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ANALYSIS OF UNMANNED AIRCRAFT SYSTEMS APPLICATION IN THE CIVIL FIELD

Volodymyr Kharchenko[1], Dmitry Prusov[2]

National Aviation University, Kosmonavta Komarova ave 1, 03680 Kiev, Ukraine
E-mails: [1]kharch@nau.edu.ua; [2]prusov@nau.edu.ua (corresponding author)

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Abstract. The basic directions of unmanned aircraft systems applications in the civil field has been reviewed, the concepts of creation and organization of civil unmanned aircraft systems has been considered depending on the task orientation as well as the wide range of issues concerning the use of existing capacity for the design, manufacture and operation, with subsequent integration into the common air space.

Keywords: unmanned aircraft systems, effectiveness, application, civil field, aviation.

1. Introduction

Ukraine is one of the few countries that has a powerful potential in aviation design and aviation industry. In recent years it has made significant contribution in developing its air industrial fields, and it is able to overcome the lag in the potential field of Unmanned Aviation Systems construction and take competitive position in manufacture and operation of unmanned aircraft systems.

Ukraine has sufficient scientific, technical and technological potential, which is important for government funding and attractive for the investment. The implementation of scientific and technical programs and projects in the sphere of high-technology engineering, the appearance of competitive technologies, equipment and tools at the market, as well as increasing of export potential is one of the priorities of development of Ukrainian economy. Ukraine saved sufficiently high scientific and technical potential, which allows doing independent engineering operations in aviation construction.

The difficult economic situation makes to search for the least costly ways of work. The construction of unmanned aircraft systems mainly of a small size is one of these directions, which allows to realize professional ambitions, new ideas and experience in the form of final products.

The use of unmanned aircraft in the civil field is intensively continuing: to protect the borders, maintenance of law and order, the control of natural disasters consequences or man-made disasters, monitoring of the environment and so on.

The problems of unmanned aircraft equipment are not connected with the unmanned aircraft, because they are only a part of unmanned aviation system, which includes aircraft, modern special on-board equipment and ground control systems, launch and landing. Thus, unmanned aviation system is a sophisticated aviation technical system which includes one or more unmanned aircraft, control point and communication facilities, equipment startup and rescue service, as well as transportation.

The elaboration of these components in the construction of unmanned aviation complex requires high development of aircraft design, electronics, information and other technologies. Therefore, many countries haven't got a complete cycle of this unique manufacture, beginning with the construction of the aircraft and its equipment and finishing with the target ground control points.

Along with the elaboration, manufacture and application of unmanned aircraft systems regulatory base of common use of airspace by the unmanned aircraft systems and by the manned one is being formed in the world.

Lack of systems to prevent collisions between unmanned aircraft with other aircraft, high probability of uncontrolled fall to the ground make the flights of unmanned aircraft impossible in the same space with other aircraft as well as their application in the areas of settlements. As a result, the benefits from the use of civil unmanned aircraft systems are lost, and the application of unmanned aircraft systems in the airspace with busy

air traffic and in the areas of settlements is completely impossible (ICAO 2011).

In such civil areas of application as the earth remote probing, communications and control of borders, relaying signals of unmanned aircraft systems reduce the cost of production of services in comparison with traditional space and aeronautical systems.

Concepts of certification, standardization and regulation of unmanned aircraft flights at the level of international governmental and nongovernmental organizations have been created (JAA/EUROCONTROL 2004; CAA 2012; EASA 2005).

In Ukraine the field of unmanned aircraft develops very quickly. The National Aviation University was one of the first institutions in Ukraine which drew attention to the problem of development of unmanned aviation system (UAS) of civil purposes. Currently in Ukraine there are no such important components as the classification of unmanned aviation system according to the common terminology, tactical and technical requirements to the complexes from potential customers, regulatory base for creation, testing and operation of the unmanned aviation complex, funding from the concerned central authorities (Kulyk *et al.* 2011).

The use of unmanned aviation complex in the national economic sector, in the interest of environmental authorities, enterprises of fuel, energy complex and other subjects of the national economy, in the problems of emergency situations, as well as for air surveillance and border security, for the monitoring of the situation on the highways also in the interests of regional bodies of economy, the bodies of land utilization, municipal and regional administrations, etc., which will improve the effectiveness of operational control by means of various departments during the performance of assigned missions in money saving with a help of creation of unified unmanned aviation complex are very important. Ukraine for a short term can receive advanced unmanned aviation complex of civil purposes with a help of joint efforts of relevant authorities of executive power and their focus on main areas is a topical issue.

