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BONDAR S.O., PhD student,
Researcher of the Intellectual Control Department.
https://orcid.org/0000-0003-4140-7985, e-mail: orangearrows@bigmir.net
SHEPETUKHA Yu.M., PhD (Engineering), Senior Researcher
Acting Head of the Intellectual Control Department
https://orcid.org/0000-0002-6256-5248, e-mail: shepetukha@irtc.org.ua
VOLOSHENYUK D.O., PhD (Engineering),
Senior Researcher of the Intellectual Control Department
https://orcid.org/0000-0003-3793-7801, E-mail: p-h-o-e-n-i-x@ukr.net
International Research and Training Center for Information Technologies
and Systems of the National Academy of Sciences of Ukraine
and Ministry of Education and Science of Ukraine.
40, Akad. Hlushkov ave., Kyiv, 03187, Ukraine.

USING OF HIGH-QUALITY POSITIONING TOOLS FOR HYBRID UNMANNED AERIAL VEHICLES AUTOMATIC CORRECTION UNDER THE LIMITED SPACE CONDITION

Introduction. *Original class of hybrid unmanned aerial vehicles is considered for multitask mission accomplishment at this article. Advantages of such vehicles usage for purposes that are always done by several different agents are considered. Perspective of the position precisioning for different tasks that could be done by unmanned aircrafts is analyzed.*

The purpose *of the paper is to universalize the process of surveillance, photo and video data collection and other missions that is provided by unmanned aerial vehicles today. The action of data precision during some periods of the misson accomplishment and increased specification for main targets of the mission could demonstrate brand new vector of the unmanned aerial vehicle usage and creation of the brand new domains for the unmanned aerial vehicles. Complex data gathering could help to avoid extra mediators and could simplify data processing on the next stages and also could do such data much more precise.*

Results. *The usable scenario of route for hybrid unmanned aerial vehicle and the model of it could be a proof of universal multitask unmanned aerial vehicle utilization. Such scenario unites several information missions of different scale and could provide data for several data centers that can use it for defferent problem solving just from one flight. Also it proves that utilization of such aircraft with an additional onboard precision block could be the next step at the mapping and digitalizing domains. Financial analysis of the market is provided for demonstration of the fact that such hybrid aircraft complex system would provide such scale as well as attention to the object details but be much cheaper then mapping and surveillance systems that are already existing.*

Conclusion. *A need for optimization of some problems that could be achieved by unmanned aerial vehicles leaded to the usage of hybrid vehicles that were represented at the paper. Complex design of such an aircraft could be a collateral disadvantage but the whole influence of the hybrid UAV usage for different tasks would optimize a lot more processes, devices and unnecessary equipment that would be needed for a large list of tasks at each domain UAVs are using right now from surveillance to agricultural tasks. Model of different scale purpose universal hybrid unmanned aerial system is a proof of the possibility to use just one single aircraft for a complex mission that needs different set of capabilities, features and equipment. Also such aircraft could provide much more certain results of missions and do it at lower pryce. Further developments could provide information about the most effective hybrid UAV type for such type of missions and provide game changing rules to the digitalizing and surveillance processes because of the new information gathering way.*

Keywords: *unmanned aerial vehicle, hybrid vehicle, positioning, multipurpose flight.*

INTRODUCTION

Throughout the unmanned aerial vehicles development history so as ordinary manned aircrafts, most attention has been paid to the development of aircrafts and helicopter (multi-propeller) types. The reliability and robustness of such designs played an important role in the construction of the first unmanned aerial vehicles. Also, limited range of tasks and lack of technological development sensibly eliminated the need to introduce other types of aircraft designs to unmanned aerial vehicles. However, in recent decades, the variety and focus of tasks that can be accomplished by unmanned aerial vehicles has expanded significantly, and there has been a need in different industries for aircraft that can provide combination of both basic aircraft types' benefits and universalize accomplishment of specialized tasks. It is exactly the case for combined aircraft types, as well as brand new aircraft types with experimental engines, to join missions of different orientation and accuracy tasks. All these new types of aircraft are combined under the concept of "hybrid". Hybrid unmanned aerial vehicles are becoming more and more popular in the world. However, today in Ukraine unmanned aerial vehicles of hybrid types are not so popular and have very narrow usage spectrum. But Ukrainian market has a high potential for usage of such UAVs for various civilian and military tasks.

A very promising area for the introduction of such unmanned aerial vehicles is the agrosphere, where aircraft of similar design could perform land irrigation more efficiently and solve other diverse problems, where the versatility of hybrid UAVs can be fully revealed. Geodesy and cartography can also be considered a promising field, where hybrid unmanned aerial vehicles can open up much more than conventional aircraft-type UAVs. In the military sphere, hybrid convertiplane aircrafts can be successfully used for border patrol tasks and pursuing violators.

PROBLEM STATEMENT

Recently, information collection by the unmanned aerial vehicles is a straight procedure that most of the time works as model one vehicle for one mission. But in some cases such type of work is not profitable. Studied area could have more than just one task to do and, also, such tasks could need different tools to accomplish the mission. Also, the mission could have several tasks that are needed diverse approach for its performance. So during the experiment the hybrid type of the unmanned aerial aircraft is needed to achieve a very special result of unity of the different scale tasks.

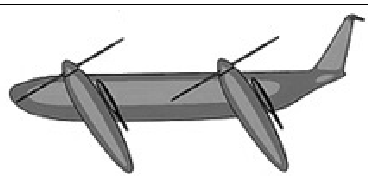
Different scale tasks could be taken at the surveillance and mapping domains – the field, where unmanned aerial aircrafts are having one of the vast usage parts already and could develop their perspectives even more.

