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Some Conditions and Factors Affecting the Creation of Signal Relay Facilities Based on Unmanned Aerial Vehicles

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Abstract. *The article was developed as part of a scientific study on the topic of the program: IRN BR21882279 «Development and manufacture of a small-sized communication repeater based on an UAV to increase the range and stability of communication». The authors explore the conditions and factors influencing the development and creation of signal relay facilities based on unmanned aerial vehicles (UAVs). A brief analysis of the technical, operational and regulatory requirements for such systems, as well as examines the impact of various conditions on their effectiveness and capabilities is also considered. Some types of aerodynamic layouts of drones used by developers as an aerial platform for a communication relay payload are considered, a brief assessment of the positive and negative properties of UAV platforms is carried out. The work has practical value for developers and users of UAV-based relay systems, as well as for specialists in the field of communications and telecommunications.*

Keywords: *unmanned aerial vehicle (UAV), communication repeater based on UAV, communication networks, drones, ground stations, electronic warfare, communication channel, signal frequency.*

Introduction. In recent years, unmanned aerial vehicles (UAVs) have been widely used in various fields of human activity, including telecommunications. UAV-based communication relay systems ensure the expansion of the coverage area of mobile and radio networks, data transmission in the absence of ground infrastructure and the organization of communications in emergency situations related to the elimination of the consequences of natural disasters, accidents and destruction at hazardous facilities. An important area of application of such systems is their use in the organization of communication and control systems during the period of special operations by law enforcement agencies or the conduct of military operations by groups of troops (forces) in conflict zones.

To create effective and reliable UAV-based relay systems, it is necessary to take into account a number of conditions and factors affecting their operation. These include the technical characteristics of the UAV, the equipment used, operating conditions and regulatory requirements. In this article, the authors analyze these factors and assess their impact on the effectiveness and capabilities of UAV-based relay facilities [1].

Research methods.

The use of UAV communication repeaters in war zones can be very effective in order to ensure continuous and reliable communication with military (special) units in the territory of active hostilities, where communication signals can be suppressed or blocked due to the actions of electronic warfare systems (EWS) of the opposing side.

Repeater drones can also be used by military and special units to increase the range of control of unmanned aerial vehicles in the depths of the enemy, carry out surveillance and reconnaissance, transmit video and photo-

graphic materials, as well as to coordinate the actions of troops (forces) in the combat zone.

However, it must be borne in mind that the suppression and destruction of communication repeater UAVs can also become an enemy target, therefore it is important to ensure the secrecy of their actions without entering the enemy's visual detection zones or air defense systems, as well as to ensure the confidentiality of the transmitted information. It is also necessary to take into account the possibility of interference in the operation of relay systems by enemy electronic warfare systems.

In general, the use of UAV communications repeaters in war zones can significantly improve communication and coordination of groups of troops (forces), but requires rational planning, ensuring the safety and effectiveness of their actions [2].

A brief overview and comparative characteristics of the main variants of aerodynamic UAV repeater layouts

Currently, there are a large number of communication repeaters based on UAVs on the drone market. They have various tactical, technical and flight qualities, which depend on the variants of aerodynamic schemes used in aerial communication relay platforms, on the characteristics of the payload, the size and layout of the placement of antennas, propulsion systems, power, navigation and other systems on the UAV.

The main variants of the aerodynamic layouts of UAV repeaters are presented below.

Let's consider in sequence the UAV platforms for relaying communications of aircraft, multicopter and hybrid types, their main advantages and disadvantages [3,4].

1. Aircraft type (Figure 1): A fixed-wing glider is used as an aerial platform. Table 1 (compiled by the authors) presents the main advantages and disadvantages of this aerial platform.

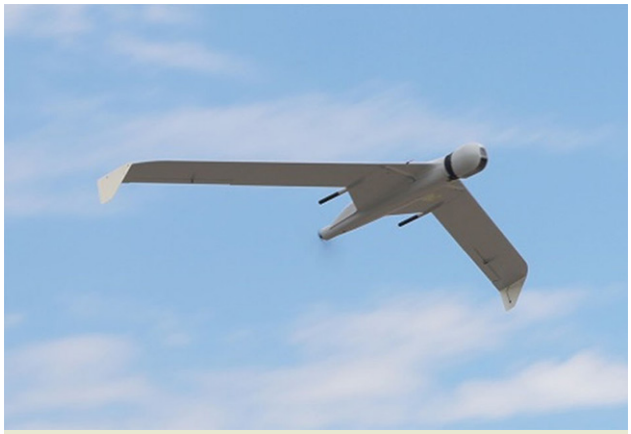

Figure 1 – An example of using an airplane-type UAV as an aerial platform for relaying communications

2. Multicopters (Figure 2): a drone with several propellers is used as an aerial platform (as a rule, from four propellers (quadcopter) and more).

