RPAS : a growing market for military and civilian applications.

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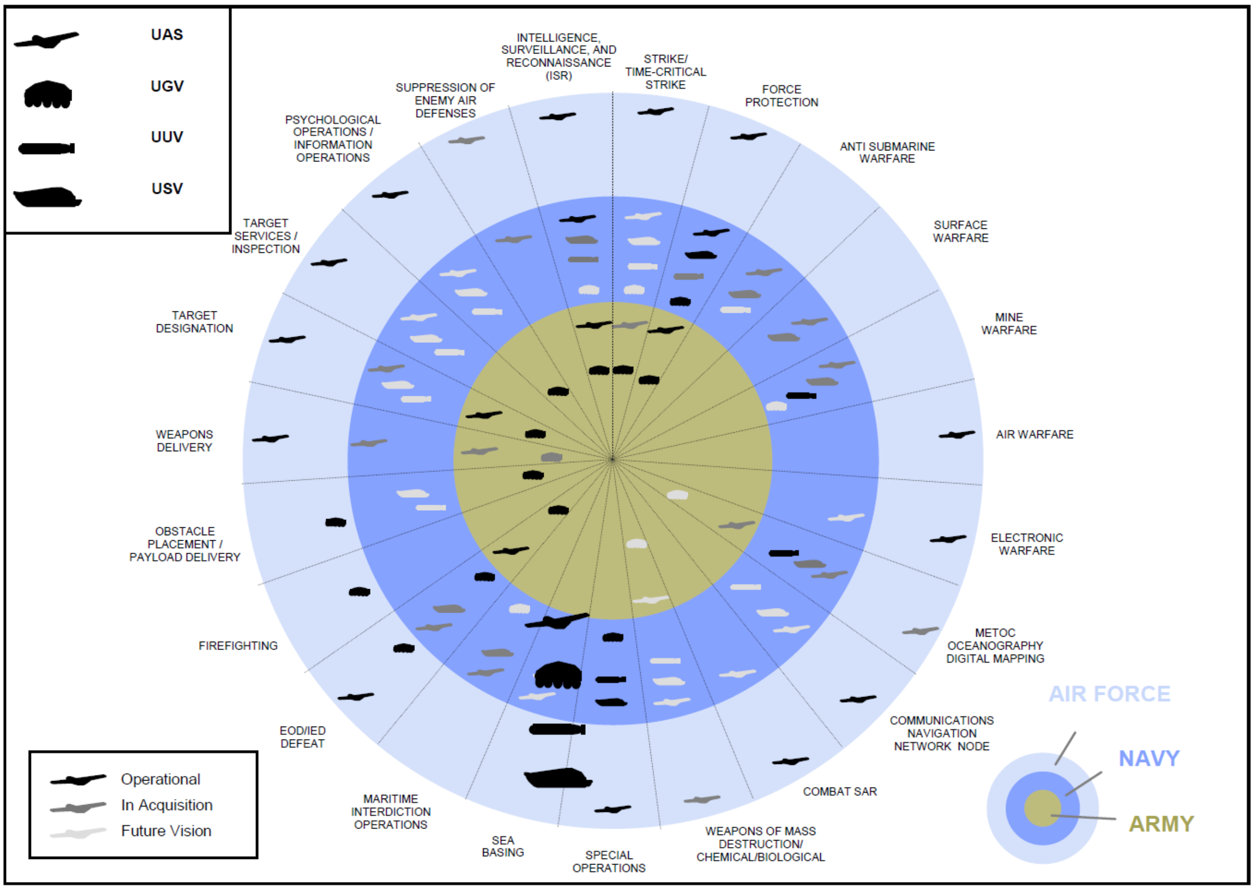
1. Introduction

The Royal Military Academy is currently coordinating two European Projects , one focusing on Humanitarian Demining, the other one on Search and Rescue Operations, both projects intending to exploit the improved performances of Robotics Systems, Unmanned Aerial Vehicles (UAV) or, better said, Remotely Piloted Aircraft Systems (RPAS) in particular.
The RPAS are characterized by an increasing development and use in the military sector for combat, combat support and logistic missions, as well as in the civilian sphere, essentially focusing on Environmental Surveillance and Security missions: The well-known acronym RSTA summarizes those missions: RECONNAISSANCE, SURVEILLANCE, TARGET ACQUISITION

From a recent Roadmap 2007-2032 developed by the US Department of Defense[1], the following picture highlights the most urgent mission needs that are supported both technologically and operationally by various unmanned systems



Depending on the mission, UGV (Unmanned ground Vehicles), USV (Unmanned Sea Vehicles) or RPAS may be required. A combination of UVS may also depend on the strategic or tactical nature of the tasks entrusted to them. Those tasks may be summarized as follows:

1. **Reconnaissance and Surveillance**. Some form of reconnaissance (electronic and visual) is the number one Combat Commander priority applicable to unmanned systems. Being able to survey areas of interest while maintaining a degree of covertness is highly desirable. The reconnaissance mission that is currently conducted by unmanned systems needs to increase

[1] First Edition of the Integrated Office of the Secretary of Defense Unmanned Systems Roadmap – Dec 2007

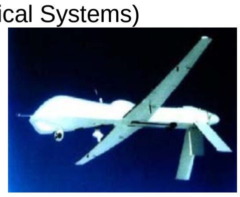
standardization and interoperability to better support the broad range of NATO DoD users.

