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USE OF UNMANNED AERIAL VEHICLES IN AGRICULTURE

Introduction. With the rapid development of information technology, miniaturization of control hardware, there has been a progressive tendency to minimize the role of man in human-machine systems, and in some cases even to exclude it from the control circuit of relatively complex, technical objects. Automation, automation, robotics, mechatronics - this is a non-exhaustive list of sciences involved in this trend. In recent years, various aspects of the creation and use of unmanned vehicles are being actively studied: cars, self-propelled vehicles, armored personnel carriers, aircraft for various purposes. Significant interest in this topic is observed in agriculture. There are many examples of successful use of unmanned aerial vehicles (UAVs) to protect plants from diseases and pests [1].

Analysis of recent research and publications. Many scientific works of domestic and foreign authors are devoted to the use of UAVs in agriculture. Analysis is devoted to the analysis, classification, purpose, both in the military and civilian segments, modern developments, design, evolution of unmanned aerial systems (UAS) [2; 3]. In [4-6] a systematic analysis of the use of different types of UAV models for aerial photography of mapping areas is presented. Prospects for the development of UAVs are covered in [7-11]. But even today, the full list of works that can be performed with the help of UAVs has not been determined yet.

The purpose of the article is to review the development of UAV applications in the world and in Ukraine, to present a SWOT analysis of UAV applications, to outline a strategy for the development of unmanned agricultural aircraft in Ukraine.

Foreign experience in the use of UAVs in agriculture

In recent years, various companies have developed a number of UAVs as part of mobile aviation complexes, but the results obtained in this process are minimal, which is a direct consequence of the lack of a clear position of the applicant on issues related to the possibility of scientific and industrial complex.

According to marketing research of foreign companies, the development of UAVs will increase the distribution of flight safety and information accounting [121]. Over the territory of Ukraine until 2040 permanently (in the mode "24/7/365") can be in the air at least 50,000 UAVs combined into a single system of work and services to meet various ever-growing needs of the economy, including agriculture. The average number of people employed in the development and production of unmanned aerial vehicles (UAS) will be up to 40,000 people, and the number of people employed in operation will be provided with a comprehensive solution and will reach 100,000 people by 2040 [13].

Estimates indicate that the global market for ALS, integrated solutions and services by 2040 will be more than 110 billion US dollars (at current prices) [14]. Therefore, not only the structure will change, but also consumer demand, which will need to adapt to new leaders in the global competition in the production of UAVs.

According to AUVSI in a report entitled "The Ecological Impact of Unmanned Systems Integration in the United States" in the official report of the International Association of Unmanned Vehicle Systems, it is stated that the use of UAVs in agriculture will take precedence over all other applications (dwarf all others) and by 2027 about 80% of the drone market will be introduced into US agriculture [15].

With State support - Ukraine can occupy from 5-10% (baseline scenario) to 15-18% (optimistic scenario) of the world market in the segment of "agriculture" until 2040. In monetary terms, the market for UAV-based services in the agricultural segment occupied by Ukrainian companies Drone UA and UkrSpec_Systems may reach UAH 600,000 million, and the sale of UAVs will significantly replenish Ukraine's budget in the form of fiscal deductions.

The global approach to the use of drones is a set of tools that use a maximum height of 120 m in line of sight. UAVs are widely used in agriculture in the following countries: Japan, Australia, New Zealand, South Korea, USA, Italy, Argentina, Brazil, Mexico and others. The use of UAVs in agriculture has a huge potential and every year the interest in their use is growing.

The use of unmanned aerial vehicles in agriculture is an innovation for Ukraine, as UAVs were primarily used for needs and only after military tests began widespread use in agriculture in agriculture.

Modern drones are equipped with multispectral cameras, the high image quality of which allows sensors to accurately diagnose problem areas of agricultural land with satellite navigation systems, compact on-board computers, as well as equipped with means for applying chemicals.

UAVs in agriculture are able to solve the following tasks:

- assessment of soil chemical composition;
- protection of agricultural lands%;
- forecasting crop yields;
- spraying with chemicals to control pests and diseases;
- assessment of crop growth;
- operational monitoring of plant condition;
- assessment of the scope of work and control of reclamation;
- inventory of agricultural land;
- construction of 3D models of the farm.

According to Greenbiz, the modern use of UAVs in agriculture for the optimal construction of irrigation and the Normalized Difference Vegetation Index of the normalized vegetation index is ahead of other areas of the US economy [16].

Vine Rangers (California) provides farm aerial photography of vineyards with UAVs for further guidance on pollination, irrigation and plant disease detection. The company collects data from drones and provides vineyard managers with access to data and recommendations through a Web interface. The planned part of the flight - once a week, the planned price of services - \$ 20 per 1 acre.