According to all listed industry problems Ukraine has a serious technical base, and all the necessary resources to create effective automatic unmanned systems. More attention both from the government and business representatives is paid to the projects of unmanned aircraft complexes creation.

2. The Application Directions of Unmanned Aircraft Systems in the Civil Field

Civil application of unmanned aircraft systems can be divided into three groups:

- safety control;
- in scientific-research aims;
- commercial.

The first group consists of: patrolling of land and sea borders, monitoring of traffic, monitoring of the emergency situations of any origin, monitoring of fire conditions, environmental monitoring.

The second group includes the following aerial works: monitoring of climate and atmosphere, monitoring of natural landscapes and vegetation, control of water, research of wildlife and others.

Monitoring of industrial infrastructure, agricultural and forest land, spraying of chemicals in agricultural purposes, geophysical aerial photography, air photo and video, air cartography are among the typical works that make up the business group.

Timely and accurate information support is a necessary condition for successful course of modern manufacturing processes. This is especially important for projects and works over the large areas. Aerial photography for decades is an effective tool for research in geodesy, geophysical studies for different types of monitoring.

With the advent of the commercial aerospace the market of geoinformatics data was formed. Modern geoinformation systems provide users with a powerful tool for visualization, analysis, classification and storing of geospatial data. Geo-information systems (GIS) are used not only by public authorities (for example, for cadastral account), but there are many corporate GIS applications that provide a reasonable decision-making in complex projects on the use of natural resources, construction, agricultural and others. Issues about the information GIS content, their updating are resolved on the basis of available funds. Basically, it is the data of space and aerial photography. However, despite the continuous improvement of tools for the earth remote probing (ERP), such survey has well-known methodological limitations which are first of all determined by being unable to shoot at any time, anywhere, by any weather conditions and taking into account the satellites geometry orbit.

Unmanned aircraft are much better than space facilities by means of prompt survey. Obviously, unmanned aircraft flight can be planned in such a way that the medium can follow along the objects of survey. Automatical devices are the main common feature of the unmanned aircraft. Such surveillance equipment as optical, radar, geophysical and desired communication channel is installed on them, that provides control and data transfer. However, the information from the unmanned aircraft can be obtained in real time or after delivery and processing, but almost at daily monitoring.

Complexes of air monitoring can be used to update and refine geospatial information. The imagery is superimposed on a digital terrain relief, then data can be used to measure distances, areas determination, and as a substrate for overlay of the other data. Peculiar original images of high resolution, which allow to identify individual objects are still accessible.

Signals relaying is another function that can be performed by unmanned aircraft. It is obvious that unmanned aircraft is unable to compete with communication satellites according to distance and coverage area, but they are able to deploy a local system for the operations duration in certain areas. During the location of transmitting antenna at a height of 20 km. transmission signal is provided in line of sight to a distance of 500 km.

Thus, basic directions of unmanned aircraft application in civil field are as follows:

- ***detection of small size objects*** – air, surface, ground, search and rescue, assistance in emergency situations;
- ***air traffic control*** – in remote areas, in case of natural disasters and accidents, on the temporal air routes during the aerial works;
- ***maritime traffic control*** – search and detection of ships, accidents prevention in ports, control of maritime borders, fishing rules control;
- ***development of regional and interregional telecommunication networks*** – communication systems, including mobile one, broadcasting, relaying, navigation systems, advertising, television, cinema;
- ***aerial photography and earth's surface control*** – aerial photography (cartography); inspection of contract liability compliance (the mode of 'open sky'); control of hydro-, meteo situation; control of actively radiating objects, control of the power transferring lines, compliance monitoring for illegal migration of people, law enforcement (control of unauthorized disturbances); forest fires detection, observation of the perimeter of objects; observation of industrial sites, control of railway tracks, control of the other linear objects;
- ***control of environmental conditions*** – radiation control; gas chemical control, control of gas and oil pipelines, survey of seismic sensors, control of avalanches;
- ***application in agriculture and exploration*** – aviation-chemical works (ACW) in agriculture and forestry, identification of soil characteristics; mineral exploration, subsurface (100 m) earth probing;
- ***oceanology*** – reconnaissance of ice conditions, sea monitoring; search of industrial clusters of fish.