The mission task would be in the simultaneous mapping of some large area part and the detailed data collection of some building that is situated at one point of such area. Task also includes further digitalizing procedure of gathered information and detailed 3D modelling of the studied area with the certain binding to the Earth coordinates.

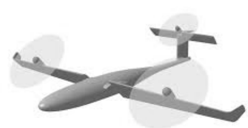
The purpose of the paper universalize the process of surveillance, photo and video data collection and other mission that is provided by unmanned aerial vehicles today. The action of data precision during some periods of the misson accomplishment and increased specification for main targets of the mission could demonstrate brand new vector of the unmanned aerial vehicle usage and creation of the brand new domains for the unmanned aerial vehicles. Complex data gathering could help to avoid extra mediators and could simplify data processing on the next stages and also could do such data much more precise.

TYPES, ADVANTAGES AND DISADVANTAGES OF HYBRID UNMANNED AERIAL VEHICLES

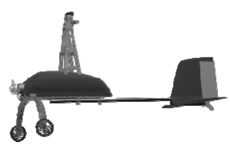
Mostly whole hybrid aircraft concept could be classified by the working engine and aerodynamic plane position changing and different combinations of it, as could be seen on the Fig. 1:



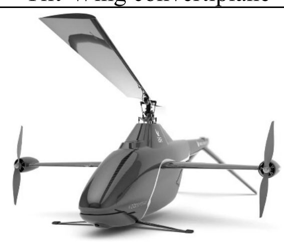
Tilt-Prop convertiplane



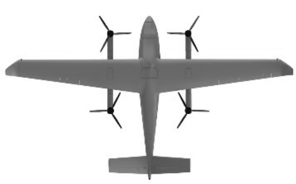
Tilt-Wing convertiplane



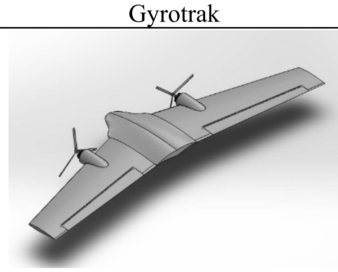
Autogyro



Gyrotrak



Vertical Takeoff/Landing Aircraft with engine fixed in one plane



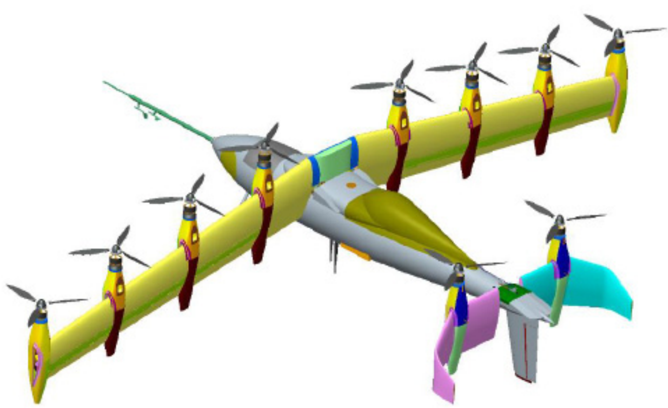
Tailsitter

Fig. 1. The most popular hybrid aircraft types classification

Survey of hybrid unmanned aerial vehicles design features. According to the vast majority of market surveys, Tilt-Prop/Tilt-Wing convertiplanes are the most common type of a hybrid aerial vehicle in the industry. Basic hybrid unmanned aerial vehicle type that has been developed since the 80s of the twentieth century. The concept of such an aircraft was at first time used in the Bell prototype, "Eagle Eye" for the US Coast Guard purposes accomplishment [1]. Its concept has been developed over more than 10 years by leading aviation corporations and leaders of electronics and high technology domain. Convertiplanes have proven their effectiveness for video surveillance purposes, aerial photography and data collection for cartography, surveying, object searching and monitoring for that flight modes are needed to be changed.

There are vehicles of all sizes and diverse aerodynamic schemes. In particular: quadcopters with tilt propellers, quadcopters with tilt wings, aiplane-type aircrafts with the “whole tilting aerodynamic plane” (Fig. 2a).

a. Tilt-Wing convertiplane «Greased Lightning»



b. Vertical Takeoff and Landing Unmanned Aerial Vehicle prototype model

Fig 2. Unmanned convertiplane «Greased Lightning» as ultimate example of Tilt-Wing aircraft

Basic technology used at “Greased Lightning” aerodynamic plane (Fig. 2b) is an aerodynamic effectiveness that can be achieved in its “cruise” configuration. Electric engine on each prop satisfies the need for actuating shafts and conjunctions that are providing this aircraft configuration with distributed electric movement. Such design is developed for usage of the hybrid electric drive that includes small diesel engines, that are setting in motion alternating current generators to supply energy for the electric motor and to charge an onboard accumulator system.

Batteries provide power increase required for vertical takeoff and landing, as well as hanging. Many other new structural elements have been built in, such as hinged propellers to minimize drag when not in active use, so propulsion efficiency can be almost ideal in both “helicopter” and “airplane” flight conditions [2].

Vertical takeoff/landing aircrafts with engine fixed in one plane. The cheapest "compromise" type of hybrid aircraft is, in fact, a full-fledged hybrid of aircraft and helicopter types. It is an aircraft with propellers attached to the wings for vertical takeoff and landing. This design eliminates influence of the inertia moment on the rotary mechanism of the screw and completely solves the problem of limited reliability of this unit. However, such propeller arrangement affects the aerodynamic characteristics of the aircraft significantly and also increases fuel loss compared to similar “plane type” aircraft. The location of the engines also importantly affects device load capacity and its design rigidity. Such devices are used mostly for the delivery of small cargos, or for surveillance, aerial photography, or patrol purposes. Usually such aircrafts have small and medium size, when the impact of aerodynamics on the behavior of such structures is not so significant and can be offset by increased engine power and making minor changes to the power structure of the aircraft [3].

