UNMANNED AERIAL VEHICLES AND THEIR GROWING ROLE IN SHAPING MILITARY DOCTRINE

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ABSTRACT
The goal of the paper is to present growing influence of unmanned aerial vehicles (UAVs) on the shape of military doctrine. Author, in the first part of article, presents terminology and classifications of the UAVs, as well as, the main criteria of the classification which are: thrust, purpose, weight, and range/endurance. The second part of the article is dedicated to military technology. In that part of the article, author presents possible kind of utilization of the UAVs, presenting in the more details military drones. In description of the drones is also part of initial conclusions addressing to the challenges new doctrine and battlefield strategy. In the conclusion author presents the expecting changes in a military doctrine, caused by employing of a new military technology, a specially the new kind of drones on the battle field.

KEY WORDS
Unmanned aerial vehicle, drone, tactics, military doctrine.

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Introduction

The goal of the paper is to present to the general reader the up-to-day military drone technology, as well as its growing influence on military doctrine.

In the first section of the paper the basic terminology is explained and four main classifications of the unmanned aerial vehicles are introduced and discussed. The drones are divided on the basis of the following criteria: thrust, purpose, weight, and range/endurance. Next, the differences between combat and surveillance UAVs are demonstrated, and the attention is turned to the relatively new hybrid type, i.e. the hunter-killer drone. The next criterion used for UAVs' classification is their weight (size). The classic NATO UAS classification is provided. The last classification discussed is pertinent to UAVs' maximal range, altitude, and endurance. Here the following types are described: low cost close range, close range, short range, medium range, medium altitude long endurance (MALE), and high altitude long endurance (HALE).

The second part of the article is dedicated to presenting in more detail chosen military drones. The section was divided into the three following subsections: battlefield UAVs (where the Black Horner, ROTEM L, and Raven are depicted), ISR UAVs (the Black Hawk, Falco), and combat and hunter-killer drones (Harpy 2 and Reaper).

In description of every drone there is a part addressing how the usage of that technology changes the battlefield strategy, and in case of the MALE and HALE class (especially the hunter-killer type) how they might influence the military doctrine and war waging in general.

The article is concluded with a more systematic discussion of the possible military doctrine alterations caused by employing new drone technologies. The main foundation for the discussion is the 2011 United Kingdom Ministry of Defence Report: *The UK Approach to Unmanned Aircraft Systems*, which is an attempt to anticipate such changes.

Classification of the Military Unmanned Aerial Systems

Due to a growing number of drone types and the considerable differences among them, any discussion about autonomous aerial vehicles should be preceded by a clear statement in regard what kind of drones one is talking about. Let us start with basic terminology explanations.

The most general dictionary definitions of a drone (not a male bee) specify it as an "unmanned aircraft,"[1] or an "aircraft that does not have a pilot but is controlled by someone on the ground, used especially for dropping bombs or for surveillance," or "as a hobby"[2]. Some definitions expand the meaning to include also marine vehicles and autonomous steering and elucidate the drone as "an unmanned aircraft or ship guided by remote control or onboard computers"[3].

There are ongoing discussions considering the definition because even those simple descriptions presented above have to be nuanced due to differences in how contemporary unmanned aircraft are flown[4]. It is not the purpose of this paper to examine that problem and try to come up with a solution. Unless specified differently I will use the general terms "unmanned aerial vehicle" (UAV) and "unmanned aerial system" (UAS) interchangebly, although the latter refers both to the drone qas well as the devices and men required for carrying out missions with it. Optionally piloted vehicles (OPV) that can fly with or without a human pilot on board, like e.g. Northrop Grumman Firebird[5], will not be discussed in the paper.

There are many types of military UAVs, and thus, there are many ways to classify them. I will propose and briefly describe four such categories, which are determined by the following criteria: 1) thrust, 2) purpose, 3) weight, and 4) range/endurance[6].

1. There are three main types of aerial drone platforms: a) multirotor, b) fixed-wing, and c) single rotor – helicopter.
   a) Multirotor UAVs, sometimes called multicopters, have more than two rotors what enables much simpler mechanics to stabilise and control it.

[1] Margaret Rouse, Drone, *TechTarget*. Retrieved from: http://internetofthingsagenda.techtarget.com/definition/drone (02.05.2017).

[2] Drone, Cambridge Dictionary. Retrieved from: http://dictionary.cambridge.org/dictionary/english/drone (02.05.2017).

[3] Drone, Merriam-Webster Dictionary. Retrieved from: https://www.merriam-webster.com/dictionary/drone (02.05.2017).