Civil unmanned aircraft systems can be used in these areas with the following tasks:

- ***geophysical research*** – gathering information about the physical condition of the earth's surface and the soil to depths where the objects infrastructure located for finding mineral deposits, their specification limits;
- ***mapping*** – works connected with a determination of the spatial location and combination of the earth's surface elements, by fixed geometry of the objects infrastructure to geodetic earth system;
- ***site protection*** – monitoring and prevention of unauthorized interference with objects; all infrastructure objects are under protection;
- ***search and rescue operations*** – are carried when it is necessary, mainly in case of contingency (emergency) situations in amounts corresponding to the capabilities of unmanned aircraft equipment – aviation monitoring of different types, cargo delivery;
- ***ice reconnaissance*** – monitoring of ice fields, mainly in aquatic waters to determine the presence of ice, direction and speed of drift ice fields, their location and values etc.;
- ***results validation of materials processing of a survey*** – is a collection and processing of the control sample of materials of ground and air surveys to confirm the stated accuracy of the measurement of natural objects or process equipment thematic characteristics.

Over the above-mentioned tasks related to the monitoring, the possibility of unmanned aircraft application in other areas is considered as well:

- ***chemical processing facilities*** – processing of the infrastructure objects by chemicals to neutralize the action of corrosive and other materials both in emergency situations and in the planned work; weather modification is also referred to the chemical processing;
- ***relay radio communications systems*** – to ensure prompt transmission of radio signals outside the line of radio horizon from the source to the consumer in areas with lack of wire, microwave and other communications;
- ***quick cargo delivery*** – delivery of cargo to the remote areas (with no transport facilities in the earth's surface) (Voronov 2009).
- There are such contributing factors in the creation of unmanned aircraft systems for the monitoring:
- the development of a high level unmanned aircraft equipment in the world;
- availability of enterprises which professionally develop the theme of unmanned aviation, which allows to use their experience and production-technical base;
- availability of unmanned aircraft systems of the manufacturers that meet the basic tasks of flight technical performance (FTP), formulated in the concept;
- significant technical progress in recent years in the field of remote monitoring and data processing, the availability of a ramified network of processing and transmitting the information.

A list of tasks that must be solved with a help of the provision of air services of the enterprises by unmanned aircraft systems, based on the analysis of the infrastructure sector and its constituent objects, including requirements for air service, has been formulated.

Production and environmental monitoring implies the collection of information about the object to determine its functional characteristics of technological and environmental standards, states of the (natural) environment to a certain distance from the object. Objects of prey, gas storage, pipelines, gas processing plants and gas chemical complexes are subjected to the production and environmental monitoring.

The above-mentioned list of tasks imposes special requirements both for the aircraft itself and for the target hardware. In spite of the similarity of the tasks of military and civil unmanned aircraft applications, there are some fundamental differences that must be expressed in the basic requirements to the unmanned aircraft complexes.

In the tasks of monitoring for civil application there is not always a need for obtaining information in real time. Data delivery to the base station will be sufficiently, where it is processed, and if it is necessary the information is sent to the relevant services. Hence, it is possible to use radio links with limited capacity, which provides only control and surveillance of the unmanned aircraft.

Standards connected with stealth and are applied to civil unmanned aircraft are not set that allow to use less expensive construction materials. Factor of the arrival rate to the patrolling area is not also significant that is why it is possible to use more efficient engines. There are a number of features related to the specific application of unmanned aircraft systems of civil purposes, including the performance of requirements of the customer in the design, development and manufacture of unmanned aircraft systems complex as to a specialized set of unmanned aircraft.

Unmanned aircraft systems can be used both separately and together with the traditionally technical means and serve to control lingering and square objects, observation of crowded places, traffic monitoring, and other urgent tasks today.

3. The Unmanned Aircraft Systems Application for the Aerial Photography

Unmanned aircraft systems in the field of the aerial photography can be also very useful. Their opportunities largely depend on the altitude. Today the limit is 20 km, and in the future it is up to 30 km. At such altitude unmanned aircraft can compete with satellite. Tracking everything that happens in an area of about one million square kilometers, it becomes a kind of 'aerodynamic satellite'. Unmanned aircraft can operate as satellite groups and perform the tasks in real time mode within a region.