The prospect such aircraft usage to deliver larger loads, as well as the prospect of aerotaxi development, stimulated the design of such aircraft by integrating engines into the main powertrain design, such as placing engines inside the fuselage and wings to improve aerodynamic performance. Such integration is reflected in the “Trifecta” and “Accendance” unmanned aerial vehicles. Such schemes have a positive effect on the aerodynamic characteristics of the aircraft, can reduce fuel consumption and contribute to the creation of a more rigid structure, more stable behavior of the aircraft. Such improvements make it possible to transport larger loads and even people on board. The downside of such schemes is significant increase in the cost of production and maintenance of such devices, as well as increased impact of integrated engines vibration on the power structures that interact with them.

Also, the “Fixar” device could be added into the list that is built according to the original scheme with fixed screws mounted on inclined planes. In the future, such solution may be used in large devices.

In general, design of devices with fixed motors can differ significantly from each other. The versatility of the devices allows use of completely different schemes of plumage, wing placement, power structures etc.

Hybrid unmanned aerial vehicle of such scheme was suggested by the “Accendance” company for the aerotaxi purposes.

“Tailsitter”. A hybrid aircraft type that can take off and land vertically. Today it is the most promising type of unmanned aerial vehicle of hybrid type. Due to the smaller number of mechanical components compared to a

conventional convertiplane or autogyro, simpler engine design than vertical takeoff and landing vehicles, less weight of the entire structure, and less impact of moment of inertia when moving from one plane to another, this type of device has a wider range promising areas of implementation than hybrid designs of other types. Such devices have already established themselves as reliable means of delivery. Today, such aircraft are being tested to perform meteorological sounding tasks, as well as air taxis etc.

The tailsitter design is based on vertically placed aerodynamic elements and fixed engines, which are placed horizontally. Most of the existing aircraft and promising projects are designed according to the tailless and flying wing scheme and may vary according to the number of aerodynamic planes that can be installed in different quantity and in variable structure. Additionally, to the usual "tailless" and "flying wing" scheme, there are examples of bi- and triplanes, "three-pointed star", quadrofoil (quadroplane), inclined hexacryl (drone Amazon Prime).

Rotary motors placed on the nose of the structure, on its tail part, or on basic aerodynamic planes are used as the engine. Some designs (DelftAcopter [4]) have smaller auxiliary motors to adjust the position of the device on a plane perpendicular to the main.

"Autogyro". The least popular and least stable type of hybrid unmanned aerial vehicles. Like its manned counterpart, unmanned autogyros remain a niche commodity and are now used to monitor objects and weather, and also as coast guard support devices and cargo delivery units. The type of autogyro for spraying chemicals in the fields can be singled out. The size of the aircraft varies from medium to large, but almost no small aircraft are used.

Autogyro designs are based on the presence of a propeller, the position and number of propellers may vary, as well as the number of aerodynamic planes and their position. For example, in addition to the standard concept of autogyros with a propeller and a push propeller between the usable volume compartment and the tail, or a propeller located at the front, two propeller concepts are developed as variant of the convertiplane scheme.

Recently, unmanned autogyros have been tested as couriers and assistants in the agricultural sector. Such tasks match the best to design features of autogyros. The possibility of autogyro development for use as an unmanned aerotaxi is also considered — an industry for which the design of autogyros and the possibility of safe landing, even with a failed engine, is the most suitable feature.

But the relative instability and design features of autogyros significantly limit their use. Compared to other types of hybrid aircrafts developed by dozens of aviation companies around the world, quantity of companies that develop autogyros is minor.

"Gyrotrak". A separate type of hybrid unmanned aerial vehicle design based on the Gyrotrak platform that combines principles of autogyro and helicopter. The scheme is developed by Airial Robotics GMbH (Germany). The structure consists of bearing propeller and two pusher propellers located on the sides of the wing. In general, the model has a scheme that is more typical for helicopters, in particular, a pronounced tail with a V-shaped plumage at the end [5].

According to the designers, the autorotation of the propeller should provide energy savings and increased flight safety level, as well as range and autonomy of action, compared to multicopter systems. UAVs are also able to hang as helicopter does [6].

Hybrid UAV type has such benefits: does not require a catapult or runway for takeoff. It can be launched from the ground from relatively small areas, or hidden areas with difficult access; has a speed and range similar to airplane type aircraft; has the maneuverability of helicopter-type aircraft and has the ability to hang in the air; universal switching from one flight mode to another in a few seconds, which can allow such aircraft to perform several tasks simultaneously; flexibility of work; does not require a full-fledged chassis.

Along with the obvious advantages of hybrid UAVs also have a number of disadvantages: more complex design, compared to aircraft and helicopter type; lower reliability than airplane and helicopter types due to suppression of the inertia moment during the transition of engines from mode to mode; less time in the air than in aircraft with similar dimensions and characteristics; higher production cost than airplane and helicopter types; higher maintenance price of hybrid devices.

As a result of the last two points, it is risky to use such aircraft for tasks with an increased risk of device damage, or its loss. To reduce risk factors, it is necessary to ensure effective adjustment of UAVs on time. The importance of this adjustment is increasing due to the fact that the long-term use of hybrid unmanned aerial vehicles involves their widespread use for emergencies, accidents at infrastructure, data collection for mapping and photo and video data collection purposes. It is for such tasks that the automatic adjustment of the position of the unmanned aerial vehicle in space is especially important.