[4] John Villasenor, for example, asks interesting questions in that regard: "consider an aircraft that is under the control of a remote pilot for most but not all of a mission. If the pilot switches to a GPS-guided autopilot mode for a few minutes, does the aircraft become a "drone" for that subset of its flight, and then lose that designation once the autopilot is switched off? Or does the presence of the GPS autopilot, regardless of how much it is actually used, make it a drone?" John Villasenor, What Is a Drone, Anyway?, Scientific American, April 12, 2012. Retrieved from: https://blogs.scientificamerican.com/guest-blog/what-is-a-drone-anyway/ (11.05.2017).

[5] Northrop Grumman, Firebird: Persistent Multiple Intelligence, Surveillance and Reconnaissance. San Diego: Marcom, 2017. Retrieved from: http://www.northropgrumman.com/Capabilities/Firebird/Documents/data_sheet_Firebird.pdf (12.05.2017.)

[6] Of course, one can list other criteria of distinguishing military UAVs like, for example, the level of their autonomy, maximum speed, or strike precision in case of UCAVs. However, the discussed four are the most common and telling when describing types of drones.

In general, they are very energy insufficient that negatively effects their endurance and coverage. They are also rather loud (even the small ones easily reach the level of 70+ dB[7]), which, on the other hand, limits their surveillance capability.

b) Fixed-wing UAVs are similar to planes as they have the same structure and aerodynamics (use wings to provide lift) but smaller dimensions. They hence require energy only to be moved forward, not to keep suspended in the air, and thanks to that they are much more efficient what translated into much longer endurance and coverage. Fixed-wing drones are powered by combustion engines or an electric battery. Their greatest disadvantage is their inability to hover in one spot. Taking off and landing are also more problematic – their cannot do it vertically and must be either skilfully thrown into the air (micro-, mini- and small-sized vehicles), or launched from a catapult (middle-sized), or require full runaway (large UAVs)[8].

c) Single-rotor type UAVs have, just like manned helicopters, a single rotor and usually one or two small tail rotors to control its heading. They are much more energy efficient in comparison to multi-rotor drones and can be powered by a gas motor for even longer endurance. Among the downsides their mechanical complexity, cost, and vibration are listed[9].

2. Traditionally military drones were divided, based on their purpose, into two categories, namely a) the intelligence, surveillance, reconnaissance type (ISR), and b) unmanned combat aerial vehicles (UCAV). It has to be noted however that that classification should be expanded by another, currently much more numerous than the previous one category of ISR-combat hybrids, i.e. c) the hunter-killer type of air vehicles.

a) Drones are a very important component of gathering information to reduce uncertainty. Large scale ISR UAVs provide "intelligence, a dynamic retasking capability, and real-time video imagery" and "an alternative to complement manned aircraft and satellites"[10]. The smaller ones, like an equipped with a camera Black Hornet nano-coper, are often used to collect information during missions. According to a member of the UK Brigade Reconnaissance Force in Afghanistan:

Black Hornet is definitely adding value, especially considering the light weight nature of it. We used it to look for insurgent firing points and check out exposed areas of the ground before crossing, which is a real asset. It is very easy to operate and offers amazing capability to the guys on the ground[11].

b) Unmanned combat aerial vehicles (UCAVs) are types of drones whose primary purpose is air-to-ground strike. As stated by the representatives of Lockheed Martin Tactical Aircraft Systems – one of the major

[7] Tim Levin, How Loud Is Your Drone? – The Drone Noise Test of P2, P3P, P4P, 12 ... WeTalkUAV, February 18, 2017. Retrieved from: http://www.wetalkuav.com/dji-drone-noise-test/ (12.05.2017).

[8] Andrew Chapman, Types of Drones: Multi-Rotor vs Fixed-Wing vs Single Rotor vs Hybrid VTOL, Australian UAV. Retrieved from: https://www.auav.com.au/articles/drone-types/ (12.05.2017).

[9] Ibid.

[10] Mark Raffetto, Unmanned Aerial Vehicle Contributions to Intelligence, Surveillance, and Reconnaissance Missions for Expeditionary Operations, Naval Postgraduate School, Monterey, 2004, p. 1. Retrieved from: http://www.dtic.mil/dtic/tr/fulltext/u2/a427707.pdf (07.05.2017).

[11] Quoted after: Ann Rogers and John Hill, Unmanned: Drone Warfare and Global Security, Toronto: Between the Lines, 2014, p. 56.

player on the military drone market, UCAVs' main function is to deliver ordnance. Near-term capability ranges from preplanned strikes against fixed ground targets to suppression of enemy air defences (SEAD). Longer term capabilities cover a full range of missions including carriage of new weapon types that are uniquely suited to the UCAV concept[12].

c) The idea behind the creation of a ISR-combat hybrid was to design from scratch a new class of UAV that unlike MQ-1 Predator, which is also often counted as a hunter-killer type but by many is considered rather as a weaponized sensor platform, would combine seeking out targets and striking them[13]. MQ-9 Reaper produced by General Atomics Aeronautical Systems from San Diego was the first aircraft of that type. As stated by Air Force Chief of Staff Gen. T. Michael Moseley: "The Reaper represents a significant evolution in UAV technology and employment (...). We've moved from using UAVs primarily in intelligence, surveillance, and reconnaissance (ISR) roles before Operation Iraqi Freedom to a true hunter-killer role with the Reaper"[14].

