ISSN: 1231-4005
e-ISSN: 2354-0133
DOI: 10.5604/12314005.1168417

THE FUTURE DEVELOPMENT OF UNMANNED AIR VEHICLES

Łukasz Andrzejewski-Popow

Chief of UAV Branch, Air Force Inspectorate
General Command of Polish Armed Forces
Żwirki i Wigury Street 103-105, 00-912 Warszawa, Poland
tel.:+48 22 261826705, fax: +48 22 261825626
e-mail: landrzejewski@mon.gov.pl

Tomasz Kotas

Chief Expert, Armament Policy Department
Niepodległości Avenue 218, 00-911 Warszawa, Poland
tel.:+48 22 261846607, fax: +48 22 261874037
e-mail: tkotas@mon.gov.pl

Abstract

This article introduces the synthetic material for future Unmanned Aerial Systems (UAS). The issues raised in it mainly concern the autonomy of these systems, applied design, propulsion systems, equipment and development trends in the UAS market. In addition, it presents global trends regarding methods of use, application and use of Unmanned Aerial Systems.

Observing the growing realm of UAV in military actions it is expected to be the development of autonomous platforms implementing transport and combat missions. Increasingly used UAV platforms in military action jointly with manned platforms (mix formation) and in mixed formations of unmanned (UAV swarms differently equipped).

Usage of unmanned aircraft in the civil sphere is very extensive and includes rescue operations – coordination and support, research – geodetic and cartographic, environmental protection, agriculture – monitoring of farmlands, natural resources, system warning of natural disasters; monitoring traffic – map navigation system; taking pictures and videos; data transfer.

Keywords: *autonomy, manned, unmanned, unmanned aerial systems, unmanned aerial vehicles,*

1. Introduction

The history of unmanned aircraft goes back much further than the idea of manned flight. The precursors of this type of aircraft can already be found in the ancient world, where the contemporary knowledge allowed the construction of aviation-related toys and which nowadays to label as "unmanned". Conceptual start of unmanned air systems are, like most inventions in the history of ancient China. The first unmanned flying apparatus was – kite.

The Chinese have used it about 2000 BC to determine the direction of the impact on the enemy troops and psychological warfare.

Further development of unmanned aviation was followed in parallel with manned aviation. Starting with the first flight of the Wright brothers in 1903, from which shall be contractually beginning of aviation, in the shadow of a manned aircraft were systematically developed unmanned structures, which in the beginning of the aviation era was not without significance, particularly in relation to the performance tests and experiments. As in the aviation manned the main reason for the development of unmanned aircraft were new technologies emerging gradually and adapted to the needs of aviation.

World War II indicated first orientations for Unmanned Aerial Vehicles (UAVs) stating for their two main use:

a) the first consisted of an unmanned flying apparatus hitting the target and detonated explosive,
b) the second was based on the use of UAVs for anti-aircraft artillery training.

Development of gyroscopic system, which was applicable in manned aviation, but was crucial for the performance of stable flight by an unmanned aircraft, contributed development for this type of Aviation.

However, the most important invention enables unmanned aircraft operations remains radio and radio waves to allow for the execution of a controlled unmanned flight. It was a breakthrough in aviation and beginning of a mass use in military applications.

In the Year of 1973. During the war of Israel with a coalition of Egypt and Syria, Syrian's battery rockets caused heavy damage to Israeli fighters. As a result of this, Israel has developed and performed the first modern unmanned flying apparatus.

In the 90s of the twentieth century, US Department of Defence began to buy unmanned flying systems from Israel, resulted in a significant development of UAVs in USA.

Later (early 90s), it was realized that the potential of the unmanned aircraft can be used in a wide range in a civilian environment.

In the past two decades shows the dynamic growth of interest and production of UAVs, both in military and civil applications. It is associated with the rapid development of electronic technology, miniaturization of components and ever, more modern technologies in the production of airframe, propulsion systems and the full autonomy of them.

Unmanned aircraft are used mainly for observation and intelligence, transportation and military tasks (targeting – identifying objectives, destruction with a precise means of destruction).

The basic mechanism that allows the functioning of the UAV is the GPS receiver, which determines the position and course necessary to comply with the scheduled flight. Drones in military applications besides the encrypted GPS signals so-called M-code, also apply inertial navigation.

2. Military use of UAS

In the military sector, but not only, you can observe a trend of gradual displacement of conventional manned aircraft for unmanned aerial vehicles. The increasing financial outlays are earmarked for the purchase of BSP and training of their operators. For example, since 2009 the US trained about 670 pilots-operators of UAV. They now represent only or as many as 10% of pilots US Air Force. Already one in three flying machines in the US Army is the UAV. In 2005, they accounted 5%, now it is 31% of military flying equipment [1].