Hybrid unmanned aerial vehicles at limited space. In many cases, a significant additional factor to consider is the limited space in which UAVs move. Adjusting the position in confined spaces is necessary for unmanned aerial vehicles to perform procedures and tasks that require extreme precision due to the importance of the task or the risk of damage to the aircraft.

Under the definition of limited space specified area limited with physical obstacle, energetical or optical defense devices or limited by the special program tool in the aircraft that accomplishes some mission software is understood. Aircraft design factors may also limit the possible space: the range of the signal controlling the flight of the unmanned aerial vehicle and the amount of fuel that the aircraft can take on board at departure.

Thus, the concept of physically limited space includes the terrain and objects in the flight path of an unmanned aerial vehicle. A promising method of studying physically confined space is computer modeling of its most important components. During the modelling process, it is necessary to consider several types of physical space constraints to demonstrate the versatility of the use of unmanned aerial vehicles and possibility of its operation during the different scale task performance.

HYBRID UNMANNED AERIAL VEHICLE USAGE ALGORYTHM

The usage of universal hybrid type UAVs makes it possible to respond as quickly as possible to unforeseen events and perform high-precision tasks over long distances. In addition to responding to emergencies, such UAVs can be used to refine the positioning of objects at a great distance from the operator. A promising area of application is also operations for which it is important to cover a large area and identify objects in the area that require high accuracy of location, and description of specific design features.

But for the successful solution of all these problems it is necessary, first of all, to ensure high-precision positioning of the hybrid UAV.

Summarizing the information provided in the specific literature, we can propose the following structure of the hybrid UAVs usage to solve following problems:

- definition of an approximate object location;
- UAV takeoff to the destination point in the “airplane” mode;
- arriving to the destination point and object localization in general;
- transition to the helicopter mode;
- detailed positioning data compilation;
- receiving information about the status and specification of the required object construction with enhanced level of the information certainty;
- an opposite transition to the “aircraft” mode;
- returning to the initial base point.

The proposed structure was used in the test implementation of the hybrid UAV exploitation scenario for the certain part of the area mapping task performing.

HYBRID UNMANNED AERIAL VEHICLE TEST SCENARIO

The small VTOL Freeman 2300 aircraft, one of the most affordable hybrid unmanned aerial vehicles in the world, was selected as a test vehicle example [7]. The main characteristics of this aircraft are that it is built according to the vertical takeoff and landing scheme, it is adapted for the use of onboard cameras, it can carry up to 1.5 kg payload, which is sufficient for the installation of professional equipment for photo and video data collection, mapping and positioning mission accomplishment. Such aircrafts can be situated on limited landing zone. Starting complex, special tools or the runway availability nonobligatoriness for such unmanned aerial vehicle is a significant benefit. Aircraft starting procedure can be done without additional staff interference, also, proximate operator eye control during the whole start procedure is not necessary. Operator can be located elsewhere and monitor the behavior of UAVs by on-board video cameras and sensors that are also on board the device.

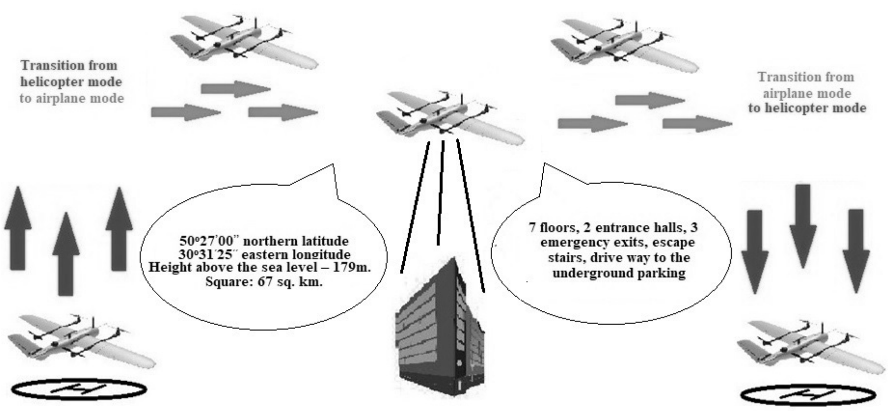


Fig. 3. The scheme of an approximate flight scenario of a hybrid unmanned aerial vehicle for future construction of a house 3D model and its exact positioning on the map