3. The next criterion that is used for classification of UAVs is their weight (mass). There are many various divisions in that regard, although the most accepted is the NATO UAS Classification Guide adopted at the JCGUAV meeting in September 2009[15]. The gross take-off weight of largest one – Northrop Grumman RQ-4 Global Hawk amounts to 14,628 kg[16], while the smallest Black Hornet that weighs just 18 grams[17].

The detail classification is presented in Table 1.

Table 1. NATO UAS Classification Guide[18]

Class	Category	Normal employment	Normal Operating Altitude	Normal Mission Radius	Example platform
CLASS I (less than 150 kg)	SMALL >20 kg	Tactical Unit (employs launch system)	Up to 5K ft AGL	50 km (LOS)	Luna, Hermes 90
	MINI 2-20 kg	Tactical Sub-unit (manual launch)	Up to 3K ft AGL	25 km (LOS)	Scan Eagle, Skylark, Raven, DH3, Aladin, Strix
	MICRO <2 kg	Tactical PI, Sect, Individual (single operator)	Up to 200ft AGL	5 km (LOS)	Black Widow
CLASS II (150 kg to 600 kg)	TACTICAL	Tactical Formation	Up to 10,000 ft AGL	200 km (LOS)	Sperwer, Iview 250, Hermes 450, Aerostar, Ranger

[12] Armand J. Chaput et al, Defense Technical Information Center Compilation Part Notice for CAS, Lockheed Martin Tactical Aircraft Systems, p. B27-2. Retrieved from: http://www.dtic.mil/dtic/tr/fulltext/u2/p010339.pdf (10.05.2017).

[13] J.R. Wilson, Hunter-Killer UAVs to swarm battlefields, Military and Aerospace Electronics, July 1, 20017. Retrieved from: http://www.militaryaerospace.com/articles/print/volume-18/issue-7/electro-optics-supplement/features/hunter-killer-uavs-to-swarm-battlefields.html (12.05.2017).

[14] Ibid.

[15] Joint Air Power Competence Centre, Strategic Concept of Employment for Unmanned Aircraft Systems in NATO, Jan 4, 2010.

[16] RQ-4 Block 30 Global Hawk, Northrop Grumman Systems Corporations, San Diego: Marcom, 2016. Retrieved from: http://www.northropgrumman.com/Capabilities/GlobalHawk/Documents/GH_Brochure_B30.pdf (21.05.2017).

[17] PD-100 Black Hornet PRS, FLIR: Unmanned Aerial Systems. Retrieved from: http://www.proxdynamics.com/products/pd-100-black-hornet-prs (21.05.2017).

[18] Joint Air Power Competence Centre, Strategic Concept of Employment for Unmanned Aircraft Systems in NATO, Jan 4, 2010., p. 6. Retrieved from: http://www.japcc.org/wp-content/uploads/UAS_CONEMP.pdf (12.05.2017).

CLASS III (more than 600 kg)	Strike/ Combat	Strategic/National	Up to 65,000 ft	Unlimited (BLOS)	
	HALE	Strategic/National	Up to 65,000 ft	Unlimited (BLOS)	Global Hawk
	MALE	Operational/Theatre	Up to 45,000 ft MSL	Unlimited (BLOS)	Predator B, Predator A, Heron, Heron TP, Hermes 900

4. The final classification presented in this paper uses UAVs maximal range, altitude, and endurance as a benchmark for defining drone types. There are six categories that can be distinguished here, namely: a) low cost close range, b) close range, c) short range, d) medium range, e) medium altitude long endurance (MALE), and f) high altitude long endurance (HALE)[19].

