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Prospects for the development and use of Unmanned Aerial Systems

Abstract: This article presents the basic assumptions concerning the prospects for the use and development of unmanned flying systems. Data on the use of combat flying platforms are presented. At the same time, the directions of development and use of civil and combat air systems in tasks for the benefit of the national economy and future armed conflicts were presented. It was indicated that unmanned aerial systems, the use of which brings significant financial benefits, are a type of weapon that changes the approach of UAV users in the most spectacular way, transforming the face of their civil and military application. The use of unmanned aerial vehicles as part of combat tasks and missions forces continuous development personnel in terms of the ability to perform complex tasks related to both civil and military use. At the same time influencing the change of tactics of using unmanned combat systems. On the basis of analyzes and comparisons, the author also proposes that the development work and construction of elements and systems for unmanned aerial platforms become an opportunity for the development of national research institutes and the defense industry, which should consequently be the main supplier of basic types of modern weapons..

Keywords: Unmanned aerial vehicle; UAV; Quadrocopter; Drone; Multisensor technologies; AI; UAV; Stealth

Introduction

The development process of Unmanned Flying Systems (UAV) and its dynamics, as in other types of military armament, is influenced by several political, economic, economic, social, and scientific factors. The arrangement and strength of individual elements cause different intensities, proportions, and directions of changes in the structure of the armed forces' equipment with manned and unmanned systems. Over the last few years, financial pressure and political conditions have become the leading factors for many countries in the face of the revision of the amount of defense spending, and thus the shaping of defense policy, entailing changes in the organization and structures of the armed forces and their equipment. While maintaining at least the current combat potential, the aim is to satisfy the set level of defense and reconnaissance ambitions by ensuring greater efficiency and effectiveness of UAVs using less costly means of combat. This trend is perfectly matched by unmanned systems, which, thanks to their ever-increasing capabilities, are increasingly replacing traditional manned combat systems.

In the last decade, the quantitative share of unmanned aerial platforms in operational activities has increased significantly, but not only.

Currently, the most common unmanned aerial platform is the quadrocopter (figure **1**). This simplest multi-rotor design is capable not only of flying along a programmed route or implementing operator's commands to change flight parameters but also, thanks to the use of variable-pitch propellers, it can perform dynamic maneuvers and aerobatic figures. Engineers Mark Cutler and Jonathan P. Howe presented their new capabilities for remotely controlled flying rotor platforms. Quadrocopters have previously unattainable maneuverability. The ability of drones with fixed-pitch propellers has been extended to include the propeller-down maneuver.

1. ANAFI WORK 4k quadcopter

A few years ago, quadrocopters were used, for example, to deliver pizza. The American Massachusetts Institute of Technology (MIT) has proven that quadrocopters can carry out missions of guides showing visitors and students around the university campus, which, according to students and visitors, is a real maze.

The system called SkyCall consists of quadcopters and an application installed on a smartphone. In the event of a loss of orientation on the campus, all you need to do is call a drone. The quadcopter will fly to the place of the call, and thanks to the destination point entered in the application, it will calculate the route and start guiding you to the destination. Prototype quadrocopters use, among others, WiFi modules, GPS, and cameras. Importantly, during the flight, the drone has the functionality of adjusting the flight speed to the person following it and avoiding obstacles in the path of movement. If necessary, the drone can go back or stop when the person it is driving stops, e.g. to talk or read something on the bulletin board. In addition, although the appropriate application is responsible for calling and determining the destination, the drone also supports voice messages. An important function of the drone is the ability to operate inside buildings. In this case, traditional doors may prove to be an obstacle. This problem can be eliminated with the use of sensors that would open the door to the incoming guide. Thanks to the use of the quadrocopter with the current connection to the mobile application, the problem of losing orientation and wasting time searching for the right path has been solved.

The experience gained during the work on SkyCall will probably pay off in another project in which a swarm of quadrocopters is to be used to collect environmental data, search, and military activities in construction facilities or an urbanized area. This will allow for a detailed analysis of the area covered by the study, taking into account, among others: the state of air pollution, water, or plants present in a given area. The idea presented by MIT seems not only interesting but also so refined that similar devices shortly could successfully replace tour guides or guides for the visually impaired and disabled in wheelchairs, as well as rescuers in areas affected by natural disasters.

Combat operations in urbanized areas are considered to be one of the most difficult. Support for soldiers by unmanned aerial platforms adapted for this purpose - quadrocopters equipped with hybrid positioning systems seem to be indispensable.

It is expected that in the next decade the share of unmanned aerial systems in the potential of the armed forces - especially NATO countries - will increase four or five times, which suggests that the use of unmanned combat systems in other types of armed forces will follow a similar trend.

In the perspective of the next decade or two, technological progress in the field of materials, nanomaterials, communication and positioning systems, propulsion systems, and armaments will stimulate the expansion of the package of possible dual-use UAVs, reducing the costs of their acquisition and operation.

