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The development strategy of unmanned aircraft systems (UAS)

T. GUGAŁA
UNMANNED AIRCRAFT SYSTEMS PROGRAMME, Polish Armaments Group, Nowy Świat 4a, 00-497 Warszawa, Polska
EMAIL: tomasz.gugala@pgzsa.pl

ABSTRACT
The beginning of the twenty-first century is characterized by an unprecedented technological progress in every field of human existence, the newest technologies have wide application not only in the military sphere but also in non-military areas. A clear example of dynamic development of intelligent transport systems are Unmanned Aircraft Systems (UAS), defined as a new kind of aviation - The Unmanned Aviation. This paper includes worldwide trends of UAS development and the variant of national strategy for the development of the unmanned aviation, based on the current possibilities of polish companies entering interalia, the Polish Armaments Group (PAG) in terms of design, development, modernization and production of Unmanned Aircraft Systems.

KEYWORDS: Unmanned Aircraft Systems (UAS), UAS Development Strategy

1. Introduction

The new kind of aviation, which becomes the „Unmanned Aviation" so called Unmanned Aircraft Systems (UAS) is a special inspiration for many aviation experts around the world. This is expressed among other things in a bid to develop a series of concepts and projects in the various countries and institutions, aimed at the application of UAS in every aspect of social life. From a few decades, unmanned aviation is one of the most dynamically developing technology in the contemporary world.

The main argument of UAS usage for military purposes beyond their combat effectiveness is a significant reduction in the degree of risk taken by human factor on the contemporary battlefield. Another major argument of development and widespread use of UAS, in both the military and civilian services is the fact, that the lion's share of accidents and aircraft crashes, is caused by human factor and less often by the technical problems. Furthermore, it is estimated that the UAS systems are about 30% cheaper than manned aircraft, mainly due to the lengthy and costly flight crew training.

To enable the development and application of unmanned aviation for military and civilian purposses, it is necessary to develop the specific organizational, legal and technical solutions. Given the fact that both, manned and unmanned aircraft are flying in the same airspace, they should strive to adapt allready existed rules and procedures applicable to manned aviation. Therefore, we should not focus on the development of a new aviation law, but on the skilful adaptation of such a law to the unmanned aviation environment. The necessary condition for UAS flights in a common airspace, is the application of appropriate avionics devices and the latest technology sensors, which effectively replace the pilot on board of UAV, providing the required level of Flight Safety in the specified airspace classes.

The main technological problem, conditioning the safe flights execution of manned and unmanned aircraft in the common airspace, is the use of appropriate collision avoidance systems and separation minima. However, there is still an open question here? Whether the system should support the UAV pilot and ATC controller in the process of ensuring the self execution of airborne missions, or to operate autonomously, without the influence of human factor ?

This issue is still in the realm of research and development of world experts in this domain. Assuming, that still human factor not the system, will be responsible for ensuring the flight safety of manned and unmanned aviation in classified airspace, the solution to this problem is becoming obvious. Collision avoidance systems should be designed to have the technological capacity to supply man with all the necessary information related to the air situation

in his area of responsibility. Based on this, the UAV pilot and ATC controller should realise they tasks in a safety manner.

But what happens, when the lack of communication and data link system will occure?

2. The global trends of UAS development

Transport Systems Telematics is an area of human activity that provides continuous technological development of all kinds of transportation means in contemporary world.

It fits perfectly into the global development trends of Unmanned Aircraft Systems, which determines rapid technological progress in the following areas:

- Human – Machine Interfaces;
- Miniaturization and Maximization of UAS Constructions;
- Autonomy of Collision Avoidance Systems;
- Development of non-military applications;
- Development of undetectable constructions;
- Laser based communications;
- Development of satelite information services;
- Development of USV (Unmanned Space Vechicle);
- Passanger transport;
- Impact on every aspect of human life.

One of the main areas of the world's scientific research and technology development, including unmanned aviation is the interface: the man (UAV - Unmanned Aerial Vehicle pilot) - machine (UAV) - the environment (ground, air). A man working in a variety of conditions, shows a remarkable ability to adapt in the working environment.

This feature allows it appropriate response and control in unforeseen circumstances. Unfortunately, the negative side of the human factor is the possibility of committing a series of errors. The point is to develop an open system of interaction between man and machine, system which will allow continuous reduction of the UAV pilot negative influence on the UAV functional systems (Fig.1.).