2. Target Identification and Designation. The ability to positively identify and precisely locate military targets in real-time is still a current shortfall with RPAS. Reducing latency and increasing precision for GPS guided weapons is required. The ability to operate in high-threat environments without putting warfighters at risk is not only safer but potentially more effective than the use of current manned systems

3. Counter-Mine Warfare. Sea mines may cause damage to ships and obviously warships. Improvised Explosive Devices (IEDs) are the number one cause of of coalition casualties in Operation Iraqi and Afghanistan Freedom. A significant amount of effort is already being expended to improve the military's ability to find, tag, and destroy both land and sea mines. Unmanned Systems are a natural fit for this dangerous mission.

4. Chemical, Biological, Radiological, Nuclear, Explosive (CBRNE) Reconnaissance. The ability to find chemical and biologic agents and to survey the extent of affected areas is a crucial effort.

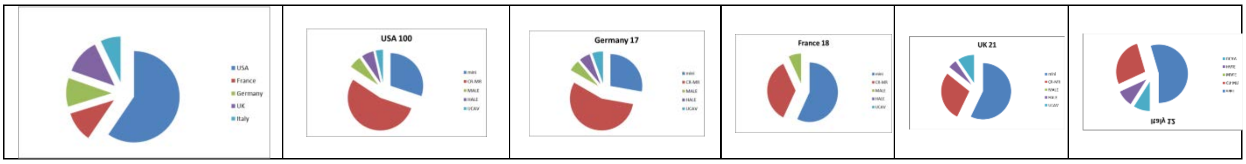
Depending on those missions (limiting the study to RPAS), the endurance, altitude and payload of the used RPAS play a crucial role: several categories of RPAS may be considered. The following table includes some statistical information on the most involved categories[2]

RPAS Category-Acronym	Range-Payload	Flight Altitude/ Endurance	Example
Microdroneμ AV	<10km < 1kg	250m / 1 h	ORBIT Geospatial technologies 
Minidrones MAV	<10km < 10kg	300m / 2 h	
Close Range (CR), Short Range (SR), Medium Range (MR)	10 km <250 km >10kg	>1000m / << 24h	FPASS (Locheed Martin – USA) 
Medium Altitude Long Endurance MALE	>500km > 100kg	>10000m >24 h	SIDMHarfang (EADS France) HERON TP (Israël) PREDATOR A/B (USA General atomics Aeronautical Systems) 
High Altitude Long Endurance HALE	>2000km	20000m >24h	Global Hawk USA (Northrop Grumman) EuroHawk USA-Germany (EADS) 
Unmanned Combat aerial Vehicle UCAV	>1000km >500kg	>10000m >1h	X-47B demonstrator (Northrop Grumann) 

Let us add that the NATO also considers two categories of RPAS, the LOS (Guidance from a Groud Station – Line of Sight) and the BLOS (Beyond Line of Sight) or Satellite Guided Drones (MALE and HALE)

[2] For a detailed information see RPAS The Global Perspective, Blyenburgh&Co © www.uvs-info.com

Referring to the USA production (100%) without giving precise (evolving) produced quantities, the following picture underlines the current status of the major RPAS producers/actors from the NATO Countries.



2. National – International Programmes

Thanks our participation to several NATO STO (Science and Technology Organisation) AVT (Applied Vehicle Technology) Panel working groups (the more recent being the AVT 175 focusing on Unmanned Systems Platform Technologies and Performances for Autonomous Operations, the AVT 174 focusing on Qualification and Structural Design Guidelines for Military Unmanned Air Vehicles), the following National and/or International still evolving programmes, figures and cooperation may be underlined.