   Very low cost close range (VLCCR) drones are the smallest UAVs with the range of 5 km and endurance time up to 45 minutes. UAVs in this class are very similar to model airplanes. Raven and Dragon Eye belong to this category.

   b) *Close range* (CR) UAVs have a range of around 50 km and can stay in the air to maximum 6 hours. They are usually used for ISR purposes. Israeli Orbiter may serve as an example of this category. It can be launched by a catapult, bungee or hand and has the range of 15 km and 1.5 hour flight endurance[20].

   c) *Short range* (SR) drones have endurance times reaching 8 to 12 hours and the range up to 150 km. Just like CR UAVs they are used mainly for reconnaissance and surveillance tasks. The examples of this drone class are Shadow v2 (endurance: 9 hours, max wingspan: 6.2 m, payload: 43 kg, range: 125 km)[21] or the Polish E-310 (endurance: 12 hours, wingspan: 5.4 m, payload: 20 kg, range: 150 km)[22].

   d) *Medium range* UAVs are able to stay in the air for up to 20 hours. They can reach the highest altitude of 4,500 m, while their maximal range is limited to between 300 to 650 km. UAVs of this type are used mainly In this category for reconnaissance and surveillance purposes, as well as for gathering meteorological data. In this category there are both, rotary wings (e.g. Northrop Grumann's Fire Scout) and fixed wings vehicles like Sagem's Spedwer-B or Watchkeeper produced by the Elbit/Thales Group.

   e) *Medium altitude long endurance* (MALE) class of UAVs have the range of 1,150 km, altitude of 15,000 m and endurance of 14 to 24 hours. The majority of them are the fixed wings type (e.g. General Atomics' Predator A, or Hermes 1500 manufactured by Elbit Systems) but there are also rotorcrafts in this class, like a retired already Boeing's A160 Hummingbird

[19] The below classification was established on the basis of: Andrea Gilli, Drones for Europe, European Union Institute for Security Studies 29, September 2013, pp. 1-2. Retrieved from: http://www.iss.europa.eu/uploads/media/Brief_29.pdf (16.05.2017); Classification of the Unmanned Aerial Systems, GEOG 892 course: Geospatial Applications of Unmanned Aerial Systems (UAS), PennState College of Earth and Mineral Sciences. Retrieved from: https://www.e-education.psu.edu/geog892/node/3 (16.05.2017).

[20] Orbiter, www.Israeli-Weapons.com LTD. Retrieved from: http://www.israeli-weapons.com/weapons/aircraft/uav/orbiter/Orbiter.html (28.05.2017).

[21] Shadow v2, Textron Systems. Retrieved from: http://www.textronsystems.com/what-we-do/unmanned-systems/shadow-family (28.05.2017).

[22] E-310 Short-Range Unmanned Air System (UAS), Poland, airforce-technology.com. Retrieved from: http://www.airforce-technology.com/projects/e-310-short-range-unmanned-air-system-uas/ (28.05.2017).

or Snark produced by TG Helicorp. The newest generation of MALE are used either for surveillance and reconnaissance, or are of a hunter-killer kind.

f) *High altitude long endurance* (HALE) class of UAVs have the range of 14,000 km, altitude of 18,000 m and endurance of 28 hours and more. They are all of the fixed wings surveillance type of drones like e.g. Northrop Grumman's Global Hawk or Boeing's Phantom Eye.

Military Drones in Action – the New Way of War

It is a clear-cut fact that the emergence of UAVs and especially UCAVs has greatly altered intelligence and warfare over the last three decades. The reasons for that are quite simple, as Andrea Gilli puts it: "at relatively affordable costs, they can deliver powerful surveillance capabilities, thus enhancing military planners' and political decision-makers' situation awareness and intelligence, as well as reducing troops' presence on the ground for both combat and non-combat missions"[23]. Moreover, as he writes further, "over the next few decades, combat drones will reshape – if not completely revolutionise – air warfare thanks to superior aerodynamic, ground-attack and swarming capabilities, whatever one may think about their ethical implications"[24].

Battlefield UAVs

Black Hornet

The system (PD-100 PRS Black Hornet 2) is advertised as the first airborne and commercially available Personal Reconnaissance System that provides the user with a "highly mobile sensor system providing an immediate Intelligence, Surveillance and Reconnaissance capability"[25]. It is a GPS guided, 18 g (including cameras) single rotor micro drone of very close range. It was used by the British military in Afghanistan already in 2012[26]. According to Major Adam Folden.

Black Hornet is a game-changing piece of kit. Previously we would have sent soldiers forward to see if there were any enemy fighters hiding inside a set of buildings. Now we are deploying Black Hornet to look inside compounds and to clear a route through enemy-held spaces. It has worked very well and the pictures it delivers back to the monitor are really clear. And Black Hornet is so small and quiet that the locals can't see or hear it[27].

The size and easiness of operating are Black Hornet's real assets. What is probably the most important it is recognized by the troops as an added value that can save lives[28].

[23] Andrea Gilli, Drones for Europe, European Union Institute for Security Studies 29, September 2013, p. 1. Retrieved from: http://www.iss.europa.eu/uploads/media/Brief_29.pdf (16.05.2017).