Observing the growing realm of UAV in military actions it is expected to be the development of autonomous platforms implementing transport and combat missions. Increasingly used UAV platforms in military action jointly with manned platforms (mix formation) and in mixed formations of unmanned (UAV swarms differently equipped). Companies producing instrumentation, equipment and weapons for UAVs, competing in the miniaturization of this type of equipment, thus enabling the increase "vitality" and ability to survive on the modern battlefield.

3. Use of UAS in the civil sphere

Modern development of unmanned aircraft in the civil sphere is inextricably linked to their use in military applications. Apart from the typical combat use of drones, most of their missions relating primarily to entertain, patrolling and monitoring will be the same or similar procedure performed both for military and civil environment [3].

Usage of unmanned aircraft in the civil sphere is very extensive:
1. Rescue operations – coordination and support;
2. Research – geodetic and cartographic, environmental protection;

3. Agriculture – monitoring of farmlands, natural resources, system warning of natural disasters;
4. Monitoring traffic – map navigation system;
5. Taking pictures and videos;
6. Data Transfer;
7. For Hobby.

4. Autonomy

In April of this year, a BAE Systems Jetstream research aircraft flew from Preston in Lancashire, England, to Inverness, Scotland and back. This 500-mile (805 km) journey wouldn't be worth noting if it weren't for the small detail that its pilot was not on board, but sitting on the ground in Warton, Lancashire and that the plane did most of the flying itself. Even this alteration of a standard commercial prop plane into an Unmanned Aerial Vehicle (UAV) seems a back page item until you realize that this may herald the biggest revolution in civil aviation since Wilbur Wright won the coin toss at Kitty Hawk in 1903.

The Jetstream flight was conducted as part of the Autonomous Systems Technology Related Airborne Evaluation & Assessment (ASTRAEA) program, which is a UK industry-led consortium aimed at developing unmanned aircraft that can operate routinely in civilian airspace. It is one of hundreds of UAV projects around the world, but what is notable about it is how the use of a passenger plane blurs the line between quadcopter-with-a-camera jobs and full-blown airliners.

The UAV revolution

For many people, UAVs came out nowhere. In the popular imagination, they started out as exotic reconnaissance aircraft in the early days of the Afghanistan War that have grown in numbers and sophistication until they've turned into experimental combat aircraft taking off from aircraft carriers. In fact, UAVs have come, as was mentioned above, from a number of areas aside from the military. Hobbyists have made their contributions, scientists as well, and, of course, aircraft engineers.

In many ways, UAVs are a bit like computers. First, they were rare and then they were everywhere. Whether they are tiny quadcopters that fly within a few hundred feet of their operator or huge winged affairs piloted via satellite thousands of miles from the joystick, UAVs are taking to the skies in ever-increasing numbers for a variety of applications.

One obvious area for UAVs to move into is police work. Take away the missiles and hunting for bad people on a civilian street is very similar to hunting them on the battlefield. The challenges are virtually the same and transferring the technology from one sphere to the other is relatively straightforward. An eye in the sky could be used for general law enforcement, border control, sea lane monitoring, traffic control, crime scene photography, searching for missing persons, and combating drug trafficking [2].

Other areas where UAVs might show applications is in meteorology with swarms of small robot planes taking up the dangerous task of storm chasing as well as being able to take measurements in situations where using conventionally piloted aircraft isn't feasible.

Another job is prospecting with drone aircraft conducting surveys for oil, gas and minerals. It is understood that UAVs are excellent platforms for cartography and geophysical and photometric surveying, allowing an aerial perspective that archaeologists, for one, could only dream of a few years ago. They can also be used for data relays or for inspection and maintenance of bridges and other structures.

All of this seems like a technology shooting off in a thousand different directions with every sort of fixed wing or copter imaginable whizzing about in a chaos of invention, but the UAV revolution is much simpler, though with great implications. It is less a matter of what is in the UAV than is not in.

Another way in which we might see the UAV move gradually into civilian life is at small airports. Currently, air traffic is a nightmare of centralized air traffic control systems moving fleets of aircraft between hub airports that are stretched to capacity. Aircraft equipped with UAV technology could change this because such craft have the potential to talk directly to one another and operate with a high degree of autonomy instead of waiting for air traffic control instructions.

What this would mean is that as the technology becomes more widespread, air traffic control becomes much simpler and small local airports would be able to do many of the things that only a major one can do today. Imagine a city the size of London or Frankfurt, which needs half a dozen major airports to operate, being served by one large airport, and a hundred small ones acting like air taxi stands and you get the idea. Indeed, it may be that the first pilotless passenger plane may not be a huge airliner but it may be a little air taxi. That ferries around only a handful of people.