Therefore this issue is the subject of continuous research of many scientific communities in the world. The model for UAV pilot's reliability analysis as an element of the UAV system, was based on a model of human activities, with particular emphasis on the interaction between man and the environment as a dynamic factor of the considered transport process.

Based on information coming from the working environment, the UAV pilot is expected to behave (react) correctly, depending on the processes occurring in the UAV system and environment in which the UAV moves. Factors influencing the ability to proper manage (control) the system are called shaping factors of the UAV pilot activity. Specified Operating Environment of the UAS is creating by situational factors, the degree of difficulty of the task and the organizational and technical conditions.

To improve individual working conditions of the UAV pilot, it is necessary to take into account aspects such as physiological efficiency, individual predisposition and resistance. The organizational structure of the UAS should define the different types of external motivation, including the creation of opportunities for making independent decisions and avoiding any possible danger.

External factors are formed generally by organizational and technical conditions. Internal factors shaping UAV pilot activity, are divided in to ability of the physiological and psychological capabilities. As part of the improvement of human action is necessary to consider those factors which most significantly affect proper operation. The external factors affecting UAV pilot including working environment, in particular the equipment of the system, the rules and management procedures and physical conditions. Internal factors are related to individual predispositions and abilities of UAV pilot such a skills, motivation and professional experience.

The direct impact on those factors have the following psychological and physiological processes:

- perception or signal detection by stimulation and conscious functions;
- interpretation through the use of knowledge needed to quickly assess the situation.

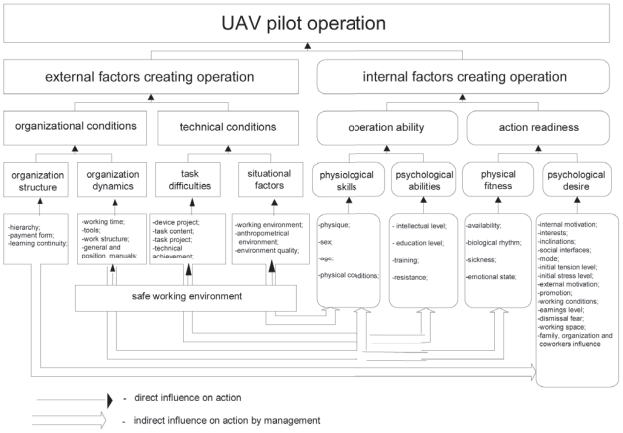

Fig.1. Direct and indirect conditions of UAV pilot operation [own study]

In complex aviation systems (pilot - UAV - ground components - environment), human error is a common cause of unproper system work and as a consequence of an air accident. The human factor can be both, an initiator and promoter of accident, but also an element of mitigating its effects. UAV pilot error is difficult to predict due to significant differences in activity between pilots in certain circumstances. UAV pilot can fulfill a variety of functions in many different ways, in a much more diverse conditions than any other component of UAS.

Taking into account the above considerations, the integration of man and machine is still open subject, requiring coordinated research, which will allow on the steady progress in this area. UAS miniaturization will oscillate in support of the activities of a single soldier on the modern battlefield, reconnaissance, tracking, following and protection of people and property (Fig.2.).

In contrast, the process of maximizing design will focus on unmanned cargo transport, sized fuel tankers for Air to air Refueling (AAR) and on military unmanned strike combat aircraft of the unprecedented firepower. Development of „Cargo" UAS will focus mainly on possibilities of carrying as much as possible payloads, and ensuring long service life. Unmanned aircraft already are characterized by a large range and

endurance as well as the continuous increase in the scope of use of the different elements of airspace.

Fig. 2. NANO UAS „PD-100 BLACK HORNET" during close to combat reality tests [own study]

Due to its robust construction, ample size and impressive performance of one of the biggest world UAVs - RQ-4B Global Hawk is under trial to extend the spectrum of functionality in AAR (Fig.3.). The expanded scope of the implementation of the Global Hawk is not only the military but also a wide range of applications in the commercial use.