[24] Andrea Gilli, Drones for Europe, European Union Institute for Security Studies 29, September 2013, p. 1. Retrieved from: http://www.iss.europa.eu/uploads/media/Brief_29.pdf (16.05.2017).

[25] PD-100 Black Hornet PRS, FLIR: Unmanned Aerial Systems. Retrieved from: http://www.proxdynamics.com/products/pd-100-black-hornet-prs (29.05.2017).

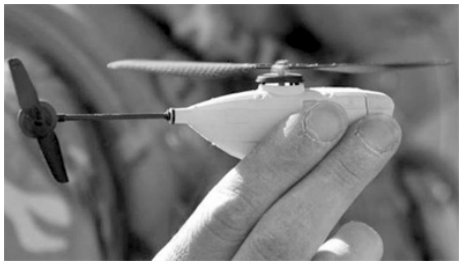
[26] Mini helicopter drone for UK troops in Afghanistan, BBC News (03.02.2013). Retrieved from: http://www.bbc.com/news/uk-21313323 (01.06.2017).

[27] Quoted after: Andrew Tarantola, Black Hornet: The $195,000 Spy Plane That Fits in the Palm of Your Hand. Gizmodo (06.02.2013). Retrieved from: http://gizmodo.com/5981975/black-hornet-the-195000-spy-plane-that-fits-in-the-palm-of-your-hand (01.06.2017).

[28] Miguel Santos, The Coming Age of the Military Micro-Drone, Futurism (02.02.2016). Retrieved from: https://futurism.com/the-coming-age-of-the-micro-drone/ (01.06.2017); Andrew Tarantola, Black Hornet: The $195,000 Spy Plane That Fits in the Palm of Your Hand. Gizmodo (06.02.2013). Retrieved from: http://gizmodo.com/5981975/black-hornet-the-195000-spy-plane-that-fits-in-the-palm-of-your-hand (01.06.2017).

[29] The source: Andrew Tarantola, Black Hornet: The $195,000 Spy Plane That Fits in the Palm of Your Hand. Gizmodo (06.02.2013). Retrieved from: http://gizmodo.com/5981975/black-hornet-the-195000-spy-plane-that-fits-in-the-palm-of-your-hand (01.06.2017).

Figure 1. Black Hornet[29]



ROTEM L

This tactical drone is an example a small, multirotor unmanned combat aerial vehicle of close range. According to the producer, Israel Aerospace Industries, ROTEM L provides "excellent capabilities dealing with low signature enemy in urban and complex environment"[30]. The UCAV is able to fly up to 45 minutes in maximal range of 10 km. It is equipped with a 1 kg warhead, strikes the target with precision below 1 m and is advertised as possessing the "highest lethality in its class"[31]. ROTEM is inaudible from a distance of few hundred meters and can stay unnoticed during the whole mission[32].

The system can be packed folded and carried by and operated by one soldier. Tamir Eshel describes it operational capabilities in the following way:

When a target is located and verified the operator can switch to attack mode, the drone responds and quickly accelerates to a high speed dive, closing in on its prey, with the target maintained in view throughout the flight, enabling the manned operator to monitor the attack and abort anytime if necessary. Using on-board sensors, ROTEM effectively avoids obstacles, enter windows at low or high levels, or manoeuvre around fences. The operator directs the ROTEM to its target – horizontally, vertically or slanted as necessary[33].

The biggest asses od ROTEM L is undoubtedly its ability to operate in complex urban areas and the possibility to be quickly switches into the combat/attack mode. The drone, then, behaves more like a big-scale killer-hunter MALE or a missile and is send to eliminate the target, also the ones located in side of buildings.

Figure 2. ROTEM L[34]

Raven

RQ-11B Raven is a small fixed-wing man-portable drone that provides direct intelligence, surveillance and reconnaissance (ISR) and target information. It was used by U.S. army in combat supporting operations in Iraq and Afghanistan. It has the wingspan of 1.37 m, cruise speed of 42 kph, range of 10 km, and endurance up to 90 minutes[35]. Raven is able to deliver "real-time colour or infra-red imagery to ground control unit (GCU) and remote viewing stations, as well as IR laser illumination of ground targets"[36].

30 ROTEM L: Multi-Rotor Loitering Munition for Ground Forces. Israel Aerospace Industries, MBT Missiles Division, p. 2. Retrieved from: http://www.iai.co.il/Sip_Storage/FILES/3/41653.pdf (13.05.2017).

31 ROTEM L. Israel Aerospace Industries. Retrieved from: http://www.iai.co.il/2013/36694-46735-en/Business_Areas_Land.aspx (13.05.2017).

32 Tamir Eshel, IAI's ROTEM – Tactical Multirotor Killer Drone. Defense Update. Retrieved from: http://defense-update.com/20160216_rotem.html (13.05.2017).

