraging investments in that sector of modern industry. It is estimated that "Venture capitalists have invested over $40 million in drone technology in the first ten months of 2013 (which is double the investment from the previous year, and expected to grow in the future), and sales of civilian drones are expected to be over $8.2 billion within the next decade" [3]. That number is growing every year with increasing speed. If such the issues as "the capability to autonomously and safely manoeuvre in confined spaces and the removal of the legal requirement of supervised operation within the line of sight" [12] will be lifted the amount of drones will be significantly bigger in airspace. The number of applications will be connected with mowing from general purpose drones toward more and more specialized platforms meeting requirements of private and commercial users. There are more capable platforms under development which in the future will carry more payloads but time is necessary to make technological jump along with increasing their safety as of growing risks for manned aircraft and people on the ground. The legal aspects are still behind technologies and it requires organizational and national solutions to follow UAVs progress and application to increase safety of their use and to enhance their supportive role when minimising risks.

3. The security aspects of using drones

The US Congress has adopted an act regarding modernization and reform of the Federal Aviation Administration (FAA). The focus of the reform has been to execute government actions to speed up an integration of all the drones within US airspace, which is recognized to be the most overcrowded airspace in the world. It was forced by enormous number of requests the FAA has been receiving to grant certificates for variety of commercial activities using new capabilities; it was mainly linked with certificates to use drones for videoing. One of reasons was that even "model aircraft may pose a safety hazard to full-scale aircraft in flight and to persons and property on the ground" [13]. However, such the permissions were treated as precedents; the situation has changed and those permissions are rather norm than precedent. The applications are mainly related to different branches of industry and economy, as: agriculture, energy sector, health care, protection of natural environment, postal services and also tourism. US Congress recognizing a challenge related to drones was concerned that those are violating right to privacy and imposed some limitations e.g. they cannot be weaponized, surveillance only in public spaces, collected videos must be deleted in 24hours (judge could extend it) [14]. There is also a law against 'drone stalking' and 'peeping drones' to avoid spying or track individuals. Among others reasons, the request of the Amazon Company to be granted approval to deliver post using drones has grasped the attention of government. Similar project was considered e.g. by the German DHL Company which was permitted to deliver the drone based services being first in Europe [15]. Also other global multinational technology companies e.g. Google and Facebook have expressed their interest in exploitation of options offered by drones.

Amazon is recognizing the risks related to uncontrolled use of airspace asking for unified solutions to meet expectations of all users. The drones in that architecture are already reality and they just must find their place. To increase safety Amazon is proposing division of airspace as follows (visualization is presented in Figure 2) [16]:

- Airspace below 152metres feet ('Low-Speed Localized Traffic') reserved for (1) terminal non-transit operations such as surveying, videography and inspection, and (2) operations for lesser-equipped vehicles, e.g. ones without sophisticated 'sense-and avoid' (SAA) technology. Those lesser-equipped vehicles will not have access to certain airspace in this zone, such as over heavily-populated areas;
- A 'High-Speed Transit' space, between 61 and 122metres for well-equipped drones following relevant performance standards and rules;
- The airspace between 122 and 152metres as a permanent drones 'No Fly Zone', except in emergencies;
- 'Predefined Low Risk Locations' regulated by aviation authorities including e.g. airfields with premeditated parameters for altitude and payloads.

The model is of course a matter of negotiations with many stakeholders to achieve consensus. There is however strong belief

that it will increase safety and will support regulating use of airspace allowing implementation of new capabilities offered by drones.
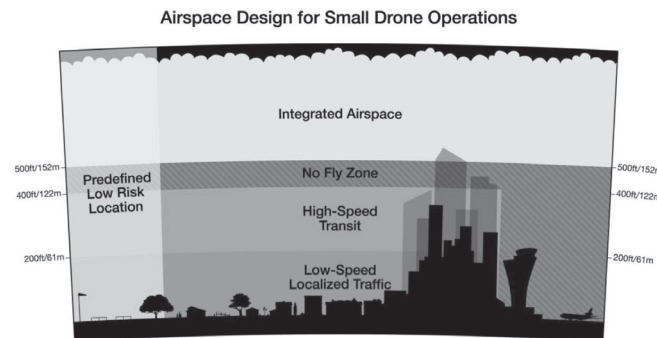