Aero Harvest is a California-based company, and Vine Rangers focuses on vineyards. The company is developing a search for drainage and optimization of irrigation schedule [17].

AgWorx is a concentrated agricultural specialist from North Carolina who promises to take the choice of the optimal harvest time, as well as provide their own applications to collect all the necessary data from land and drones.

Sense Fly (Switzerland) has developed the eWeeAg system, which includes eMotion software and a flying module with a built-in camera. Combining these components, the company builds accurate 3D maps.

Leading Edge Technologies, a Minnesota-based company, turns the collected data into a "Farm Intelligence Survey" that is applied to applications such as grain management and farmer-based management decisions [18].

Wibur-Ellis is the largest agricultural supplier from San Francisco, working on software for agronomists, integrating satellite data and UAV images.

Trimble Navigation is a California-based company that specializes in applications for a variety of monitoring and management, from crop monitoring to water management.

Lancaster UAV -allows you to collect the data needed to make management decisions on farms and in gardens. Field trials are conducted for several years in Ontario before starting work for farmland.

DJI (China) - in 2015 developed the DJIAgrasMG-1 UAV, which is created in a wet and dust-protected version of non-corrosive materials, in connection with which after the work the device can be washed and folded for transportation. The eight-engine AgrasMG-1 can carry up to 10 kg of spray liquid and handle a plane of 3.2 to 4 km / h. This is 40 times more efficient than manual spraying. An unmanned aerial vehicle can develop a speed of up to 8 m / s. and thus adjust the intensity of spraying depending on the speed of flight without reducing the efficiency of spraying.

Precision Hawk is a startup that builds a "market of algorithms" that help interpret data collected from satellites and drones.

The state of unmanned agricultural aircraft in Ukraine

Drone UA is a Ukrainian company with the most innovative enterprise in the agricultural sector and allows to solve the most difficult problems of the agricultural market of Ukraine. Satellite monitoring, laboratory soil studies, aerial plant control, aerial photography of farmland.

UkrSpec_Systems - Ukrainian flagship in the solution and application of UAV glider type PD-1 with the latest equipment and television cameras.

UAVs can be equipped with multispectral cameras, which are used to monitor plant performance using the infrared spectrum. Indicators obtained using the near-infrared spectrum allow us to determine changes in vegetation long before the corresponding changes manifest themselves in the visible spectrum.

Strategy for the development of unmanned agricultural aircraft [SWOT analysis]

STRONG POINTS	WEAK POINTS
<ul style="list-style-type: none"> • high economic efficiency (dozens of times cheaper) • small shooting height • punctuality • mobility • there is no complicated procedure for permits and coordination of flights • high efficiency • ecological cleanliness of flights 	<ul style="list-style-type: none"> • short flight time • the need to keep the device in direct line of sight • inability to use in strong winds and rain
OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> • operational monitoring of fields from a height of tens and hundreds of meters • identification of problem areas that cannot be done by traditional methods • quality control of sowing works, tillage • measurement of fields taking into account a relief, with high accuracy and GPS communication • calculation of germination and biological yield 	<ul style="list-style-type: none"> • breach of confidentiality and privacy • limited use of additional devices due to the geometric dimensions of the UAV • dangerous: with uncontrolled landing property damage or injury • imperfect legal regulation

Fig. 1. SWOT - analysis of the development of unmanned aerial vehicles

Conclusions. Unmanned aerial vehicles (UAVs) are becoming more and more popular around the world, as evidenced by the growing number of UAVs of various classes at air shows around the world. This popularity of this class of aircraft is due to a number of advantages over manned aircraft to solve a wider range of problems, the main of which is the lack of crew, relatively low cost of UAVs, low cost of their creation, production and operation, long duration and range. Analyzing the situation and summing up, we can say that over the past 5-7 years of development of this branch of mechanical engineering has done much more than in all previous years. It should be noted - rapid development and great prospects in the field of aviation in a variety of design solutions. We especially note the creation of a large number of unmanned aerial vehicles, portable, less than 1 m². Great success awaits the development of small aircraft with a wingspan of 2 to 5 meters. The functionality of the UAV is constantly being improved.

The lack of a state order for research and development and the need to use own funds in the creation of UAVs: without clear guarantees to make a profit in the future - encourages developers and owners to abandon science-intensive research in this area. In most cases, the experience of creating and using already dormant UAV models is used.

Prospects for further research

The effectiveness of UAVs in agriculture is of great importance. With the help of "cloud" means of data processing from drones and small unmanned aerial vehicles, farmers monitor not only the ascent of plants, but also can observe the deviation of equipment from a given course of field work, without leaving the office. Unmanned aerial vehicles are a new transport paradigm that is actively developing and should be regulated by legislation in the legal field of Ukraine.

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