The „Joint Unmanned Combat Air System (J-UCAS)" is the advanced stage of project development of unmanned strike platforms built for the needs of the US Armed Forces such as the Boeing X-45C and Northrop Grumman X-47B Pegasus (Fig.4.) UAS representing reduced radar cross-section, to conduct deep-bomber strikes against strongly defended objects, combat systems and air missile defense of potential enemy. They can carry about 2500 kg of various kinds of weapons, including modern bombs GBU-31 precision guided through satellite systems. Their tactical parameters (tactical radius of 2300 km / 1250 NM) allow to operate for two hours in the area at a distance up to 1800 km / 970 NM from the airfield, at speed of 0.67 Ma.

Fig. 3. HALE UAV "RQ 4 A/B Global Hawk" – air to air refueling [own study]

To meet the same criteria of flight safety as the manned aviation, unmanned aircraft must be equipped with adequate collision avoidance systems having further appropriate design solutions, providing transmission of relevant information to UAV pilot being located at GCS (Ground Control Station), allowing him on this basis to bypass the obstacle, remotely controlling the plane.

Fig. 4. Strike/Combat UAV „X – 47B Pegasus" [own study]

Currently the work on new generation advanced technology collision avoidance systems, which will be featured in both manned and unmanned aircraft, is continued. The leading project in this area is MIDCAS (Mid-air Collision Avoidance System), whose main task is to determine (indicate) an appropriate technology, make a significant contribution to the issues of standardization (normalization) and to demonstrate that a substantial part of this project, a system of „Sense and Avoid" - (detect, think and skip obstacle), designated for UAS, will be able to meet requirements of the collision avoidance and separation standards for air traffic in Non-segregated airspace.

„Sense and Avoid" technology is developed in the same direction as previously used in regular manned aviation systems such collision avoidance TCAS/ACAS, or on the basis of the work of appropriate on-board units, that detect danger of collision (*reception of signals from transponders for aircraft operating modes A/C and S*) and transmitting adequate information to UAV pilot in the GCS with a suggested solution to solve the problem.

Simultaneously, it is foreseen the development of this technology in the direction of the autonomous operation mode (*maneuver without interference from UAV pilot*), but under the condition that the autonomous system reaction would be no longer then response of UAV pilot in an adequate situation. The primary objective pursued by designers with collision avoidance systems is the development of appropriate technological solutions that will allow the integration of UAS with manned aviation, both in controlled airspace, uncontrolled and on the ground aerodrome traffic.

However, no matter how advanced technologies and design solutions will be used for the construction of collision avoidance systems, remember that each device is unreliable and that the human factor, not the system is responsible for flight safety.

Based on current technology and continuous progress in the areas of information technology, computerization, miniaturization and cryptology, it must be anticipated further dynamic development of UAS in non-military areas. Analysis of current global development of UAS programs for the purposes of national economy, shows making increasingly bold attempts to adapt UAS for civil applications.

Successful attempts in use of UAS in non-military areas are included the following groups of tasks:

- commercial „Cargo" transport;
- human aid transport;
- air search and rescue over land and sea;
- - suport of counter natural disaster:

a. floats and droughts;

b. earthquakes and avalanches;
c. fires and hurricanes,
d. vulcanic erruptions – flights in the zone of volcanic ash.
• border patrol:
a. detection of illegal migration;
b. countering all spectrum of smuggling.
• environmental protection:
a. sea tanker leaks;
b. industral waste;
c. polluted areas (biological, chemical, nuclear).
• climat changes observation;
• weather conditions monitoring;
• property protection;
• dettering birds in airfield zones or FAORs (Fighter Area of Ressponsibility);
• police actions (*prevention, patroling).*

It is also envisaged further development and improvement of undetectable constructions, UAS avionics, including in particular collision avoidance sensors and communication systems (*the amount of data needed for safe use of UAS in Non-segregated airspace may be increased several tens of times compared to current standards*). World experts therefore focus on finding ways of increasing the possibility of the flow of information. Increasingly advanced research conducted in the field of laser communication with the prospect of its introduction for use by 2025.

An interesting direction of the comprehensive development of UAS is the construction and operation of the **Unmanned Space Vehicles (USV)**. They can revolutionize not only the life on the ground but also in the universe. An example of advanced stage of research and development prototype unmanned spacecraft is „Boeing X-40A Space Maneuver Vehicle", which has already done a lot of suborbital test flights and can become the reusable spacecraft in the future. Analyzing the further development of this type of unmanned vehicles, it can be expected that soon they will be used, even for the defense of the globe, eg. by sending USV in the direction to large size asteroids approaching to terrestrial globe that could strike the Earth and cause enormous destruction (*extent of damage to the outbreak huge atomic bomb*). Thus bringing USV to collide with the asteroid in space, resulting change of the flight path and consequently safe bypass of our planet.