1. The United States

The United States have the most important RPAS fleet covering all categories and characterized by a high interoperability thanks to their system ROVER allowing all Land, Sea, Air Forces to get in real time all necessary information for filling their missions. As an example, PREDATOR B have been deployed by the Navy for struggling against the sea piracy.
Even if categorized MALE, the MQ1 PREDATOR (General Atomics Aeronautical Systems, Inc), equipped with a Laser designator and precision-guided munitions, is now a multi-mission vector engaged for 80% in Combat missions. The MQ-9 Reaper is the new version, a medium- to high-altitude, long-endurance UAS. Its primary mission is to act as a persistent hunter-killer for critical time-sensitive targets and secondarily to act as an intelligence collection asset. The integrated sensor suite includes a SAR/MTI (Moving Target Indicator) capability and a turret containing electro-optical and midwave IR sensors, a laser rangefinder, and a laser target designator.
Let us also remind the Combat mission support entrusted to the MQ-5B HUNTER (Northrop Grumman Corporation) in the Balkans and in Irak, the RQ-7 Shadow 200 at disposal of the US Army in Afghanistan, the MQ-8 Fire Scout chosen by the US Navy.
The 2013 investment reached about 500M$ for UGV, 3000M$ for RPAS and 170M$ for USV

2. The United Kingdom

The UK has acquired the PREDATOR B Reaper and is currently developing a MALE system through the program MANTIS entrusted to the Society BAE Systems (Rolls Royce – QinetiQ – GE Aviation - Meggit – Selex Galileo) and in close cooperation with the program WATCHKEEPER related to the development of Tactical Drones developed by Thales UK for an investment evaluated to 1 Milliard Euro. An UCAV system is also in development, namely the TARANIS.
Let us also remind the operational use of the HERMES 450 (from the Society Elbit Systems in Israël) in Irak and Afghanistan.
Beside those MALE vectors, a lot of mini-RPAS as well as CR, MR drones, like the PHOENIX and the VIGILANT are operational.

3. Germany

Germany considers the drones as an important military tool and owns many tactical drones like the Short Range LUNA or the mini ALADIN. But Germany, in favor of International or European cooperation in the domain of HALE or MALE drones, and recently engaged in Afghanistan, focus on the development of the EuroHawk system (inspired by the US Global Hawk).The Bundeswehr favors the Reconnaissance Systems, equipping the drones with cameras, IR sensors and SAR and oriented its choice to the MALE offered by the Reintmetal society, based on the HERON platform from Israël
About 2 Milliards Euros have been foreseen over the periode 2010-2015, about 900M€ for the EuroHawk, but also about 450M€ for the NATO Program called Alliance Ground Surveillance (AGS)

4. Italy

Italy invests in HALE drones with the program MOLYNX (Selex ES&Thales Aliena Space), in UCAV with the SKY-X (Alenia Aeronautica) and above all in MALE drones, the PREDATOR A and B involved in reconnaissance missions in Afghanistan. The PREDATOR are also used for border and maritime surveillance missions.

5. France

The French capacities include MALE and tactical drones. The SIDM-Harfang acquired by the Air Force in 2008, based on the Israeli platform HERON, was developed by EADS DS France and IAI-Malat Israël. It is foreseen with the SAR/MTI (Ground Moving Target Indicator) and has been involved in Afghanistan. Such MALE induces a total cost of about 50 M€/year
The Army has used tactical MR drones Patroller, developed by SAGEM, for close reconnaissance missions (to 12 km), involved in KOSOVO and Afghanistan while new or renewed SPERWERs are now equipping the Armed Forces. Mini-drones are also equipping the French army, for example the DRAC developed by EADS with SMEs like Survey Copter, while the SKYLARK 1 from Israël, with similar performances have completed their Arsenal.

6. The NATO objectives

The previously mentioned program AGS concerns the acquisition of Global Hawk Drones essentially devoted to Surveillance missions. The program, with a participation of 15 Countries and estimated to about 1.5 Milliards euros is funded by Canada, Italy and Germany for about 70%. The partners France, UK and the Netherlands, not directly involved in this program, are focusing on the MAJIIC project (Multi-sensor Aerospace/Ground Joint ISR Interoperability Coalition), a multinational program where to Germany, Canada, Spain and the USA are the major contributors .

Summarized:

The advantages offered by RPAS to the Defense are numerous and essentially focusing on the so-called dull, dirty, and dangerous areas. This refers to missions which would generally be long, tiring, and in some cases boring for aircraft pilots, and which would present a high risk factor for them[3]
In order to decrease the force sizes and the danger of specific activities, RPAS are force multipliers that can increase the Unit effectiveness. Let us mention the threat of NBC attacks on Military Forces abroad or, less critical but even dangerous, the detection of IED actions in countries affected by civilian conflicts. As suggested in the US Roadmap[4] , in a climate more demanding of lossless engagement, UAVs can assume the riskier missions and prosecute the most heavily defended targets. Unaccompanied combat UCAVs could perform the high-risk suppression of enemy air defenses (SEAD) missions currently flown by accompanied F-16 In such a role, RPAS would be potent force multipliers, directly releasing aircraft for other sorties.