It is well-known that we need 24 satellites to hold photos and video or to observe any object from space, but even then the information from them will come once per hour. The satellite is above an object of observation only 15÷20 minutes and then it goes from the area of his sight and return to the same place, making a rotation around the earth. At the same time the object comes from a given point, as the earth rotates, and again stays in it only in 24 hours.

Unlike the satellite, unmanned aircraft accompanies the point of observation all the time. After completing the task at a specified altitude and within the stipulated time, the unmanned aircraft returns to the base, and in the sky it is replaced by the other one. Another unmanned aircraft is in reserve. This is the main component of the economy, because the unmanned aircraft is more cheaper than the satellites. The unmanned aircraft can also compete with satellites and in the creation of telecommunications networks and navigation systems. Unmanned aircraft can provide continuous monitoring of the earth's surface over a wide frequency range. It is possible to create an information field of the country, covering the traffic control air and the control of water transport, because unmanned aircraft is able to operate as a land, air and satellite radars (shared information from them gives a complete picture of what is done in the sky, on water and on land).

Unmanned aircraft help to solve a range of scientific and applied problems connected with geology, ecology, meteorology, zoology, agriculture, with a study of climate, extraction of minerals and etc. They can follow the migration of birds, mammals, fish, changing of the weather conditions and ice conditions on rivers, the movement of vessels, transport and movement of people, to conduct aero-, photo-and video survey, radar and radiation reconnaissance, multispectral monitoring of surface penetrating inside to 100 meters etc.

4. Monitoring the Gas and Oil-Pipelines' Objects by Using Unmanned Aircraft Systems

The optimal combination of all modern means of remote probing for both space and air bases, processing and data transfer will allow to expand the system of information application of the consumers of gas and oil, which covers the whole territory and provides high quality, timely and uninterrupted data collection which is critical for the security of object operation of gas and oil pipelines, and unmanned aircraft are considered as a future component of aerospace monitoring.

Development of oil and gas industry in the coming years is determined by the successful occurrence of such business processes as an increase of long-term goals for gas, gas condensate and oil extraction, priority development of gas and oil systems transportation, the creation and development of the gas transmission system, implementation of large-scale program of the country gasification that requires a lot of project works for geodesic provision of regional gas networks construction, efficient development of the resource base, extended reproduction of the mineral resource base, a significant increase of geologic exploration both in traditional and in new areas of work.

Taking into account the deployment of these business processes in areas of difficult availability with difficult climatic conditions, information application becomes critical for safety, rational planning, resource management and facilities.

The unmanned aircraft manufacturers are moving from the experimental flights in order to prove the effectiveness of technology to perform flight operations of the sites monitoring of different purposes, even in smaller scale. For the analysis of manufacturers' elaboration there are unmanned aircraft elaborations with basic sizes, and their level corresponds to the present level of development of aviation construction, communication means, control and systems remote probing. Some of the elaborations are in the stage of readiness for serial production of prototypes and are offered as a complete system that include medium of different sizes, complexes of target loads, ground support equipments and data processing. Elaborations which are a complex system integration platform of tools for collection and monitoring of data aroused in the greatest interest.

5. The Unmanned Aircraft Systems Application for Public Events Security

Monitoring of public events security is one of the tasks which are effectively solved with a help of the unmanned aircraft systems application.

Unmanned aircraft can be applied to monitor the public order during the various events. They should be equipped with video cameras and night vision devices; they should be almost noiseless and be able to conduct a visual observation of a given area from the altitude of about five hundred meters. Images obtained from the unmanned aircraft, come to the ground stations in real time, to the control desk of operator, or to the specially equipped police car. The application of such systems may be also useful to monitor the meetings, rallies and other crowded places as well as to patrol urban areas, traffic and for crime prevention in general.