However, despite their present wide range of applications, it is not expected to replace the manned platform by unmanned ones in the future. They will rather complement them.

3. National strategy for UAS development

In Poland the Armed Forces successfully utilize UAS MINI category (*Orbiter, Fly Eye, Scan Eagle*) over ten years. Those systems supported the activities of land forces and special forces of Polish Armed Forces in the Afghan conflict.

All efforts to use unmanned platforms in non-military fields are also successfully attempted. So far Poland has not developed a single, national strategy for the development of UAS. However, there is a strategy of acquisition and use of UAS for military purposes, described in the Technical Modernization Program (TMP) designed for Polish Armed Forces.

To meet these challenges, polish industry comes with an offer with indigenous products of the type of **Fly Eye** (*WB Electronics*) (Fig.5.) and **E-310** (*Polish Armaments Group*) (Fig.6.). Those offers are complemented by foreign products from Israel, USA and France.

Fig. 5. UAV Fly Eye (WBE) – MINI category [own study]

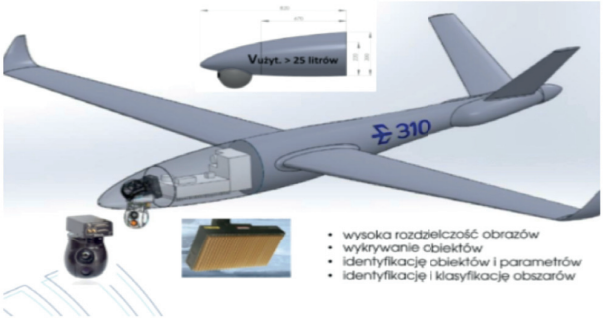

Fig. 6. UAV E-310 (PGZ) –Tactical Short Range category [own study]

Knowing the current operational needs of the Armed Forces and the capabilities of Polish defense industry in the design and manufacture of unmanned platforms it can be expected, that the UAS development strategy in Poland will oscillate toward an efficient manufacturing and rapid application of these systems for the defense sector and for the national economy.

Both public and private entities of defense industry make an effort to integrate into this new, most rapidly growing area of the global industry, attracting domestic and foreign market.

Necessary condition for the implementation of these assumptions is to produce technologically advanced products that meet the high demands of potential customers, while being competitive in relation to foreign producers. Based on a deep analysis of the achievements of foreign armaments companies in this domain, we can expect specific integration efforts of Polish industry, national academic and scientific research in order to take this challenge.

Polish Armaments Group (PAG) as the largest defense company in the country, offers a wide range of armaments, including unmanned platforms (Fig.7.). At the same time, actively participates in several programs of continued research and development of UAS, while

taking care to create of more than ministerial „**National Programme for the Development and Construction of Unmanned Platforms**" in the dimension of air, land and sea.

This may force a takeover the role of the Strategic Leader by PAG, which would take on the task of effective consolidation of the achievements of all interested in the topic organizations (eg. Ministry of Defense, Ministry of Interior, Ministry of Economy, Ministry of Treasury, defense industry, Polish Civil Aviation Agency, Polish Air Navigation Services Agency, universities and research institutes).

Fig. 7. Polish Armaments Group current business offer [own study]

This adopted concept of the future development strategy of UAS in Poland, may help to take advantageous cooperation of Polish defense industry sector with European and world wide countries in this domain.

Bibliography

[1] Unmanned Aircraft Systems Roadmap 2005 -2030, Office of the Secretary of Defense, Washington D.C. 2005.

[2] The JAPCC Remotely Piloted Aircraft Systems in Contested Environments, September 2014.

[3] Blyenburgh & Co: 2015/2016 RPAS Yearbook – The Global Perspective – 13th Annual Edition – June 2015.

[4] GUGAŁA T.: Koncepcja Eksploatacji Systemów Bezzałogowych Statków Powietrznych w Przestrzeni Powietrznej Kontrolowanej, Rozprawa Doktorska, ITWL, Grudzień 2013.