Fig. 2. Visualization of Amazon proposed airspace design model [16]

The challenge connected with drones is quite often related to their security or rather safety of their utilization for private and commercial purposes and also with privacy. It was recognized and approached by US Congress which revised a legal act related to FAA. It was focused on better integration of drones toward US airspace being overcrowded airspace in the world and the trend will continue so "by 2020, the FAA expects to have as many as 30,000 drones flying over the United States" [17]; the numbers are different in other sources. The number of commercial requests to grant certificates for variety businesses is constantly growing; many are coming also from private users. It is linked with safety as many users are not properly trained and there is a tendency to overestimate skills and it could lead to accidents, and even "model aircraft may pose a safety hazard to full-scale aircraft in flight and to persons and property on the ground" [13]. US Congress is treating very seriously privacy as of national laws and regulations based on the correct estimate that drones are easy tool to use for illegal activities violating personal privacy. Similar conclusions came from a research published Philip Boucher with the aim "to provide an early understanding of first impressions and visions of civil drones, and the boundaries of acceptability in their development" [18]. It was recognized that many participants of the research were concerned e.g. about privacy, function creep that could violate the boundaries of acceptability, border between acceptable and unacceptable use. It was linked with recommendations for necessary solutions like "licensing of pilots, registration of devices, mandatory liability insurance" and others to limit "use to trusted authorities and require authorisation, which would depend upon the application and its social benefits".

The European Aviation Safety Agency (EASA) has already developed road map to develop necessary rules for using UAVs. It released in 2015 the Technical Opinion 'Introduction of a regulatory framework for the operation of unmanned aircraft' with proposals "for a regulatory framework and for low-risk operations of all unmanned aircraft irrespective of their maximum certified take-off mass" [19]. It recognised security and privacy as major concerns as safety must be related to avoiding harming propel on the ground, mid-air collisions with manned aircraft; and damage to critical and sensitive infrastructure [19]. The document includes 24 specific proposals to be further researched and implemented to regulate use

of drones as another contributor to air traffic. The latest development is the EASA's document "'Prototype' Commission Regulation on Unmanned Aircraft Operations" [20] released on 22 August 2016 allowing stakeholders' familiarization with propositions to make consultations later. This is to be further developed in EU nations with some national characteristics. In the United Kingdom there is no need to register a non-commercial drone as for now. However, that type of flying vehicles in under concerns as there is growing number of incidents related to them. Arthur Cracknell made a research and recognized significant growth from 2014. When comparing year 2015 and 2016 he recognized more than doubled number of drone related incidents (from some 30 up to some 70) [21]. He is presenting some incidents as one at Heathrow Airport on 17 April 2016 – "a British Airways Airbus A320 on a flight with 132 passengers and 5 crew from Geneva and an alleged collision with a drone as the plane was near to landing" [21]. Another one happened on 20 July 2016 when an Embraer 190 after taking off from London City airport was enforced to turn and climb to avoid collision with a drone. The challenge is that many of drones are just anonymous and it is not easy to track their operators. The better situation is related to commercial drones as obtaining permission from the UK's Civil Aviation Authority (CAA) is regulated by law with specific requirements defining: visual line of sight, the minimum distance from people and properties, restricted airspace, collection, storage and use of obtained data[21].