Of course, this sort of a future depends on many technological hurdles being overcome. As was seen in the Jetstream experiment, UAVs have to see and avoid other aircraft. They need to operate with piloted craft, and they need to be supported by an air traffic system that plays to their strengths instead of against their weaknesses. Worse, UAVs need massive amounts of bandwidth, which the military has, but civilian air systems lack.

Finally, there is the fact that fully autonomous devices are not completely trustworthy. Even an autonomous machine needs a human for when things go pear shaped. In an emergency, automated systems can do a lot, but sometimes-human improvisation on the spot is key.

Ultimately, what the world where UAVs are part of everyday life looks like will depend on the decisions we make. Will we have flying robot baristas delivering lattes to our tables? Will we be stepping aboard a crewless airliner as comfortably as we do an automated train? Only time will tell, but the technology is moving at such a rate that these are questions we need to start asking ourselves now.

5. The way ahead for UAV's

You would be hard pressed to cite a segment of military systems development that so directly relies on embedded computing innovations more than unmanned systems. Unmanned systems in their various forms UAVs, unmanned ground systems and unmanned underwater systems are an area where size; weight and power concerns are side by side with a strong desire for computer-based automation and functionality. This year, with the U.S. defence budget under the knife for cutting programs, UAVs and unmanned systems in general seem poised to retain more than their share of funding versus other areas.

Charting the way forward for unmanned system development, last fall the Department of Defence published its latest version of its Unmanned Systems Integrated Roadmap outlining the direction and challenges ahead for 2013 to 2038 for the U.S. military is unmanned platforms. While there are numerous areas in the document that telegraph opportunities for embedded electronics and computing products, the one area that caught my eye was the chapter on autonomy. Autonomy in this context focuses on a system's ability to be goal-directed in unpredictable situations to make a decision based on a set of rules and/or limitations. In 2010, the USAF released the results of a yearlong study highlighting the need for increased autonomy in modern weapon systems, especially given the rapid rollout of UAV systems. The study called the need for greater system autonomy the "single greatest theme" for future USAF science and technology investments.

For unmanned systems fully to realize their potential – according to the roadmap – they must be able to achieve a highly autonomous state of behaviour and be able to interact with their surroundings. This should include an ability to understand and adapt to their environment, and an ability to collaborate with other autonomous systems. Meanwhile, there needs to be new verification and validation (V&V) techniques to prove the new technology does what it should.

For an autonomous unmanned system to sense and understand the environment, it first has to be able to create a model of its surrounding world by conducting Multisensor Data Fusion (MDF). It then has to convert these data into meaningful information that supports a variety of decision-making processes. The perception system must be able to perceive and infer the state of the environment from limited information and be able to assess the intent of other agents in the environment. The roadmap describes that understanding is needed to provide future autonomous systems with the flexibility and adaptability for planning and executing missions in a complex, dynamic world. Although such capabilities are not currently available, recent advancements in computational intelligence especially neuro-fuzzy systems, neuroscience and cognition science, may lead to the implementation of some of the most critical functionalities of heterogeneous, sensor net-based MDF systems.