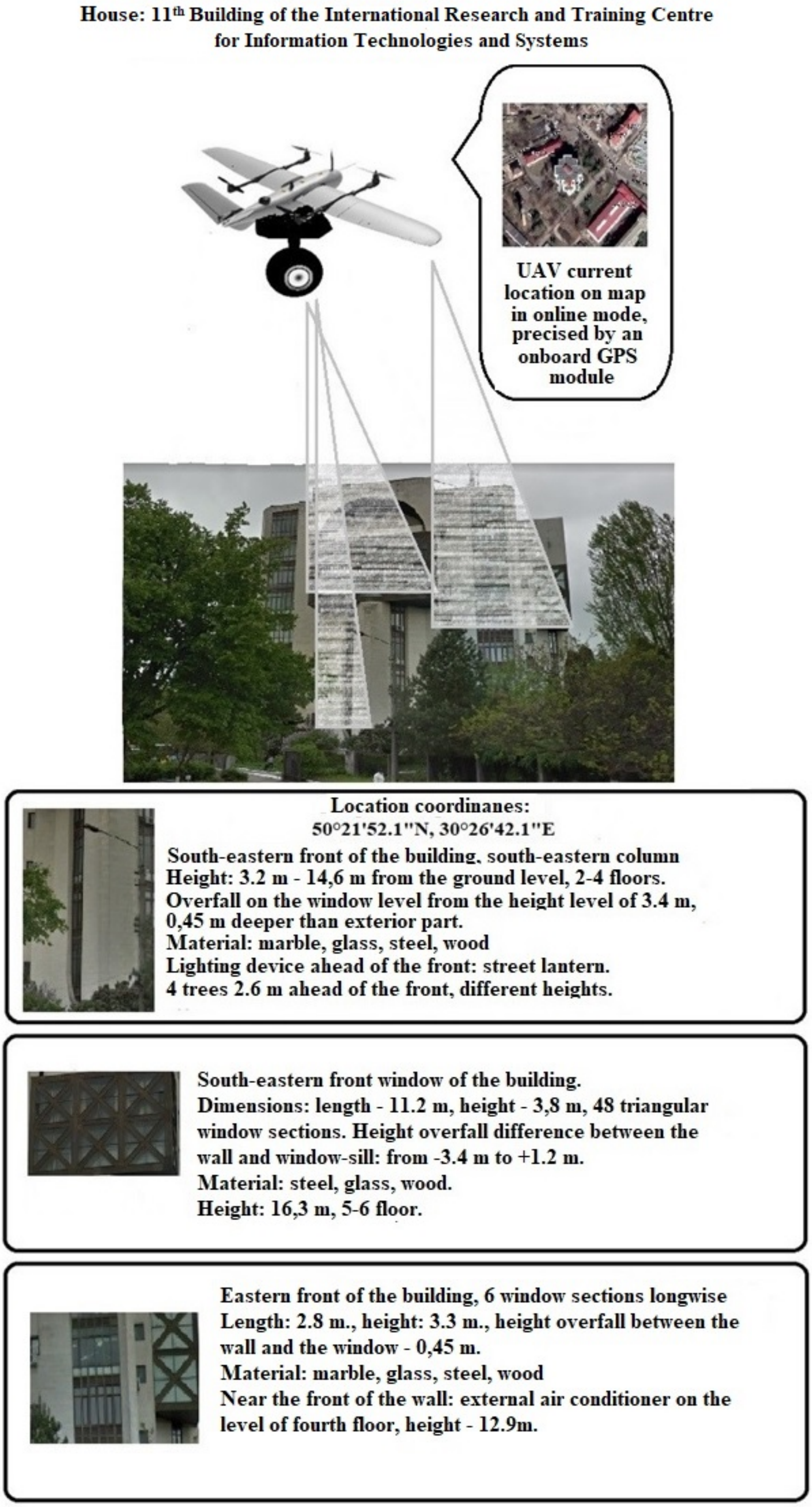


Fig 4. Unmanned Aerial Vehicle information gathering for the purpose of following house 3D model construction

During the tests a UAV flight with a mapping misson at the point 50 km from the aircraft start point has been simulated (Fig 3). Construction of the landscape map includes detailed reference to coordinates with inaccuracy value not more than 1m (that is certain enough correspondingly to the available landscape maps) and mapped landscape area 3D model construction.

The aircraft was operated from a control station located near the take-off point. Departure took place vertically from the base and at an altitude point around 800 m above the ground the aircraft switched to horizontal “airplane” flight mode. The transition from one mode to another took 8-10 seconds, which allows you to do it with an accuracy of 1-2 meters in height. The altitude stabilization mode made it possible to return to the exact height of 800 m at the end of the transition maneuver. With the help of additional helicopter propellers that action does not affect the horizontal flight, the position was adjusted to the course without changing the plane of flight. The software adjustment was carried out by obtaining updated information from the autopilot, which aims to optimize the flight path of the UAV and is based on the method of managing the full unmanned aerial vehicle energy. The use of software and hardware complex of the control system of unmanned aerial vehicles has detailed and optimized the redistribution of the aircraft energy [8]. It also made possible to reduce the error of information perception during the collection data on photo and video equipment installed on board the aircraft. When the aircraft approached the measurement site, the hybrid UAV again switched to "helicopter" response mode and "hung" in the air to clarify the positioning of objects and the device itself during the necessary data receiving process. An example of data collection to clarify the particular object positioning for further 3D model construction and clarifying its location is represented on Fig. 4.

ANALYSIS OF TEST RESULTS

One of the important advantages of hybrid UAVs is that in presence of terrain differences, such a device can measure with high accuracy the difference in altitude and the type of obstacle in the vision area of the onboard cameras. If such measurements are required, the overflight device can switch to helicopter mode and study the required object in detail at close range. Detailed flight of the selected object and data collection from all possible points allows building a high accuracy model of any selected object. Additionally, emergency sensors help to avoid contact with obstacles and to protect the aircraft from unwanted damage.

A critical advantage of hybrid aircraft usage is that high-precision positioning makes it possible to operate such an unmanned aerial vehicle in fully autonomous mode, and the presence of an autopilot with virtual control of course, pitch and yaw in both modes significantly reduces deviation from the specified route [9]. During the work in autonomous mode, the aircraft can perform the task of collecting photo and video information independently on a pre-programmed route (Fig. 5). In case of obstacle appearance that has not been previously described during the construction of the route, the aircraft is able to build the adjusted route and enter information about its change in the system. Thanks to a combination of both aircraft and helicopter capabilities, a hybrid unmanned aerial vehicle can also perform a detailed study of the objects assigned to the study.

At the same time, upon completion of a study, a hybrid unmanned aerial vehicle can return to general site monitoring till the next target object appears, which requires a detailed study and construction of an accurate virtual model based on the collected data. At the same time, the refinement module and the system for adjusting the position of the unmanned aerial vehicle in space will provide it with the most optimal flight trajectory between objects, as well as reduce energy consumption compared to other examples of unmanned aerial vehicles.