6. The Unmanned Aircraft Systems Application for the Traffic Monitoring

Traffic monitoring is also one of the tasks that can be solved by the use of unmanned aircraft systems. By using unmanned aircraft systems for identification of the traffic offenders, the traffic police representative together with the experts in the field of unmanned aircraft systems are inside the ground control station of unmanned aircraft, while the number of patrol cars which are equipped with video terminals are patrolling the road situations and then send the video in the real time mode. Conducting of such air patrolling by unmanned aircraft systems will improve the traffic control and increase the safety on the roads.

The possibility of efficient detection of 'problem' places on the roads and, therefore, redistribution of traffic to avoid congestion is considered. Application of unmanned aircraft systems with unmanned aircraft both of aircraft and helicopter types is efficient, and the use of secondary devices with greater duration of flight and better monitoring devices are the most promising for the proper monitoring of traffic.

7. The Unmanned Aircraft Systems Application for Carrying Out the Anti-Terrorist Missions

A large range and flight duration are always required during the anti-terrorist missions, but the hovering over the certain objects, the possibility to take high-quality surveillance equipment on board and a small aircraft visibility are also very useful and important.

Unmanned aircraft systems with the unmanned aircraft of a small size which meet the following objectives: application from the small areas that make them indispensable during the special operations in urban places, a small weight of unmanned aircraft with a possibility of payload, longer duration of flight to ensure adequate speed should be created to fulfill these tasks. The complex must monitor the territory, discerning people, vehicles license plates and other small parts. The possibility to use the unmanned aircraft in difficult weather conditions and low acoustic visibility is one of its special features.

8. The Unmanned Aircraft Systems Application in Combating the Proliferation of Drugs

At the stage of airborne surveillance complex formation the issues of unmanned aircraft adaptation to the specific conditions of the future application may be considered.

From the technical point of view the application of unmanned aircraft systems in combating the proliferation of drugs can be limited by the observation of the certain areas of the earth's surface with a given frequency by the time. However, the specific production and distribution of drugs from the manufacturer to the places of their realization requires continuous monitoring of large spaces, the areas which often do not have distinct boundaries. By the way, the list of solved tasks by the unmanned aircraft can be very big.

The unmanned aircraft can also solve the following tasks connected with combating the proliferation of drugs:

- search and detection of places in order to find the production (growth) of raw materials for drugs;
- opening the transport communications of the drugs moving;
- search and detection of drug products stockpiles outside the settlements;
- support of actions of special groups that perform operations;
- radio engineering reconnaissance;
- the designation of coordinates targets;
- messages relaying on the control point of operational activities;
- support of the observed object;
- statement of selective radio interference, etc.

9. The Concept of Creation and Organization of Civil Unmanned Aircraft Systems and the Principles of their Economic Motivation

Design and manufacture of modern unmanned aviation complex is a task not only of the field of aviation construction in its traditional sense as an aircraft production but also it focuses on the task which is a distinctive feature of the unmanned aircraft, and in this sense the aircraft is a means of transportation. So the word 'complex' is a key word and the development and production of unmanned aircraft systems even before their operation will have already provided the advanced technologies development in the country.

Only basic technologies which are used in the production of unmanned aircraft complexes are listed below:

- development and manufacture of advanced structural materials, especially composites, using nanotechnological covering;
- modern computer technologies, including multiprocessor systems for collection, processing and storage of information;
- theory of automatic control systems, as a branch of cybernetics, which is connected with the theory of information transfer, encryption and data compression;

- communication means and systems, including the space one;
- technologies of the remote earth probing (radiolocation, optoelectronic systems, multispectral sensors);
- energy technologies, alternative energy sources application: super capacious batteries, solar energy, fuel elements;
- navigation means and systems, air traffic management with a help of the introduction of automatic dependent surveillance (ADS);
- geographic Information Systems (GIS);
- image processing technologies, pattern recognition;
- the task of man-machine interface elaboration;
- the task of artificial intelligence elaboration.

Obviously, the list of above-mentioned tasks requires the availability of the target load complex on board, and the unmanned aircraft itself should have very high aircraft performance characteristics. Technical analysis of the military unmanned aircraft shows that it is impossible to create the unmanned aircraft of a high quality for the listed operations. This requires the application of advanced methods of the development of new equipment with extensive use of modularity capabilities of the construction building and the modifications at the level of structural building blocks.

Theoretical number N_B of unmanned aircraft models can be defined by the expression:

$$N_B = \prod_{i=1}^{n} m_i, \tag{1}$$

where: n – is a number of variables of structural building magnitudes in the unmanned aircraft; m_i – is a number of models of one structural building magnitude.

