ANALYSIS OF THE OPPORTUNITIES FOR EMPLOYMENT UNMANNED AERIAL VEHICLES CLASS MINI IN ARTILLERY FORMATIONS

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ABSTRACT*: Nowadays, the use of Unmanned Aerial Vehicles (UAVs) has a growing presence in both civilian and military environments, which has resulted in an opportunity to explore this technology, its benefits and how it can be improved. This paper aims to present a study focused on the impact of UAVs in the military environment, how they can play a vital role in contemporary military conflicts and to improve awareness regarding unmanned systems.*

KEY WORDS: *Unmanned Aerial Vehicles (UAVs), Military drones, Artillery.*

Introduction

The basic definition of a drone is "an unmanned aircraft that can fly autonomously, without human control and without direct visibility". There is a common definition, which can also be found in various dictionaries: "A drone is an unmanned aerial vehicle (UAV) controlled remotely or by an on-board computer". UAVs are vehicles that operate by air, don't carry an onboard pilot or crew, and can be controlled by onboard electronic equipment, or by a ground control station, through the use of waypoints, pre-established goals, or through manual radio operation. There can also be designated terms like Remotely Piloted Aerial Vehicle (RPAV) and Remotely Piloted Aircraft Systems (RPAS). RPAV can be defined as "An unmanned aircraft which is piloted from a remote pilot station". RPAS can be defined as "A remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design". Other definitions are presented on figures 1 and 2.

Term	UK definition[11]
Unmanned aircraft	An aircraft that does not carry a human operator, is operated remotely using varying levels of automated functions, is normally recoverable, and can carry a lethal or non-lethal payload.[12]
Unmanned aircraft system	A system, whose components include the unmanned aircraft and all equipment, network and personnel necessary to control the unmanned aircraft.
Remotely piloted aircraft	An aircraft that, whilst it does not carry a human operator, is flown remotely by a pilot, is normally recoverable, and can carry a lethal or non-lethal payload.
Remotely piloted aircraft system	The sum of the components required to deliver the overall capability and includes the pilot, sensor operators (if applicable), remotely piloted aircraft, ground control station, associated manpower and support systems, satellite communication links and data links.

Figure 1 United Kingdom's military doctrine definition of UA, UAS, RPA and RPAS [2].

It is easy to see how Drones (UAVs and RPAVs), can be seen as a modern invention, but if we could travel back in time to just ten years ago, the idea of online ordering flying drone with camera would seem more science fiction than science fact. This is especially true for easily accessible drones with payloads capable of producing thermal, multispectral and LIDAR-based imagery. It could come as a surprise to most, that the first UAVs dates back to the late 18 century, those UAVs were hot-air balloon and later they were used for military purposes(bombing the enemy's cities).

Term	NATO definition[15]
Unmanned aircraft system	A system whose components include the unmanned aircraft, the supporting network and all equipment and personnel necessary to control the unmanned aircraft.
Remotely piloted aircraft	An unmanned aircraft that is controlled from a remote pilot station by a pilot who has been trained and certified to the same standards as a pilot of a manned aircraft.

Figure 2 NATO's military definition of UAS and RPA [2].

At the end of 19 century, Nikola Tesla invented the first radio-controlled craft (radio-controlled boat), which led to a new stage of evolution in radio-controlled crafts (aircraft especially). They were used during WWI and WWII mainly for reconnaissance purposes and also for pilot training.

The next stage of military drone employment was during the Lebanon war. The battle of Jezzine (1982) represented the first battle where drones made a considerable difference in the engagement's outcome. Israel employed their drones to outmaneuver the Syrian Air force and win the battle with minimal casualties. The legitimacy of UAVs in warfare was established.

The final stage of drone evolution can be declared when "Predator" drones were developed by a consortium of Israel and US scientists, the RQ-1 "Predator" can be defined as a reconnaissance-strike drone.

1. Classification of drones

The basic and most common classifications are presented in Figures 3, 4 and 5, where military classification is presented in figure 3. There is also two specimens of UAV class "mini" presented on figure 6 and 7 , types fixed-wing (6) and multi rotor (7).