From the aforesaid, it can be concluded that the presence of such a combination as a high-precision positioning device and a hybrid unmanned aerial vehicle makes it possible to study in detail the hard-to-reach places on the Earth's surface. Such as, for example, the interiors of houses, deepening quarries, caves and mines, large-diameter pipelines, reservoirs, tunnels and power grids, forests and agricultural land.

Thus, such unmanned aerial vehicles with an installed unit of positioning precision and adjusting the position of the aircraft in space are indispensable for mapping, data collection from the state of individual buildings, accounting for architectural management, creating models of functioning and development of cities, transport models, control the state of infrastructure facilities. It is also possible to perform tasks in response to emergencies; accidents, fires, evacuations from closed premises. It is also important to make a detailed assessment of losses and ways to reduce them when heavy equipment cannot access the required areas. It will also be easier to comprehensively assess the factors that have led to such emergencies and ways to prevent them.

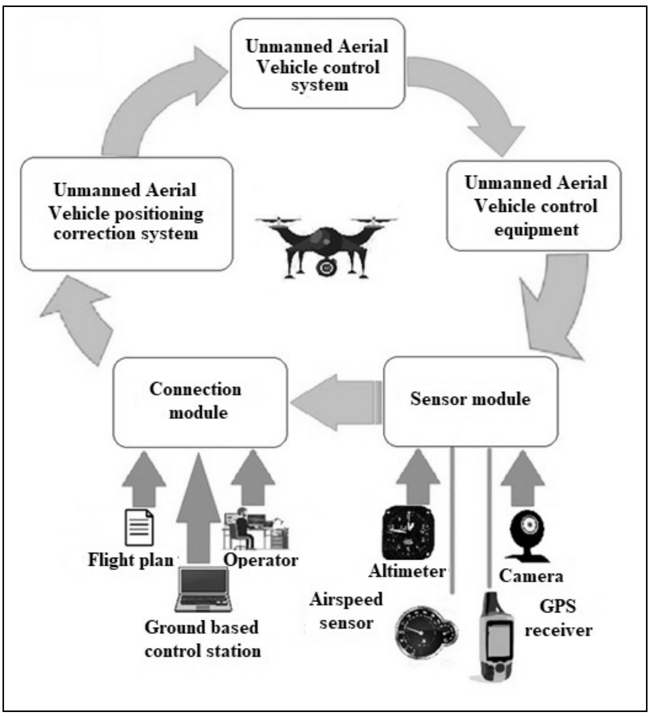


Fig. 5. Scheme of Unmanned Aerial Vehicle with positioning in space correction system working process.

USAGE PERSPECTIVES

Thus, it can be concluded that usage of unmanned aerial vehicles for such tasks is quite justified at this stage of development of observation methods and technologies. Satellites, helicopter and aircraft UAVs, and ground equipment can be used for the described positioning scenarios. Each of these technical measures is characterized by its specific scope, has its advantages and disadvantages.

Thus, satellites are used for general mapping of the area with relatively low accuracy and little attention to detail and conditional accuracy of coordinates. The quality of the satellite image is insufficient without external intervention and clarification by above-ground photography. Therefore, maps obtained by the help of satellites can only be used as a starting point for data collection by unmanned aerial vehicles. Additionally, satellite systems can serve as consumers of updates collected by unmanned aerial vehicles. The disadvantage of satellite technology is that such technology is complex, and as a result, too expensive to be fully used for mapping and clarifying locations and objects, creating models.

Another technological solution involves data collection by unmanned aerial vehicles of helicopter and airplane types. Such solution is very popular now, but lacks the versatility that hybrid drones can offer, including vertical takeoff and landing vehicles and “tailsitters”. These tools can offer increased required data collection accuracy about points and obtaining more information about the same area. The versatility of this concept of obtaining information about the area allows you to reduce the number of aircraft required to collect data from a particular area. It also reduces the number of departures required to maintain accuracy that is several times higher than what modern systems can offer today. Additionally, it is possible to reduce area size required for deployment of the complex, storage of equipment and take-off and landing procedures accomplishment.

Proposed approach usage advisability techno-economical feasibility. The proposed approach is not only determined by scientific novelty, has technological advantages, but also is justified economically.

According to available data, one Freeman 2300 VTOL aircraft with a set of on-board cameras and a suspended camera with 360-degree image coverage is needed to deploy one mapping system that could cover up to 160 km around the landing zone. The range of device prices can vary from $ 1,000 to $ 15,000 depending on the type of onboard equipment. Extended control station for the device, which can cost up to $ 7,500, GPS-tracker for $ 150–350. Totally, the cost of a complex consisted of one device for object monitoring located within a radius of 80 km is $ 23,000 [10]. Such amount is significantly less than the usual price of the equipment used for surveillance purposes at present. For example, the cost of aircraft photography and mapping system with less versatility of the system are often several times higher. And the cost of military drone implementation on the market is 10–12 times higher. If we also taking into account price of participation in global space programs, such numbers would differ from the complex presented here by thousands of times.

Along with a significant price reduction, proposed approach will ensure high-precision system operation. Modern equipment usually involves usage of space technologies and ground-based refinement systems. Due to the GPS-tracker installation and use of high-quality photographic equipment, positioning objects accuracy on the map can be increased by 1 to 10%, depending on the type of object, which is a significant clarification compared to the techniques used to solve most cartographic tasks today. Additionally, technology will be perfect enough to obtain accurate data to create a 3D model of objects. All this will be a significant step towards creation of accurate 3D models of cities, which in turn will improve the prevention of emergencies, facilitate tasks of general planning, development of certain areas, functioning of sewerage systems and public transport etc.