It can also be expected that Unmanned Aerial Systems will strengthen the capabilities of observation and aerial reconnaissance to an even wider extent. In particular, reconnaissance

from a long (and therefore safe) distance. The scope of conducted reconnaissance activities will expand thanks to the use of multisensor systems. Currently, it is envisaged to place on board an unmanned aerial vehicle (UAV) a radiolocation station, or a synthetic aperture radar (SAR). Synthetic Aperture Radar (SAR) is used to obtain images of stationary objects with high resolution, it is used to create images of the Earth's terrain and other planets using remote sensing techniques. Military aviation uses such radars for reconnaissance. Presumably, especially concerning large UAVs, the construction of multi-task reconnaissance and communication platforms will become visible, which, thanks to a wide range of technical devices located on the platform's base, will be able to provide information to the army, search, and rescue services and public order services in the field of all categories of reconnaissance information, from optoelectronic through electronic and signal detection of contamination agents and weapons of mass destruction. Having many sources of obtaining information will make the process of obtaining information independent of, for example, weather conditions (cloudy, dusty, etc.).

Due to the varied scope and nature of the information needed at individual levels of command, there are significant differences in equipment, tactical and technical capabilities for unmanned aerial vehicles, but above all in the aerodynamic system and in solving propulsion problems. Unmanned aerial vehicles (UAVs) in the quad and tethered multicopter systems are becoming more and more common. This solution allows the platform to stay in the air practically uninterruptedly because the tie wire is simultaneously supplied with electricity. Of course, UAVs of this type can also be used for civilian purposes, thus reducing the costs of their production and operation. Structures used to directly support the fighting forces will require increased survivability in an environment of operations highly saturated with means of warfare. Hence, many designed UAV structures are made in the "stealth" technology.

Over the last decade, there has been a dynamic development of unmanned aerial vehicles of various classes and in various aerodynamic systems, which is mainly due to the number of companies that design and manufacture them, offering solutions that meet the requirements of future armed conflicts and the needs of public order services.

The analysis of source materials allows us to conclude that, as in the case of manned aircraft, the development of unmanned aerial vehicles will also take place in two main directions, namely: improvement and retrofitting of the already operated UAVs and design, construction, and implementation of new qualitatively and operationally new flying structures.

The next generations of unmanned aerial vehicles will be characterized by increased reliability and flight safety (it is expected that the system's failure-free operation time will increase from 300 to 1,000 flight hours). What's more, thanks to the lower take-off weight, unmanned aerial vehicles will become more mobile and will not require permanent bases and runways as well as extensive infrastructure. The number of maintenance staff can be reduced to a few ground handlers and operators while maintaining the ability to conduct flight operations around the clock.

At the same time, from the perspective of the next two decades, the development of new specialized unmanned aerial vehicles can be expected. Most likely, this type of means of warfare will be present in electronic warfare (WE), both in terms of electronic shielding and offensive impact - destroying electronic systems or disrupting their operation. It is also envisaged that the activities of UAV electronic warfare will be combined to achieve complementarity of the electronic interaction system with specialized manned platforms, in particular by cooperating in a dangerous zone of armed conflict, in the vicinity of disrupted objects. This view is consistent with the development plans for unmanned systems articulated by American planners. In the further perspective of the development of Unmanned Combat Systems, they indicate the need to combine the activities of manned platforms and systems

with the unmanned part. A qualitatively new system referred to as *Manned-Unmanned System Teaming* (MUM-T) will have the ability to perform the following groups of tasks:

- combating ground and surface offensive forces from greater distances (*Stand-off Distance*);
- ensuring the mobility of troops in the operation of entering the theater of operations (*Initial Entry*);
- ensuring the ability to move and maneuver during offensive operations;
- providing funds for the development and maintenance of communication and logistic lines;
- providing cover for deployed elements of troops;
- ensuring continuous observation and reconnaissance of the theater of operations and neutralization of detected and identified threats.

The specified list of tasks allows identifying another area of development of unmanned aerial vehicles, namely support for the transport of troops and supplies carried out in various dimensions: strategic, operational, and tactical. Tasks of this type will be performed based on a variety of technical and tactical parameters on unmanned aerial platforms. Currently, unmanned aerial vehicles for air transport tasks are primarily equipped with subunits of special forces, i.e. units operating with a high degree of autonomy, in a hostile environment, and in isolation from their sources of supply. However, it is expected to expand the circle of potential users of transport unmanned aerial vehicles, leading to the development of various classes of this equipment. Thanks to these solutions, the national economy will probably also become a beneficiary, especially transport, and logistics.