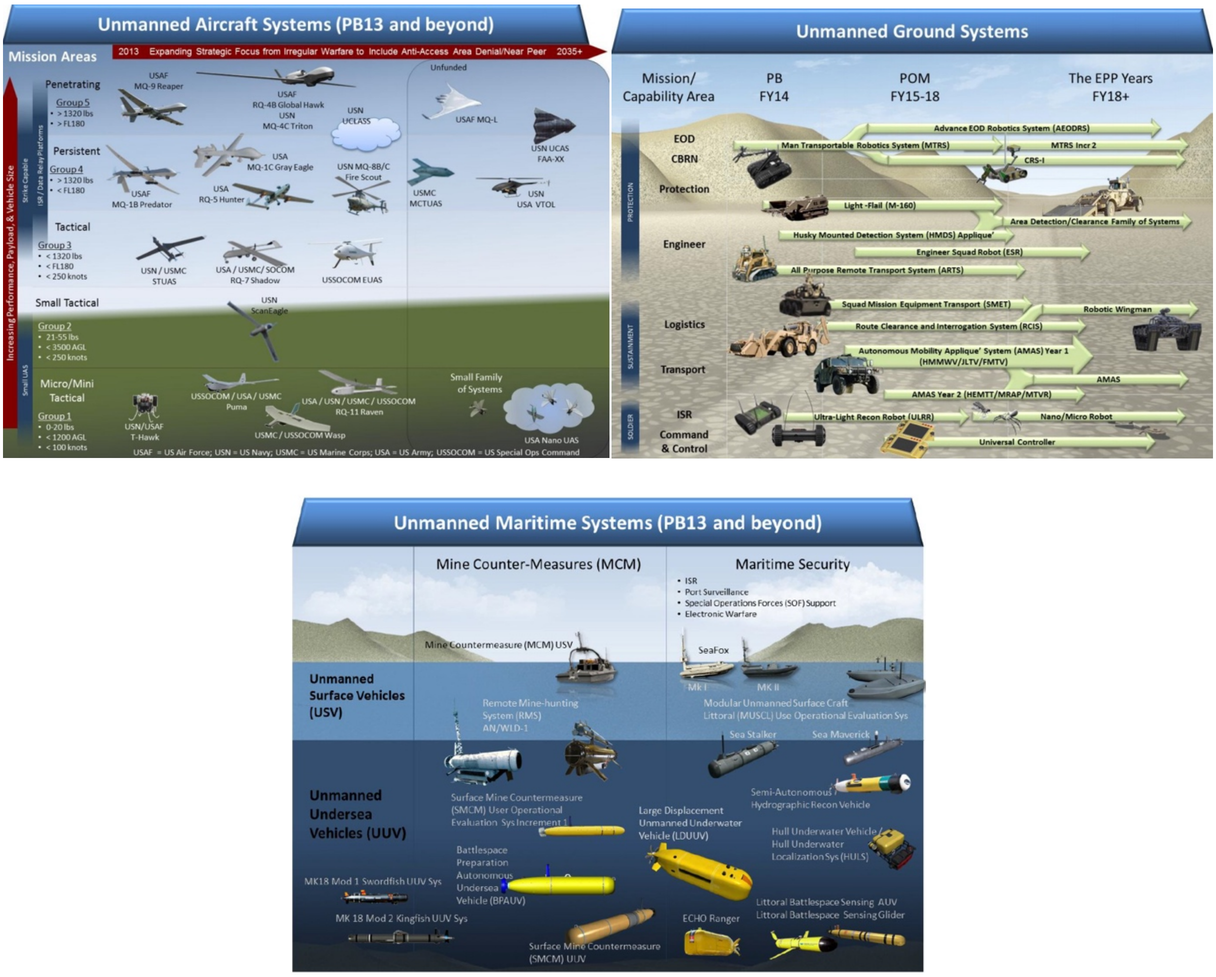

Fig. 1. Unmanned Systems Integrated Roadmap FY 2013-2038 [4]

Beyond just the command and control aspects of unmanned system autonomy, there is the issue of autonomy for the Tasking, Processing, Exploitation and Dissemination (TPED) side of a UAV or other unmanned systems' duties. Traditional TPED processes offer huge opportunities for reducing the degree of human involvement. Near-term developments could introduce a greater degree of automation, ultimately evolving to systems that are more autonomous. Current TPED processes are manpower-intensive. In today's combat environment, most full-motion video and still imagery is monitored and used in real time, but then stored without being fully analysed to exploit all information about the enemy. This challenge is not unique to the unmanned environment, but it has been exacerbated by the large numbers of ISR-capable, long-endurance unmanned systems being fielded. The sheer quantity of information that these systems are collecting is overwhelming current TPED processes.

Applications of face recognition software could enable high-fidelity full-motion video to identify individuals of interest. Increased automation in COMINT sensors has the potential to identify key words and even specific voices to rapidly alert operators to targets of interest. Ultimately, automated cross-cueing of different sensor types in a networked environment could enable greater autonomy in tasking systems and their sensors to identify and track threats more rapidly. Increased processing power and information storage capacities also have the potential to change how unmanned systems operate. For example, many current UAVs transmit ISR data that is processed and exploited in ground stations.

If more processing and exploitation processes can be accomplished on board a UAV like the automatic target recognition or communications intelligence examples discussed above the system can disseminate actionable intelligence for immediate use and reduce bandwidth requirements. Video ISR, for example, uses roughly an order of magnitude more bandwidth than the C2 data for a UA. By accomplishing more of the TPED process on board the unmanned system, the link bandwidth can then be focused on transmitting only what is needed, and the overall bandwidth requirements can be reduced.

The good news for the embedded computing market is that all the challenges of achieving autonomy in UAVs are directly attached to the use of ever-increasing compute density. That compute density is achieved by packing more processing power, memory and I/O functionality into smaller boards or in rugged box-level systems. In addition, as pressures mount to control costs of all defence efforts, military system developers will need to rely on the best of breed off-the-shelf solutions supplied by the military embedded computer industry.

References

[1] Brzezina, J. M., *The attack of drones,* Military Publishing House, Warsaw 2013 (in Polish).
[2] Cwojdziński, L., *Unmanned combat systems – characteristics, some problems of use and exploitation,* Military University of Technology, p. 130, Warsaw 2014 (in Polish).
[3] Zieliński, T., *The functioning of unmanned aircraft systems in the civil sphere, Introduction,* SILVA RERUM Scientific Publishing House, Poznan 2014 (in Polish).
[4] http://leaksource.info/2013/12/26/dod-unmanned-systems-integrated-roadmap-fy2013-2038/.