3. Legality, Safety, Interoperability, Ethics

Also, RPAS systems must comply with rigorous certification and airworthiness procedures, including communications, flight controls and ground stations, they also have to demonstrate safety in relation to loss of communication with air vehicle, resistance to jamming & correct failure-mode recovery; Sense-and-avoid technology/architecture will almost certainly be required, in particular for micro- and mini UAV. We strongly suggest the readers to consult the ' RPAS global Perspective' edited by Peter Van Blyenburgh, President UVS International[3]: the use of RPAS is recognized by the International Civil Aviation Organization (ICAO), a policy for the airworthiness of light RPAS (less than 150kg) has been introduced by the European Aviation Safety Agency while the European Commission launched a European Steering Group (ERSG) focusing on the coordination of the European RPAS Market: this ERSG includes the JARUS[5] group which aims to develop operational requirements and certification specifications.

When considering combined military missions devoted to UGV, USV and UAV/RPAS, let us say UXV, the minimum operational requirement for UXV or UXS is interference-free compatibility. The optimum synergy among the various national Systems deployed requires close co-ordination and the ability to quickly task available assets, the ability to mutually control the UXS (including their payloads), as well as rapid dissemination of the resultant information at different command echelons. This requires the employed UXS to be more than just compatible, i.e. interoperable, in order to be of any meaningful operational utility for the commanders, particularly in a very fluid/dynamic mixed and non-segregated operational environment.
Currently, many UXS are not fully interoperable, some are not even operationally compatible. Current or "legacy" UXS have been designed and procured nationally and contain system elements that are generally unique and system-specific. They do not have standard interfaces between the system elements. This results in a variety of non-interoperable/non-compatible systems. Although commonality of hardware and software would be a solution

[3] P.Van Blyenburgh, The Global Perspective 2013/2014, www.uvs-info.com
[4] USA DoD Roadmap 2000-2025 (Office of the Secretary of Defense, D.R.Oliver, A.L.Money)
[5] www.jarus-rpas.org

to achieve interoperability and may be desirable from an economic standpoint, commonality is not mandatory for operational purposes. In order to enable interoperability for UXS, the implementation of compatible standards for key system interfaces and functions is required. The operational requirements and approved concept of operations will determine or drive the required Level of Interoperability (LOI) that the specific UXS have to achieve.

Last but not least, ethical considerations are discussed not only in the context of military combat/combat support missions but also in civilian applications.
While remotely piloted aircraft systems are very useful to several applications and may even become a tool of choice (for instance in Demining Technical Survey or Search and Rescue Operations in affected Countries or Areas, they also create some strong opposition. The main concerns include the protection of human rights such as privacy or life and the negative connotations attached to these tools are due to being used as weapon carriers in military conflicts.
The development of a technology, including robotics, takes account of a number of factors. These include social, economic, application and environmental implications and associated issues. In this context the design of the technology is constrained and thus dictated by associated national and international standards and regulations. From the standards perspective the developer of the technology is required to carry out proper risk assessment so that the technology complies with safety requirements as emphasized in the standard.
The UK Robot Ethics (UKRE)[6] group formed as part of the BSI AMT/00-/02 (Robots and Robotic Devices) committee has identified various ethical issues of robotics, and has classified these into four main categories, namely societal, application, commercial/financial and environment.
Some of the fundamental societal robot ethics issues include among others the Privacy and confidentiality, the respect for human dignity and human rights, the respect for cultural diversity and pluralism, the De-humanization of humans in the relationship with robot, the responsibility and legal issues. Concerning the Application issues, let us limit them to the military applications: The development of robots for military applications, especially for combat is a matter of serious discussion and debate. Concerns are shown over the use of robots in combat scenarios, and these include how combatants and innocents may be discriminated from one another in close-contact encounter. Although,many of the ethical questions in this respect have been contained into the military command and control framework (by keeping human in the loop), i.e. where commanders are responsible for issuing orders and the soldiers are for carrying out those orders, the system becomes very complex as the number of robots deployed in combat scenarios increases.

4. Conclusion

Let us give a first conclusion to Christian Bréant, Director of the Research&Technology of the European Defense Agency: civil and military resources are today combined to achieve societal acceptance of using RPAS in airspace. The EDA tries to clearly define the necessary cooperation between both sectors: the military missions and the civilian missions for overcoming the Security challenges of our Societies and a sustainable Economic policy.

A second conclusion has been expressed by Major André Haider[7] from the joint Air power Competence Centre (JAPCC) of the NATO: facing future unexpected adversaries empowered by the growing development of the modern technologies, UAS involvement in future operations, including offensive ones, is expected to escalate and mission planning and execution will be even more dependent on unmanned support than today: we must thus prepare ourselves for all aspects of automated RSTA

[6] www.robotethics.org.uk
[7] UAS Operations in Contested Environments, Major A.Haider, RPAS The Global Perspective 2013/2014 www.uvs-info.com