There is another term a 'politics of verticality' which "has emerged with drones in the domestic realm, not only in the physical sense, but institutionally and organizationally" [1]. It is linked with emergence of the third dimension of physical space as of 'bird's eye' view is affecting privacy and is a danger e.g. for air traffic as of growing presence of drones close to airports. 'Geofencing' could be a solution toward that challenge by adopting software denying UAVs use in the vicinity of specific locations as airports, governmental infrastructure, critical energy infrastructure (nuclear power plants, pipelines, electric grids etc.) and others. This a real vulnerability as "the adoption of drones in the domestic realm, by government and public agencies, as well as commercial organizations, highlights the primacy of the visual and makes the surveillance and monitoring of large sections of civil life possible, whether or not the technologies are being used for surveillance and data collection in policing and public safety" [1]. The problem is that data collected could be used for variety of purposes including illegal and immoral utilization for personal or organizational profit. Drones are silent, well equipped in cameras, surveillance devices allowing collecting data in secret way to be used for civilian and military applications. It can be seen during protests, manifestations presenting public disappointment against some governmental decisions as drones are used to monitor, record people to use it against them later. Space and location are not playing a role allowing multidimensional view. On the other hand, UAVs are to supervise remote areas, inaccessible locations, borders saving resources and money when providing valuable and precise information. Utilization of drones includes criminal organization as those are very effective in adopting new tools recognizing their value and lack of clear legal regulations.

It is worth to notice, that from security point of view, every air and land component of a drone could be a subject of terrorist

or cyber-attack; in specific conditions it could cause a danger for air traffic and aviation in general. It is also relatively easy to overtake control of a drone. Todd Humphrey, professor at the University of Texas at Austin's Radio navigation Laboratory, has demonstrated that hacking a civilian drone is ease. He presented for the Department of Homeland Security that using a limited budget and some persons, he is able to "send signals to an UAV's GPS receiver, hijack the aircraft in mid-air, and control its route" [17]. He spent some 1,000 USD on equipment and designing an application. The threat of hijacking UAVs is not to be excluded as it is doable and possible to be used by illegal or even terrorists' organizations. The safety is an issue and it will be a challenge but "progress in regulating civilian UAV use is likely to lead to additional sensors and communications devices to avoid restricted airspace and collisions with other aircraft" [22] like Automatic Dependent Surveillance-Broadcast (ADS-B) systems used on manned aircraft, GPS, advanced software, sophisticated data or communications tools making them more resistant for cyber or electronic attacks.

5. Conclusion

The drones have variety of opinions among society and they are often connected with negative impression, which is caused by their utilization during military conflicts of last years. The US unmanned combat aerial vehicle MQ-1 "Predator" has been a symbol of UAVs combat role targeting terrorists, however often killing innocent civilians. That perception is changing as more and more drones applications are supporting daily life and those are visible in many roles as presented before. The number of drones' application is and will be growing to support peoples life in developed and developing countries and it is recognized by modern societies. Citizens are recognizing that those "eyes in the sky" are not aimed to endanger them but rather to support their daily life. The number of applications will inevitable raise in coming years as there are more capabilities coming from miniaturization, software, engineering and other research and science domains. Those are easily adoptable by producers to meet expectations of private users and commercial organizations. The trend is positive in nature. The legal aspect must however follow technology and innovative utilization to be sure that drones will not be used to harm democratic nations which believe that technology is only to support and not to undermine their values and way of life.