Functional models of the unmanned aircraft is presented in Table.

Thus, during the creation of unmanned aircraft systems, the main focus was made on increasing the aircraft application while reducing the required series of the unmanned aircraft to the one type.

Group application of the same type of unmanned aircraft of 'different models' provides a solution to many problems which require several types of unmanned aircraft. In this case, the maintenance costs connected with different types of unmanned aircraft and ground facilities which are the part of unmanned aircraft complexes are significantly reduced.

The unmanned aircraft application in solving various problems requires not only direct control over the parts of the earth's surface but it requires the formation of a temporary network of information exchange in the areas of tasks performance. This approach greatly reduces temporary costs and allows to:

- illuminate the operational situation in the standby time, near to the real one;
- dramatically improve the selectivity in the support of developing objects at great distances;
- improve the management efficiency of material and human resources during the special events;
- provide target designation for mobile and permanent fire means;
- reduce the volume and duration of supervision procedures at the control borders.

The assessment of unmanned aircraft systems efficiency to solve the above-mentioned problems by determining the cost of removal of information from one area of the earth's surface $\overline{C}_I$ is an important fact that allows to use the ideology of aerial reconnaissance means and surveillance:

$$\overline{C}_I = \frac{\frac{C_{AC}}{n_{AP}} + C_{AED} + C_{FEM}}{P_{PSP} \cdot F_{\Sigma}^{1}}, \tag{2}$$

where: C_{AC} – is a cost of a new aircraft; n_{AP} – is an estimated amount of unmanned aircraft application (multiplicity); C_{AED} – is a cost of additional expendable devices for one flight (the cost of powder accelerators, bolts, etc.); C_{FEM} – is a fuel cost and expendable materials (fuel lubricating materials, industrial gases, etc.); P_{PSP} – is a probability of simultaneous performance of other tasks; F_{Σ}^{1} – is a total area of the earth's surface in one radius (Klochkov, Nikitova 2007).

Monitoring of the territories, water zones, roads and borders is one of the major areas of unmanned aircraft systems application in the civil field.

Lack of crew on board of the unmanned aircraft and its systems of life support, smaller sizes and less power will significantly reduce the cost of flying hours.

This will allow not only to reduce the costs for unmanned aircraft systems application during the monitoring, but it will also increase the intensity of some patrol

Table. Functional models of the unmanned aircraft

Magnitude	Functions
Nose-mounted magnitude	Optical reconnaissance in the visible, infrared, ultraviolet ranges, target designation, reconnaissance of the radiolocation of a front hemisphere
Front magnitude	Radio engineering reconnaissance, statement of obstacles, spectral analysis, detailed optical reconnaissance, side radiolocation reconnaissance
Wing magnitude	Change of maximum flight duration
Fuel tank magnitude	Change of the full type
Aircraft systems magnitude	Change of unmanned aircraft operating modes
Power plant magnitude	Change of the power plant type

flights and, consequently, to reduce the estimated loss in case of emergencies.

At the same time, the organization of the patrolling process in reality requires more detailed account of heterogeneity of serviced routes, route optimization overflight, the location of ground infrastructure, etc.

Objects monitoring has the economically important characteristic feature. On the one hand, the more frequently the overflight is performed, the higher costs of patrolling organization. On the other hand, the increasing intensity of patrolling allows to update information about the status of objects more frequently, which contributes to elimination of emergency situations and, consequently, enables to reduce the expected losses.

At the present stage of development of aviation industry and in the conditions of functioning of many independent operating organizations, the economic efficiency of aerotechnics is individually identified for each potential task. By the way, in the connection with specific applications of unmanned aircraft systems it is correct not to speak about the efficiency of aircraft as they are. The efficiency of an integrated system which includes the unmanned aircraft fleet and belongs to a particular operating organization is a better concern.

The criteria of economic efficiency and the methods of their calculation have been changed. Due to this fact the analysis of the economic efficiency of unmanned aircraft systems in the civil field is based on the development of appropriate models, for example the model of volume optimization of the patrol flights, which is used to assess the cost of air monitoring in view of 1 year and the elaborations of appropriate methods for assessing demand on unmanned aircraft systems and their application efficiency.