CONCLUSION

Hybrid unmanned aerial vehicles are the most promising tools for positioning, mapping, monitoring and modeling. The design of such aircraft makes it easier to maneuver in space and explore hard-to-reach objects.

The position adjustment system, especially in limited spaces, can ensure the safety of such an aircraft both at high speeds when operating in "airplane" mode and during the "helicopter" flight in dangerous proximity to the object that needed to be investigated.

Adjusting the position of the UAV in space is possible only by accurately calculating its location and using the positioning refinement module. This increases not only the accuracy of location calculation, but also the accuracy of observated object coordinates determination. Main domains of this complex improvement are ensuring high accuracy of data collection and positioning of the object under investigation, flexibility in the use of different types of data and the ability to use the complex to perform tasks of different scales simultaneously.

The paper contains an example of a hybrid aircraft flight scenario and shows the possibility of its application for tasks requiring different speed modes, different ranges of observation tasks, data collection simultaneously for several purposes that can be located at considerable distances from each other and perform general observation tasks by location area paralelly.

It proves that usage of modern hybrid aircrafts can be completely autonomous, safe, and have quite large working time periods. It may allow you to collect detailed information and cover a larger area / perform fewer flights than during the usage of other UAV types. Also, the use of such systems will optimize the performance of tasks of different directions, reduce the number of different unmanned aerial vehicles to perform different types of tasks and, at the same time, increase the accuracy of any type of tasks related to positioning, surveillance, delivery etc.

REFERENCES

1. FAS Intelligence Resource Program. Eagle Eye UAV. URL: https://irp.fas.org/program/collect/eagle-eye.htm
2. Flores Reyes A., Flores Colunga G.R. Design and Development of an UAV with Hybrid Flight Capabilities. Leon, Guanajuato, Mexico, 2018. URL: https://cio.repositorioinstitucional.mx/jspui/bitstream/1002/800/1/17444.pdf
3. Saeed A.S., BaniYounes A., Cai Ch., Cai G. A Survey of Hybrid Unmanned Aerial Vehicles. *Progress in Aerospace Sciences Journal*. Oxford, United Kingdom, 2018. Vol. 98, pp. 98–105. https://doi.org/10.1016/j.paerosci.2018.03.007
4. delftAcopter: innovative single-propeller hybrid drone URL: https://tudelftrobotics-institute.nl/robots/delftacopter

5. Douglas A. Airial Robotics develops “new type” of UAV for global commercial drone market. Commercial Drone Professional website. 2020. URL: https://www.commercialdroneprofessional.com/breaking-news-airial-robotics-develops-new-type-of-uav-for-global-commercial-drone-market/
6. Barskiy R. Gyrotrak: brand new hybrid UAV concept. *Science and technic*. 2020. URL: https://naukatehnika.com/gyrotrak-novaya-gibridnaya-koncepcii-bespilotnikov.html
7. Makeflyeasy Freeman 2300 Tilt VTOL Aerial Survey Carrier Span Fpv Rc Fix-wing Model drone Wing 2300mm UAV mapping Long range pryce. URL: https://www.uavmodel.com/products/makeflyeasy-freeman-2300-tilt-vtol-aerial-survey-carrier-span-fpv-rc-fix-wing-model-drone-wing-2300mm-uav-mapping-long-range
8. Grytsenko V.I., Volkov O.Ye., Komar.M.M. et al. Modern unmanned aerial vehicle automatic control systems intellectualization. *Cybernetics and Computer Engineering,* 2018, № 1(191), pp. 45–59. URL: http://kvt-journal.org.ua/834/ (in Ukrainian)
9. Volkov O.Ye., Grytsenko V.I., Komar M.M. et al. Integral Adaptive Autopilot for an Unmanned Aerial Vehicle. *AVIATION: Scientific journal: scientific article*. Vilnius, Lithuania, 2018. Vol. No 22. pp. 129–195.
10. Makeflyeasy Freeman 2300 Specification & Options URL: https://aliexpress.com/item/10000223137957.html

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ЛІТЕРАТУРА

1. FAS Intelligence Resource Program. Eagle Eye UAV. URL: https://irp.fas.org/program/collect/eagle-eye.htm
2. Flores Reyes A., Flores Colunga G.R. Design And Development Of An Uav With Hybrid Flight Capabilities. Leon, Guanajuato, Mexico, 2018. URL: https://cio.repositorioinstitucional.mx/jspui/bitstream/1002/800/1/17444.pdf
3. Saeed A.S., BaniYounes A., Cai Ch., Cai G. A survey of hybrid Unmanned Aerial Vehicles. *Progress in Aerospace Sciences Journal*. Oxford, United Kingdom. 2018, Vol.98, pp. 98–105. https://doi.org/10.1016/j.paerosci.2018.03.007
4. delftAcopter: innovative single-propeller hybrid drone URL: https://tudelftroboticsinstitute.nl/robots/delftacopter
5. Douglas A.Airial Robotics develops “new type” of UAV for global commercial drone market. Commercial Drone Professional website. 2020. URL: https://www.commercialdroneprofessional.com/breaking-news-airial-robotics-develops-new-type-of-uav-for-global-commercial-drone-market/
6. Р. Барський Gyrotrak: новая гибридная концепции беспилотников. *Наука и техника,* 2020. URL: https://naukatehnika.com/gyrotrak-novaya-gibridnaya-koncepcii-bespilotnikov.html
7. Makeflyeasy Freeman 2300 Tilt VTOL Aerial Survey Carrier Span Fpv Rc Fix-wing Model drone Wing 2300 mm UAV mapping Long range pryce. URL: https://www.uavmodel.com/products/makeflyeasy-freeman-2300-tilt-vtol-aerial-survey-carrier-span-fpv-rc-fix-wing-model-drone-wing-2300mm-uav-mapping-long-range
8. В.І. Гриценко, О.Є. Волков, М.М. Комар, Ю.П. Богачук. Інтелектуалізація сучасних систем автоматичного керування безпілотними літальними апаратами. *Кибернетика и вычислительная техника*, 2018. № 1(191). С. 45–59. URL: http:// http://kvt-journal.org.ua/834/
9. Волков О.Є., Гриценко В.І., Комар М.М., Волошенюк Д.О. Integral Adaptive Autopilot for an Unmanned Aerial Vehicle. *AVIATION: Scientific journal: scientific article.* Vilnius, Lithuania, 2018. Vol. No 22. С. 129–195.
10. Makeflyeasy Freeman 2300 Specification & Options. URL: https://aliexpress.com/item/10000223137957.html