Class	Category	Normal employment	Normal Operating Altitude	Normal Mission Radius	Primary Supported Commander	Example platform
CLASS I (less than 150 kg)	SMALL >20 KG	Tactical Unit (employs launch system)	Up to 5K ft AGL	50 km (LOS)	BN/Regt, BG	Hermes 90 Luna
	MINI 2-20 kg	Tactical Sub-unit (manual launch)	Up to 3K ft AGL	25 km (LOS)	Coy/Sqn	Aladin DH3 DRAC Eagle Raven Scan Skylark Strix T-Hawk
	MICRO <2 kg	Tactical Pl, Sect, Individual (single operator)	Up to 200 ft AGL	5 km (LOS)	Pl, Sect	Black Widow
CLASS II (150 kg to 600 kg)	TACTICAL	Tactical Formation	Up to 10,000 ft AGL	200 km (LOS)	Bde Comd	Aerostar Hermes 450 Mew 250 Ranger Sperwer
CLASS III (more than 600 kg)	Strike/ Combat	Strategic/National	Up to 65,000 ft	Unlimited (BLOS)	Theater COM	
	HALE	Strategic/National	Up to 65,000 ft	Unlimited (BLOS)	Theater COM	Global Hawk
	MALE	Operational/theater	Up to 45,000 ft MSL	Unlimited (BLOS)	JTF COM	Predator B Predator A Harfang Heron Heron TP Hermes 900

Table 1 - NATO UAS Classification Guide. September 2009 JCGUAV meeting

Figure 3 NATO's military UAVs classification.

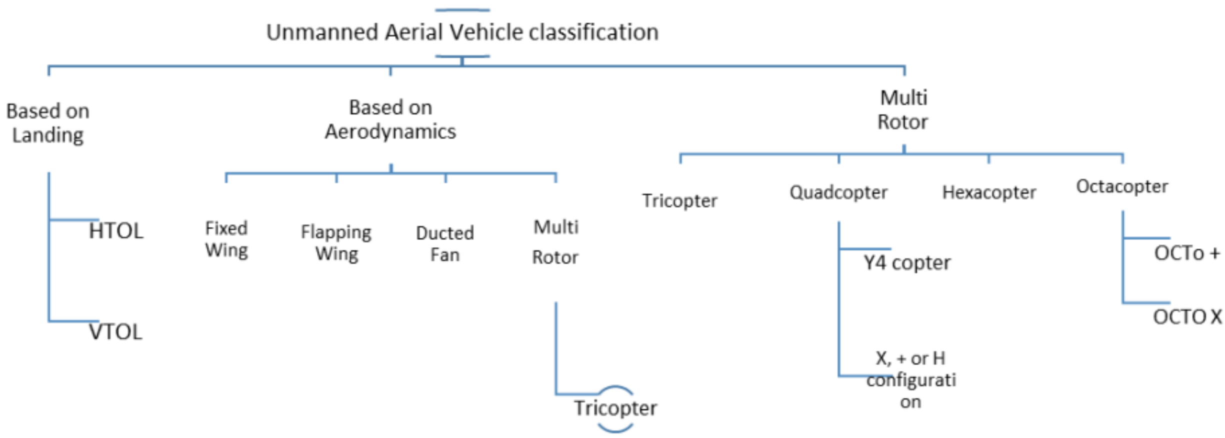

Figure 4 UAVs classification (landing/take off and aerodynamics).

Type	Maximum Weight	Maximum Range	Category
Nano	200 gms	5 Km	Fixed wing, multirotor
Micro	2 Kg	25Km	Fixed wing, multirotor
Mini	20 Kg	40 Km	Fixed wing, multirotor
Light	50 Kg	70 Km	Fixed wing, Multirotor
Small	150 Kg	150 Km	Fixed wing
Tactical	600 Kg	150 km	Fixed wing
MALE	1000 Kg	200 Km	Fixed wing
HALE	1000 Kg	250 Km	Fixed wing
Heavy	2000Kg	1000 Km	Fixed wing
Super Heavy	2500 Kg	1500 Km	Fixed wing

Figure 5 UAVs classification (Weight).

Figure 6 RQ-11 Raven drone, military grade class "mini".