33 Tamir Eshel, IAI's ROTEM – Tactical Multirotor Killer Drone. Defense Update. Retrieved from: http://defense-update.com/20160216_rotem.html (13.05.2017).

34 The source: Kim Bồng, Việt Nam nẹn tham khảo "UAV sát thủ" Rotem L của Israel? (07.06.2016). Kienthuc. Retrieved from: http://kienthuc.net.vn/quan-su-viet-nam/viet-nam-nen-tham-khao-uav-sat-thu-rotem-l-cua-israel-693083.html (01.06.2017).

35 RQ-11B Raven, U.S. Air Force. Published: October 31, 2007. Retrieved from: http://www.af.mil/About-Us/Fact-Sheets/Display/Article/104533/rq-11b-raven/ (10.05.2017).

36 RQ-11 Raven Unmanned Aerial Vehicle, United

In spite of the initial success and good reception Raven nowadays is considered to be rather controversial. Many troops complain about the difficulty of launching it into the air[37]. However, the real criticism of the drone came from the December 2016 Reuters report, where it was stated that it not only under-performed in eastern Ukraine, but that its employment might actually have put Ukrainian troops in danger due to its obsolete, analogue control system. Raven, as it turned out, was vulnerable to Russian state-of-the-art jamming systems. Far more worrisome was, as Joseph Trevithick writes: that insurgents or their Russian partners might have the ability to intercept and view the Raven's camera feed. Depending on the drone's route, the camera might end up showing Ukrainian positions to the enemy, becoming a sort of flying double agent[38].

Figure 3. RQ-11 Raven[39]

States of America, army-technology.com. Retrieved from: http://www.army-technology.com/projects/rq11-raven/ (10.05.2017).

37 Why Soldiers Hate the Raven UAV, Military.com (29.05.2012). Retrieved from: http://www.military.com/video/aircraft/pilotless-aircraft/why-soldiers-hate-the-raven-uav/1661802396001 (01.06.2017).

38 Joseph Trevithick, America Is Still Training Ukrainian Troops to Fly a Drone They Have, The Warzone (04.04.2017), Retrieved from: http://www.thedrive.com/the-war-zone/8921/america-is-still-training-ukrainian-troops-to-fly-a-drone-they-hate (01.06.2017).

39 The source: John F. Guilmartin, Unmanned aerial vehicle (UAV): Military Aircraft, Encyclopaedia Britannica. Retrieved from: https://www.britannica.com/technology/unmanned-aerial-vehicle (01.06.2017).

Intelligence, Surveillance, Reconnaissance (ISR) Drones

Global Hawk

The RQ-4 Global Hawk is the largest drone ever constructed. The UAV has the wingspan of almost 40 m, can reach the speed of 310 knots (574 km/h) and last in the air form more than 34 hours[40]. It is a HALE-type aircraft that can be used to collect weather measurements (like NASA does[41]) or day or night intelligence information. Its mission is "to provide a broad spectrum of ISR collection capability to support joint combatant forces in worldwide peacetime, contingency and wartime operations. The Global Hawk provides persistent near-real-time coverage using imagery intelligence (IMINT), signals intelligence (SIGINT) and moving target indicator (MTI) sensors"[42].

The UAV has been in active operation with the U.S. Airforce since 2001 and has flown more than 200,000 flight hours in support of military operations in Iraq, Afghanistan, North Africa, and the Asia-Pacific region. Global Hawk, according to its producer – Northrop Grumman, "sees potential threats to allow commanders to gain greater understanding of an area of interest"[43].

40 RQ-4 Global Hawk, U.S. Air Force (27.10.2014). Retrieved from: http://www.af.mil/About-Us/Fact-Sheets/Display/Article/104516/rq-4-global-hawk/ (04.06.2017).

41 Monroe Conner, NASA Armstrong Fact Sheet: Global Hawk High-altitude, long-endurance science aircraft, NASA, 06.08.2015. Retrieved from: https://www.nasa.gov/centers/armstrong/news/FactSheets/FS-098-DFRC.html (04.06.2017).

42 RQ-4 Global Hawk, U.S. Air Force (27.10.2014). Retrieved from: http://www.af.mil/About-Us/Fact-Sheets/Display/Article/104516/rq-4-global-hawk/ (04.06.2017).

43 Global Hawk, Northrop Grumman. Retrieved from: http://www.northropgrumman.com/Capabilities/GlobalHawk/Pages/default.aspx (04.06.2017).

44 The source: Free Press Agency (26.12.2015). Retrieved from: https://fpa2000.wordpress.com/2015/12/26/cinque-spy-droni-a-sigonella-quando-luomo-e-aiutato-dal-robot/ (01.06.2017).