The markets of patrol operations and the unmanned aircraft are relatively new and have been rapidly developing in recent years. Therefore, many recommendations which were produced empirically for the airline markets are unsuitable. On the one hand, this fact generates new methodological problems in marketing. On the other hand – the solution of these problems may be relevant for the traditional market segments of aerotechnics, which begins to change (Rostopchin, Fedin 2006).

The new monitoring tools, information and control systems and the organizations which are interested in unmanned aircraft systems application increase economic efficiency and its operation safety. They also contribute to the development of high-tech industries and diversification of the Ukrainian economy.

Thus, the demand on unmanned aircraft and the patrol work, performed by them is determined by economic efficiency of patrolling. Application of patrolling means can save the costs not only by the reduction of patrol flights, but by the reduction of the expected loss due to early detection of abnormal and emergency situations, which is achieved by increasing the patrolling intensity.

Considerable uncertainty of output data, depending on the specific areas and the tasks of unmanned aircraft systems application requires the parametric calculations in a wide range of model parameters. Development of appropriate economic and mathematical models can be an effective marketing tool which enables developers and potential customers of unmanned aircraft systems to predict the efficiency of their application in the civil field, to coordinate the approximate amount of their release, mutually acceptable specifications and prices.

10. The use of Different Categories of Unmanned Aircraft

The main directions of unmanned aircraft design are:

- providing of high aircraft performance characteristics;
- great value of instant areas during the survey of the earth's surface area;
- relatively low cost of the unmanned aircraft;
- versatility and multi-variation of the unmanned aircraft;
- unmanned aircraft integration into temporary information networks in the areas of application.

The use of aerial reconnaissance and surveillance is a means to increase efficiency, and altogether with other technical means and organizational solutions it will allow to solve the formulated tasks successfully.

Due to the wide range of tasks listed above, the use of several categories of unmanned aircraft both of aircraft and other types has been considered.

According to the weight and type the unmanned aircraft are conventionally divided into four categories:

- ***Class 1*** – Unmanned aircraft of an aircraft type with a take-off weight till 10 kg with an electric engine that can be used as a means of operational monitoring in the stationary watchposts or mobile groups. Payload of the unmanned aircraft includes camera of a day or infrared ranges, which transmits real-time image on the unmanned aircraft remote control;
- ***Class 2*** – Unmanned aircraft of an aircraft type with a take-off weight till 100 kg with an internal combustion engine. They can be used to monitor the lingering objects according to the flight range of such unmanned aircraft. A digital camera with high resolution or photogrammetric complex as well as radar and gas analyzer are installed as the payload. Calculations show that the use of such kind of unmanned aircraft may be the most effective and economically justified. Unmanned aircraft of Class 2 can conduct the flights lasting 8÷10 hours, thus providing a survey up to 500 miles per one flight. However, the unmanned aircraft weighing up till 100 kg are rather mobile and compact and can efficiently operate without a special airfield base, with a minimal set of ground infrastructure means;
- ***Class 3*** – Unmanned aircraft of an aircraft type with a take-off weight till 500 kg can be used both for chemical processing of large areas and for efficient transportation of cargo. Taking into account the large size of these devices, they will need the airfield base;

- ***Class 4*** – Unmanned aircraft of a helicopter type is also of great interest for the objects monitoring. Such systems are at the initial stage of the enterprises development.

11. The Structure of Unmanned Aviation Complex (UAC)

Unmanned aircraft operate without human on board. Unmanned aviation complex can have one or more unmanned aircraft. In general, the unmanned aviation complex consists of unmanned aircraft and a ground (air, water) control point. To provide a flight of the unmanned aircraft, unmanned aircraft complex should consist of the following elements:

- unmanned aircraft itself;
- control stations (management) of unmanned aircraft and antennas system;
- software and the systems of on-board monitoring of the unmanned aircraft;
- communication means (earth / air and air / earth) for air traffic control and unmanned aircraft payload;
- terminals of data processing;
- landing system;
- launch system and systems of the flight refreshment;
- maintenance equipment and the support of unmanned aircraft and its systems;
- systems of storage and transportation of unmanned aircraft complex.

Meanwhile the unmanned aircraft complex must be serviced by qualified ground personnel.