According to the Technical Modernization Plan of the Polish Armed Forces, at the beginning of the third decade of the 21st century, the Polish Armed Forces are to have at their disposal 5 basic categories of unmanned aerial systems (UAV):

- mini UAVs of very short range (code name "Wizjer", up to 40 sets), dedicated to use at the battalion level
- mini UAVs of vertical take-off and landing (code name "Dragonfly", up to 15 sets), thanks to the possibility of hovering and conducting point observation, capable of operating in urbanized areas
- short-range tactical UAVs (code name "Orlik", up to 15 sets), dedicated to use at the brigade level
- tactical medium-range UAVs (code name "Gryf", up to 10 sets).
- combat unmanned aerial systems of the 2nd generation, made in the technology of difficult detection, capable of operating in conditions of intensive countermeasures against the enemy's air defense systems. These will be primarily reconnaissance and strike systems, capable of a joint operation with manned air platforms, i.e. conducting semi-autonomous operations.

The F-35 purchase program is closely related to the acquisition of an unmanned reconnaissance and strike system, capable of a joint operation with manned air platforms - Loyal Wingman [5]. The construction of this subsonic UAV will be adapted to operate in a multi-domain battlefield environment (adequate security in the cyber domain and communication with the satellites of the system dedicated to cooperation with the UAV swarm), as well as adapted to independent operations, including in a swarm of unmanned aerial vehicles, exchanging information about the situation in the space of fighting among themselves and about the objects of impact. The Loyal Wingman program (Figure **2**) is intensively developed by the United States.

So far, several scientific and research programs have been initiated, including by companies:

- Kratos Defense & Security Solution - XQ-58 Valkyrie program;

- Lockheed Martin - NexGen program;
- Boeing - Airpower Teaming System, a program developed for Australia;
- FCAS - European Loyal Wingman concept developed jointly by Dassault and Airbus Defense & Space;
- Tempest, a program developed by Great Britain.

Communication between the control station will be based on laser data transmission links (*reducing the electromagnetic footprint*).

On board, the UAV Loyal Wingman, a multilateral control and navigation system based on artificial intelligence (*AI*) algorithms will be implemented. UAV will operate based on YOLO (*You Only Look Once*) predictive imaging algorithms (*conducting pre-emptive strikes based on data obtained from artificial intelligence systems*).

2. Boeing's Loyal Wingman
Source: [5]

Ultimately, one of such structures (probably an American solution) is to be purchased by Poland under the "Harpi Szpon" program.

Summary

The use of specialized unmanned aerial platforms brings significant benefits, including reducing financial expenses, reducing the costs of training and maintaining the readiness of the system to perform tasks, and reducing the risk of unintentional losses, and moral and political consequences of intercepting the aircraft crew. Experience shows that many missions so far carried out by airplanes or helicopters can be successfully carried out by unmanned systems. Nevertheless, manned aircraft will remain a part of the military arsenal, because in the foreseeable future of UAVs, due to the insufficient technological advancement to win air battles and gain control over the air, they will not replace manned systems, but rather they will complement them.

The seriousness of long-term planning strategies to achieve the assumed results is shown by the American concepts of the development of unmanned systems contained in the *"US Air Force South Africa Vector: Vision and Enabling Concepts 2013 - 2038"* published in February 2014 [7]. This detailed document replaced the *United States Air Force Unmanned Aircraft Systems Flight Plan 2009-2047* development concept [6].

The development trend of Unmanned Aerial Systems indicates that the process of saturation of the armed forces with this type of combat means will progress dynamically, especially in the field of reconnaissance and strike means.

Considering the geopolitical location of Poland - regardless of how we assess the likelihood of an armed conflict that could affect us - in the process of developing plans for the technical modernization of the Armed Forces, the focus should be on ensuring the ability to repel an attack on Polish territory. While an armed conflict in its classic form does not currently seem a likely scenario, other uses of armed forces should not be called into question. The ability to conduct retaliatory actions (strikes) should therefore be treated as an integral element of the deterrent potential that the Polish Armed Forces should have. Defining the required capabilities will broaden the range of available response options in crisis and conflict situations below the threshold of war. Weakening the enemy's strike potential is a more politically risky solution, but from an operational point of view, it gives greater benefits than trying to destroy incoming ballistic missiles or cruise missiles. Theoretically, the Russian Federation could decide to attack a specific NATO member only in the absence of a firm stance from the other signatories of the Washington Treaty.

The Polish Air Force (also Land forces and Navy) should therefore have weapons systems capable of engaging battlefield objects at a depth of 100 to at least 500 km, i.e. AGM-158 JASSM (*Joint Air-to-Surface Standoff Missile*) and JASSM ER. The lack of this ability is currently one of the main weaknesses of the Polish Armed Forces. A conflict of a limited scale, including a conflict below the threshold of war, seems today to be the least likely scenario, although of course it cannot be ruled out, especially assuming a 20-year time horizon.

Source materials

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