Figure 4. RQ-4 Global Hawk.

Falco

The Falco developed by an Italian company Selex ES (introduced in 2003) is another example of an ISR UAV that has been successfully used. It is a fix-wing, medium range, Class II drone with the wingspan of 7.2 m, maximum take-off weight of 420 kg used equipped with, i.a., electro-optical camera, infrared camera and a laser rangefinder. It is used for patrol and surveillance flights[45].

The Falco is most famous from being chosen by the United Nation for their peace mission in Congo. The eastern parts of the country have been in war for 20 years. The UN's peacekeeping forces arrived to the Democratic Republic of Congo in 1999. Their primary goal has been to protect the civilians. The contingent has currently five Falcos and the UN pays Selex $13 per year to run the drones. They have been well received by the soldiers. According to Lieutenant Colonel Matt White who was the head if UAS operations in 2015, the Falco is "absolutely outstanding value for money. It brings situational awareness to the mission that you previously didn't have. I wouldn't like to guess at the magnitude improvement, but I would suggest it's large"[46]. There are no doubt that Falcos were better at aerial reconnaissance than helicopters that had been used before; the drones found a whole village that was missed by the helicopters[47]. However, the employment of the drones as an integrated part of the overall operations leaves a lot of room for improvement. The drones, as Kakaes writes, "can in principle act as a force multiplier"[48] but now, very often, the intelligence they gather are not used in conjunction with other sources of information.

Figure 5. Selex Es Falco[49]

Combat and Hunter-Killers UCAVs

Harpy 2

The Harpy 2 (isr. Harop) is a UCAV designed to detect, attract and eliminate targets by self-destructing into them (the so-called "suicide drone"). This aircraft, developed and produced by Israeli Aerospace Industries Ltd., has a 3 m wingspan, a range of 1000 km, endurance of up to six hours, and is equipped with a 23 kg warhead.[50] The system, so far, has been purchased by Azerbaijan, Kazakhstan, Turkey, and Uzbekistan[51], and India[52].

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[48] Ibid., p. 93.

[49] The source: U.N. Surveillance Drone Crashes In Congo, Airport Sources Report, Huffington Post (17.03.2014). Retrieved from: http://www.huffingtonpost.com/2014/01/15/un-drone-crash-congo_n_4600685.html (01.06.2017).

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Figure 6. Harpy 2[53]

Reaper

Developed and produced by General Atomics Aeronautical Systems MQ-9 Reaper is an armed, a Class III hunter-killer type of MALE, remotely controlled aircraft that is primarily employed "against dynamic execution targets and secondarily as an intelligence collection asset. ... [Due to] its significant loiter time, wide-range sensors, multimode communications suite, and precision weapons – it provides a unique capability to perform strike, coordination, and reconnaissance against high-value, fleeting, and time-sensitive targets"[54]. It can perform the following tasks and missions: "intelligence, surveillance, reconnaissance, close air support, combat search and rescue, precision strike, buddy-lase, convoy/raid overwatch, target development, and terminal air guidance"[55]. The Reaper, which was introduced in 2007, has got a 20.1 m wingspan, has the maximum take-off weight of 4,760 kg, range of 1850 km, and maximum speed of 370 km/h. It is operated by two people – the pilot and sensor operator[56]. The Reaper, called sometimes Predator B, is a larger and more powerful version of its predecessor – the MQ-1 Predator; it can be equipped with up to four Hellfire missiles, two GBU-12 Paveway II laser-guided bombs or two 500-pound GBU-38 Joint Direct Attack Munitions[57].

The Reaper, alongside with Predator, are lethal drones that are primarily used by the U.S. in Afghanistan and Pakistan[58]. They are also employed in striking operations in Syria, where they are employed in hunting-killing operations. Killing the Islamic State militant known as "Jihadi John" (a Kuwaiti-born British citizen, who often appeared in videos of beheadings of Western hostages) can serve as an example of such actions. On November 13, 2015, the Pentagon announced that they were "reasonably certain" that a Reaper strike had hit the intended target[59].

The UCAV attacks are becoming more and more popular. As reported by the Bureau of Investigative Journalism, 1 in 4 missiles in Afghan airstrikes are fired by drones[60]. In 2016 there were 1072 air- and drone strikes in Afghanistan and 239 were reportedly carried out by UCAVs[61].

from: http://www.israeli-weapons.com/weapons/aircraft/uav/harpy/HARPY.html (02.06.2017).

53 The source: http://aermech.in/iai-haropiai-harpy-2-attack-ucavdroneindian-army/

54 MQ-9 Reaper, U.S. Air Force. Retrieved from: http://www.af.mil/About-Us/Fact-Sheets/Display/Article/104470/mq-9-reaper/ (02.06.2017).