The developments of unmanned aircraft systems in Ukraine meets the modern standards of aviation construction, communication means, control systems and the systems of the remote probing, among which the complex system integration platform of means for collection and processing of information monitoring is of a great interest. Some developments are in the stage of pre-series prototypes and are offered as a complete system that include the medium of different size, target loads complexes, ground support equipment and data processing.

There is no difference between the flights of unmanned aircraft and the manned one. The unmanned aircraft are equipped with guidance systems, on-board complexes of radiolocation, sensors and video cameras.

During the flight, the unmanned aircraft control is done automatically by the onboard navigation complex and control complex, which includes:

- satellite navigation receiver that provides the reception of navigation information from the GLONASS and GPS system;
- systems of inertial sensors that provides finding of orientation and parameters of unmanned aircraft motion;
- the system of air signals, which provides measurement of altitude and air speed;
- different types of antennas are designed to perform tasks.

The system of on-board navigation and control provides:

- a flight on a given route (the route task is performed by the designation of coordinates and the altitude of the route turning point);
- change of the route task or the return to the start point for the team under a command from the ground control point;
- overflight of specified area;
- car guiding of a chosen goal;
- stabilization of the orientation angles of unmanned aircraft;
- support of given altitudes and the airspeed;
- collection and transmission of telemetry data and the flight parameters and the work of the target equipment;
- devices software management of the target equipment.

Onboard communication system:

- operates for the allowed range of radio frequencies;
- provides data transfer from the board to the earth and from the earth to the board.

Data transmitted from the board to the earth are:

- parameters of telemetry;
- streaming video and pictures.

Data transmitted to the board include:

- steering commands of the unmanned aircraft;
- steering commands of the target hardware.

Information received from the unmanned aircraft should be classified depending on the degree of threat that appears. The Classification is carried out by the operator of ground control station (GCS), or directly by the on-board computer of the unmanned aircraft. In the second case, the software contains the elements of artificial intelligence and it is needed to develop quantitative criteria and the grades of the threat levels. These criteria can be formulated by the expert assessments and formalized with a minimizing of the errors probability.

12. Conclusions

Thus, there are developments, which allow the widespread application of unmanned aircraft systems in the civil field, namely the effective implementation of daytime and night time search of various objects, areas patrolling, security of the state border, environmental monitoring, radio relay, finding, radio-position finding, reconnaissance of the areas of major accidents and disasters, the delivery of small loads of drop strictly to the set point, etc. This defines the broadest spectrum of unmanned aircraft systems application – from rescue operations to geodesic works.

Despite the fact of the application need, the unmanned aircraft systems application in the civil field is currently at the stage of solution of some technical and organizational problems which make the unmanned aircraft systems application impossible. The main problems associated with the use of airspace, allocation of frequency range for unmanned aircraft control and data transfer from the board to the earth and vice versa, and

finally, with the market development of civil service which is under development.

Some of the tasks which were formulated by the civil sector of the unmanned aircraft application are of a great demand. First of all, there are control function of unmanned aircraft system with a help of which it is possible to control both the maintenance condition of objects their safety and operation. By the way, the controlled objects can be situated on the big distances (lingering objects).

That is the reason why there are a lot of organizations that are directly interested in using the unmanned aircraft systems in their field, and the concepts development of the unmanned aircraft systems application should provide the greatest effect (particularly the economic one).

The unmanned aircraft systems application is in the initial stage, which is characterized by a significant level of unmanned aircraft development and its elements, and by the lack of the basis of unmanned aircraft application in real technological processes. Resolution of this contradiction requires the solution of diverse problems of conceptual, technical, technological, methodological, organizational and legal – normative character.

Thus, the unmanned aircraft systems application in the airspace of Ukraine is necessary. The unmanned aircraft flights are possible providing the requirements for the Certificate of airworthiness Registration. Nowadays the issues concerning the use of unmanned aircraft systems in civil field for satisfying the requirements of economic needs are in the first place.

In general, today the unmanned aircraft systems application in the civil field is practically limited by particular cases of local applications in favor of the solution of current production or economic problems, mainly by the experimental procedure. Therefore, the market growth of the unmanned aircraft systems is expected providing the capability of a number of technical and administrative barriers that restrict the use of unmanned aircraft systems in the national airspace.

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