Figure 7 Israelian TICAD drone, military grade class “mini”.

2. Basic UAV and UAS characteristics

UAVs can have a large amount and variety of components, sensors and devices, both on board and on the ground (in the composition of the ground control station), but all of them have the following basic (main) components:

- Frame;
- Drone motors (brushless, electric);
- Drone Propellers;
- Drone Flight Controller;
- Electronic Speed Controller (ESC);
- Power distribution board(PDB);
- Launching / Landing gear;
- Camera and video transmitting module;
- Inertial Measurement Unit (IMU);
- Radio transmitter and receiver (ground control station).

UAV is part of Unmanned Aerial System (UAS), which can be divided into four main parts (figure 8):

- Command and Control – includes the ground control station (GCS), communication sub-system, launch and recovery, and support equipment;
- Data link – establishes a communication link (uplink: land-to-air, downlink: air-to-land) between the communication subsystems of the ground control station and the vehicle;
- The Aircraft includes the payload, a navigation subsystem, sensors, a communication subsystem, power and propulsion;
- Accessories – payload, camera and other removable (mountable) sensors and devices.

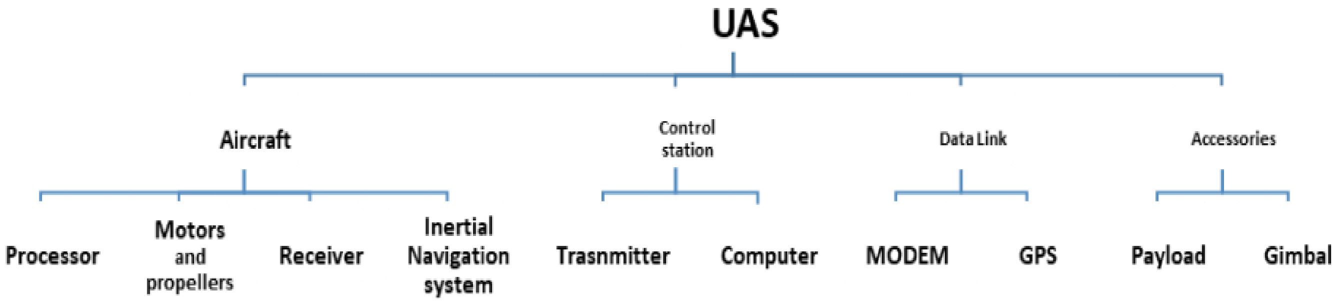

Figure 8 Unmanned Aerial System components.

3. Military usage of drones

The creation and development of Unmanned Aerial Vehicles (UAVs) have provided a valuable opportunity to develop tasks such as search and rescue (SAR), surveillance, reconnaissance, inspection, patrolling, hazardous materials detection, among many other tasks. Particularly in military scenarios, where danger is more significant, which motivates the use of UAVs to perform certain missions since its use promotes the safeguard of human lives.

In military environments, the advantage of using the operating capability UAVs provide can be demonstrated through a variety of missions and tasks that UAVs can perform:

- Intelligence, reconnaissance and surveillance;
- Search and rescue;
- Transport cargo or passengers and payload delivery;
- Communication and navigation;
- Inspection/Identification, insertion and extraction;
- Analysis of damage attack;
- Artillery fire adjustment;
- Electronic Warfare;
- Aerial Warfare;
- Border (fire position) patrol.

Due to the wide range of tasks that UAVs can perform, they prove to be one of the most important technical improvements that need to be adopted in the military environment. Artillery formations, in turn, are in dire need of such technology, as it will lead to the increment of capabilities:

- Improve the accuracy of artillery reconnaissance;
- Improve the quantity and quality of information gathered on enemy targets;
- Accelerate the decision-making process;
- Enhancement of time and accuracy of artillery fire adjustment;
- Battle damage assessment.

Artillery batteries have the ability to use UAVs for:

- Reconnaissance of roads and deployment areas;
- Reconnaissance of routes and areas for firing positions,
- Rough targeting of howitzers;
- Protection and surveillance of fire position borders (area) from enemy attacks.