55 Ibid.

56 Ibid.

57 Joakim Kasper Oestergaard Balle, About the Predator and Reaper, Aeroweb (27.07.2016). Retrieved from: http://www.fi-aeroweb.com/Defense/MQ-1-Predator-MQ-9-Reaper.html (02.06.2017).

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59 'Jihadi John': US 'Reasonably Certain' Strike Killed IS Militant, BBC News (13.11.2015). Retrieved from:http://www.bbc.com/news/uk-34805924 (03.06.2017).

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61 Jack Serle and Jessica Purkiss, Drone Wars: Full Data, The Bureau of Investigative Journalism (01.01.2017). Retrieved from: https://www.thebureauinvestigates.com/stories/2017-01-01/drone-wars-the-full-data (01.06.2017).

62 The source: https://humanoides.fr/black-dart-convention-moyens-defense-contre-drones/

Figure 7: Reaper (Predator B)[62]

Military Drones and How They Change Military Doctrine – the Conclusion

Ann Rogers and John Hill in their book *Unmanned: Drone Warfare and Global Security*[63] discuss the potential of the military drones, both the ISR and combat (or hunter-killer) types, to alter military doctrine. They invoke the UK Ministry of Defence *Joint Doctrine Note* report on the approach to UAVs[64]. Let me quote a part of it after them:

> *Unmanned aircraft now hold a central role in modern warfare and there is a real possibility that, after many false starts and broken promises, a technological tipping point is approaching that may well deliver a genuine revolution in military affairs*[65].

In the drone technology they see an approaching "genuine revolution" that will have the power to change military affairs. It is hart to disagree. Rogers and Hill point at several areas where UAVs should operate better than their manned counterparts. Persistent surveillance is one of them and as we have seen from the engagement of the Falco in the UN's peacekeeping mission in Congo, the drones are much more thorough, more efficient, way safer and cheaper (in spite of many still persisting problems) than helicopters. The next category of missions is defined as "dirty". The tasks that to be undertaken in environments hostile to human health (including chemical, biological, radiological and nuclear type missions) belong to this category[66]. The third category, named "dangerous," describes "the most obvious military advantages of the UAVs: carrying out missions where relationship between importance and risk to personnel doesn't justify putting human operators in danger"[67]. Basically all the presented drones in this paper can be listed in that category: from the micro Black Hornet to the largest UAV – the Black Hawk. Of course, all of them serve different purposes and have different functionalities but, and it should be stressed here again, the very idea behind developing and operating unmanned aircrafts is to reduce manpower engaged in intelligence collection and fighting; to make the warfare safer for the troops and personnel.

Small UAVs introduce important and positive changes into conducting the surveillance and reconnaissance (e.g., the Black Hornet in buildings or other close spaces, the Raven in open, larger proximity spaces), or can be used as a new kind of track-strike weapon (e.g. ROMEM L). However, the real change when it comes to ways of waging the war is being brought by MALE and HALE hybrid hunter-killer types of drones. It is important to see that they do much more than simply emulate manned aircraft – "they enable different behaviours, reducing risk to your own personnel, making war less terrible and therefore risking making war 'more likely'"[68].

[63] Ann Rogers and John Hill, Unmanned: Drone Warfare and Global Security, London: Pluto Press, 2014.

[64] Joint Doctrine Note 2/11: The UK Approach to Unmanned Aircraft Systems, Ministry of Defence, 2011. Retrieved from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/33711/20110505JDN_211_UAS_v2U.pdf (08.05.2017).

[65] Ann Rogers and John Hill, Unmanned: Drone Warfare and Global Security, London: Pluto Press, 2014, p. 48.

[66] Ibid., p. 51.

[67] Ibid., p. 51.

[68] Ibid., p. 57.

Another quite significant factor worth noticing is the growing endurance of the aircrafts. The direction in which the technology is being developed seems unequivocal – the producers want to exchange persistence with permanence, so air forces "would potentially in some sense always be operational, available to planner and decision makers. (...) The date for this? Sometime after 2030"[69]. The researchers at General Atomics have the same idea and the successor of the MQ-9 Reaper – the Avenger (Predator C), which "will contain an airborne network of automated repositioning, precise geo-location, fuser sensor video, and (...) 'autonomous target prioritization'"[70].

The conceptual and technological development of unmanned aerial vehicles seems to gain more and more speed every year. The well-established classifications or typologies become obsolete in a decade. The current bottom-line difference lies, as Rogers and Hill write, in the UAVs' capacity for persistence. In the war that extend across time and space, the persistent presence of the UAV due to its constantly smaller price of production and endurance will lead to the growing amount of data and further automation of the analysis[71] and maybe more autonomous decision-making processes.

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