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Бондар С.О., аспірант,
наук. співроб. відд. інтелектуального управління
ORCID: 0000-0003-4140-7985, e-mail: orangearrows@bigmir.net
Шепетуха Ю.М., канд. техн. наук, старш. наук. співроб.,
в.о. зав. відд. інтелектуального управління
ORCID: 0000-0002-6256-5248, e-mail: shepetukha@irtc.org.ua
Волошенюк Д.О., канд. техн. наук,
старш. наук. співроб. відд. інтелектуального управління
ORCID: 0000-0003-3793-7801, E-mail: p-h-o-e-n-i-x@ukr.net
Міжнародний науково-навчальний центр інформаційних
технологій та систем НАН України і МОН України,
40, пр. Академіка Глушкова, м. Київ, 03187, Україна

ВИКОРИСТАННЯ ВИСОКОЯКІСНИХ ІНСТРУМЕНТІВ ПОЗИЦІОНУВАННЯ ДЛЯ АВТОМАТИЧНОЇ КОРЕКЦІЇ ГІБРИДНОГО БЕЗПІЛОТНОГО ЛІТАЛЬНОГО АПАРАТУ В УМОВАХ ОБМЕЖЕНОГО ПРОСТОРУ

Вступ. Для виконання завдань з різною кількістю різномасштабних підзавдань ефективно використовують клас так званих гібридних безпілотних літальних апаратів (БпЛА). Безпілотні літальні апарати такого класу мають низку переваг, зокрема використання таких транспортних засобів для цілей, що завжди виконуються кількома різними виконавцями, які часто навіть не зв’язані між собою. Проводиться спроба виконати аналіз перспективи уточнення місцезнаходження досліджуваного об’єкту для різних завдань, які можуть виконуватися безпілотними літальними апаратами.

Метою статті є універсалізація процесу спостереження, збору фото- та відеоданих та інших завдань, які сьогодні забезпечують безпілотні літальні апарати. Процес визначення точності даних протягом окремих періодів виконання місії та підвищення специфікації основних цілей місії може започаткувати абсолютно нову сферу використання безпілотних літальних апаратів та підштовхнути розвиток абсолютно нових напрямів застосування безпілотних літальних апаратів. Комплексний збір даних виключає наявність додаткових посередників і міг би спростити процедуру оброблення даних на наступних етапах операції, а також забезпечувати набагато точнішою інформацією потенційних споживачів даних картографування, геолокації, диспетчеризації та універсуалізувати джерело отримання інформації для них.

Результати. Сценарій використання саме гібридного безпілотного літального апарату та його реалізація в 3D середовищі можуть слугувати гарним прикладом виконання універсальної багатоланкової задачі з різним масштабом дистанцій для кожної окремої ланки. Такий сценарій об’єднує кілька інформаційних місій різного масштабу і може надати дані для кількох центрів оброблення даних, які можуть використовувати їх для розв’язання різних завдань лише під час одного польоту. Також це доводить, що використання такого апарату з додатковим бортовим уточнювальним блоком може стати наступним витком розвитку галузей оцифровування даних та картографії. Фінансовий аналіз ринку надається для демонстрації того, що така гібридна авіаційна комплексна система забезпечить виконання завдань різного масштабу, точніше опрацює деталі об’єкту-цілі і водночас буде значно дешевшою за наявні системи картографування та спостереження.

Висновок. Потреба в оптимізації деяких завдань, які могли б виконувати безпілотні літальні апарати, привела до впровадження гібридних транспортних засобів, наданих/описаних/проаналізованих в роботі. Складна конструкція такого літального апарату може бути побічним недоліком, але вплив використання гібридного БпЛА для виконання різних завдань оптимізує набагато більше процесів, скоротить витрати на побічні пристрої і обладнання, що потрібно для великого переліку завдань у кожній галузі, де використовуються БпЛА сьогодні, від спостереження та аерофотозйомки до сільськогосподарських та військових завдань. Модель універсальної гібридної безпілотної літальної системи різного масштабу є доказом можливості використання лише одного літального апарату для виконання складної місії, яка потребує різного набору можливостей, функцій та обладнання. Також такі літальні апарати могли б забезпечити набагато точніші і місткіші дані за результатами виконання місій за рахунок менших матеріальних витрат. Подальші розроблення допоможуть отримати інформацію про найефективніший тип гібридного БпЛА для місій такого типу і сформулювати абсолютно нові постулати в галузях процесів цифровізації та спостереження, використовуючи новий спосіб збору інформації.

Ключові слова: *безпілотний літальний апарат, гібридний апарат, позиціонування, багатоцільовий політ.*