Artillery reconnaissance formations using UAVs have the opportunity to:

- Reconnaissance of roads and deployment areas for observation posts;
- Rough orientation of recon means;
- Reconnaissance and surveillance of battle area;
- Reconnaissance of enemy targets;
- Creation of a 3D digital map of the area (enemy targets and location of enemy formations) and reconnaissance of enemy actions.

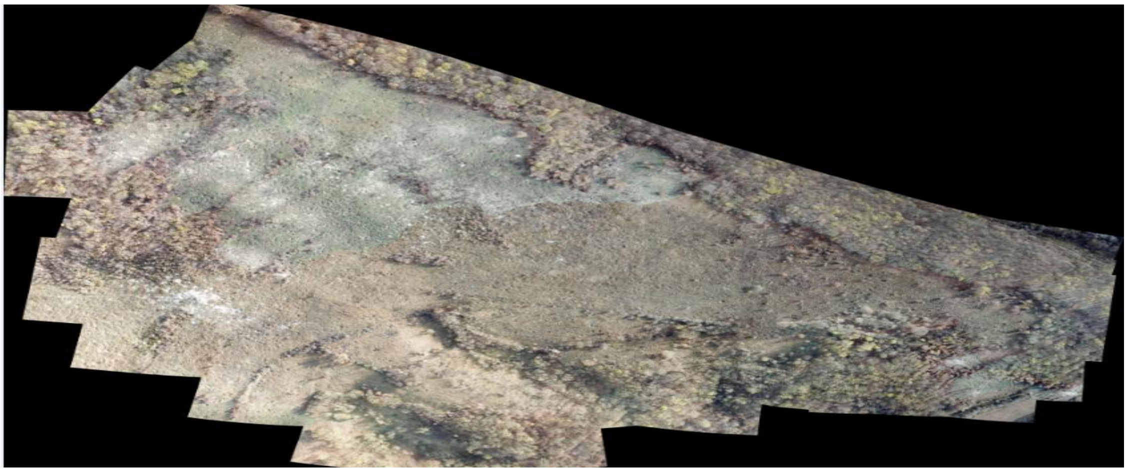

Figure 9 Assembled digital map of the area using Pix4D mapping software.

Although the deployment of an UAV grants an edge in the performance of a mission, the deployment of several different unmanned systems working together would result in an improvement of the operational capabilities. The successful achievement of a feat of such dimension can be made possible through the integration of interoperable systems that work together to achieve common objectives. This involves the creation of standard software and protocols that support unmanned systems in order to guarantee smooth and reliable services and information exchanges, i.e. Interoperability.

According to the technological efforts that support interoperability it is important to state that the main benefits interoperability provides are:

- Reduction of operational costs and complexity;
- Reduction of compatibility issues;
- Successful cooperation and interaction between different systems;
- Promotes the creation and the growth of heterogeneous structures;
- Promotes joint collaboration and the creation of joint technology;
- Enhances the operational capability of a system (p.e. NATO).

Although interoperability provides several benefits, there are some limitations caused by standards with low accessibility and challenges related to information security requirements.

Overall, UAVs prove advantageous when deployed in military environments, since they reduce the risk of endangering human lives; involve fewer costs when compared to their manned counterparts; several vehicles can be deployed at the same time without the need of multiple pilots; its performance isn't affected by dull tasks; and prove a valuable extension to a unit's operational capability. This potential can be further developed when paired with other unmanned systems (US) (ground, surface, and underwater).

Conclusion

The creation and development of UAVs have provided an opportunity for worldwide military entities to extend their operational capability while performing a number of different tasks and missions. This opportunity has motivated the creation of projects that studied the potential of UAVs, resulting in the creation of more UAVs and on the identification of requirements to implement, according to the task at hand. Regarding the advantages that the use of UAV provides, it is crucial to further explore and develop these benefits through the creation of systems that promote interaction and cooperation between UAVs and other unmanned vehicles. Fortunately, the projects that delved into these concepts have proven successful, which further motivates the creation of new projects. Through the study of the capabilities of a UAV and the growing impact this technology caused in military environments, this paper has resumed the potential of UAVs used to perform certain tasks and has also elevated the benefits of interoperability in the development of technology regarding unmanned systems.

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