Bibliography

[1] BRACKEN-ROCHE, C.: Domestic drones: the politics of verticality and the surveillance industrial complex, Geographica Helvetica No 71, Copernicus Gesellschaft mbH, 15 July 2016.
[2] LAWLOR M.: Robotics Concepts Take Shape, The Armed Forces Communications and Electronics Association (**AFCEA**), Fairfax 2003, http://www.afcea.org/content/?q=robotics-concepts-take-shape [date of access: 12.03.17].
[3] ELZWEIG, B.: Civilian Commercial Drones Are Coming; Are We Ready? Southern Law Journal, the Southern Academy of Legal Studies in Business, Vol. XXV, spring 2015.
[4] FINN, R., WRIGHT, D.: Unmanned aircraft systems: surveillance, ethics and privacy in civil applications, Computer Law & Security Review No. 28, Elsevier Ltd. 2012.
[5] HING J., OH P.: Development of Unmanned Aerial Vehicle Piloting System with Integrated Motion Cueing for Training and Pilot Evaluation, in Valavanis K., Oh P., Piegl L. (eds.) Unmanned Aircraft Systems, International Symposium On Unmanned Aerial Vehicles, UAV'08, Springer Science & Business Media 2008.
[6] ELIAS B.: Pilotless Drones: Background and Considerations for Congress Regarding Unmanned Aircraft Operations in the National Airspace System, US Congressional Research Service, Washington 10 September 2012.
[7] SCHREIBER L.: Ostiari E., Game of drones: do civilian applications harbour opportunities for sustainable development? Groupe BPCE Paris 20 May 2014.
[8] Amazon Prime Air, Website of Amazon Company, https://www.amazon.com/Amazon-Prime-Air/b?node=8037720011 [date of access: 12.03.17]
[9] Unmanned Aircraft Systems (UAS), Website of The National Atmospheric and Oceanic Administration, https://uas.noaa.gov/About [date of access: 12.03.17]
[10] LEMONICK M.: Scientists Turn to Drones for Closer Look at Arctic Sea Ice, Scientific American, a Division of Nature America, Inc., 23 April 2015 https://www.scientificamerican.com/article/scientists-turn-to-drones-for-closer-look-at-arctic-sea-ice/ [date of access: 12.03.17]
[11] Transplant Transportation Services, Inc. Unveils Its Own R&D Project Utilizing Unmanned Aerial Vehicles For Donor Organ Transport As Part Of Its DonorLogic™ Platform, Transplant Transportation Services, Inc. Press Release Petaluma 3 December 2013.
[12] FLOREANO, D., WOOD, R.: Science, technology and the future of small autonomous drones, Nature Vol. 521, Macmillan Publishers Limited 28 May 2015.
[13] MARSHALL, D.: U.S. Aviation Regulatory System, in D. Marshall et al. (eds.), Introduction to Unmanned Aircraft Systems, CRC Press Boca Raton 2011.
[14] GUSTERSON, H.: Drone. Remote Control Warfare, the MIT Press, Massachusetts 2016.
[15] SIMONIDES, J.: Prawno międzynarodowe problemy użycia dronów w walce z terroryzmem. Debaty i kontrowersje (Legal and international problems of using drones to fight terrorism. Debates and controversies), Bellona Quarterly No 4, Warsaw 2014.
[16] Revising the Airspace Model for the Safe Integration of Small Unmanned Aircraft Systems, Amazon Company, https://images-na.ssl-images-amazon.com/images/G/01/112715/download/Amazon_Revising_the_Airspace_Model_for_the_Safe_Integration_of_sUAS.pdf [date of access: 12.03.17]
[17] PAGANINI, P., Hacking Drones … Overview of the Main Threats, General Security 4 June 2013, http://resources.

infosecinstitute.com/hacking-drones-overview-of-the-main-threats/ (accessed: 22 February 2017).

[18] BOUCHER, P.: 'You Wouldn't have Your Granny Using Them': Drawing Boundaries between Acceptable and Unacceptable Applications of Civil Drones, Science and Engineering Ethics No 22 (2016), published 04 November 2015.

[19] Introduction of a regulatory framework for the operation of unmanned aircraft, The European Aviation Safety Agency, Brussels December 2015, available at: https://www.easa.europa.eu/system/files/dfu/Introduction%20of%20a%20regulatory%20framework%20for%20the%20operation%20of%20unmanned%20aircraft.pdf [date of access: 20.02.17]

[20] 'Prototype' Commission Regulation on Unmanned Aircraft Operations, The European Aviation Safety Agency, Brussels 22 August 2016, the draft of the regulations available at: https://www.easa.europa.eu/system/files/dfu/UAS%20Prototype%20Regulation%20final.pdf [date of access: 20.02.17]

[21] CRACKNELL A., UAVs: regulations and law enforcement, International Journal of Remote Sensing, 38:8-10, 22 March 2017.

[22] HARTMANN, K., GILES, K.: UAV Exploitation: A New Domain for Cyber Power, in Pissanidis N., Rõigas H., Veenendaal M. (eds.) 8th International Conference on Cyber Conflict Cyber Power, NATO Cooperative Cyber Defence Centre of Excellence Publications Tallinn 2016.