Table 2 (compiled by the authors) presents the main advantages and disadvantages of this aerial platform.

3. Hybrid drones (Figure 3): A VTOL (vertical take-off and landing) drone is used as an aerial platform.

Table 3 (compiled by the authors) presents the main advantages and disadvantages of this aerial platform.

Table 4 (compiled by the authors) provides

Table 1 – Comparative table of aircraft-type UAV platforms

Advantages:	Disadvantages:
High speed and flight range	High cost and complexity of construction
Good stability in flight	For some models, there is a need for a runway
The possibility of equipping with heavy equipment	Limited maneuverability, lack of the ability to «hang» at one point

Table 2 – Comparative table of UAV platforms of multicopter type

Advantages:	Disadvantages:
High maneuverability and hovering in the air	Low speed and flight range
Relatively low cost and simplicity of construction	Low load capacity
The ability to take off and land from restricted areas	Vulnerability to wind

Figure 2 – An example of using a multicopter-type UAV as an aerial platform for relaying communications

Figure 3 – An example of using a hybrid-type UAV as an aerial platform for relaying communications

a generalized comparison of aircraft-type UAV repeaters, multicopters and hybrid drones according to their main characteristics.

Thus, each aerodynamic layout has both positive and negative properties, so developers should take them into account when deciding on the choice of an aerial platform for relaying communications.

Conditions and factors influencing the creation of radio relay facilities based on unmanned aerial vehicles

In the research work [3], the main conditions and factors influencing the creation of signal relay facilities based on UAVs are analyzed. During the study, the conditions and factors described in the works of Kashtanov V.V., Nemtinov V.A. [5], Ananyev A.V., Stafeeva M.A., Makeev E.V. [6], Karpychev V.Yu. [1], Tishkov V.V., Ivanov V.G., Lukyanchik V.N. were considered [7], Ananyev A.V., Ivannikov K.S., Filatov S.V. [2].

The main factors influencing the creation of radio relay facilities based on unmanned aerial vehicles include [3]:

- the high cost of developing and implementing new technologies in this area, the economic opportunities of the manufacturing country and the level of development of domestic enterprises, including the defense com-

Table 3 – Comparative table of UAV platforms of hybrid type

Advantages:	Disadvantages:
Combine the advantages of airplanes and quadrocopters	Higher design complexity than multicopters
Higher speed and range than quadrocopters	Higher energy costs for flight performance
Higher maneuverability than aircraft	Higher cost

Table 4

Characteristics	Aerodynamic layout of the repeater air platform		
	Aircraft type	Multicopters	Hybrid drones
Speed and range	High	Low	Medium
Load capacity	High	Low	Medium
Maneuverability	Low	High	Medium
Cost and complexity	Medium	Low	High
Stability	Good	Moderate	Medium
Hanging	No	Yes	Yes
Runway requirements	Yes (except for those launched from launchers)	No	No (or short)

plex, the availability of specialists and scientific results in the development of UAV components and systems and radio relay equipment;

- limitations on the possibilities of placing radio relay equipment on board a specific type of UAV, related to the weight, size and energy characteristics of the UAV and payload;

- the existing difficulties in the compatibility of radio communication systems in the Armed Forces, other troops and military formations of the Republic of Kazakhstan, especially when they work together in emergency situations and when martial law is imposed on the territory of the Republic of Kazakhstan;

- the negative attitude towards unmanned aviation in Kazakhstan society as a whole due to the existing cases of UAV invasion of privacy, expressed in aerial videography of real estate, etc.

- the existing negative attitude in the state military and special bodies towards the field of UAVs due to the frequent cases of UAV flights of various types in the area of specially protected and important state facilities;

- existing restrictions on the use of unmanned aerial vehicles in peacetime related to the legislation and regulatory legal acts of the Republic of Kazakhstan.

Summary

Based on the analysis of the above-mentioned types of UAV repeaters, it was revealed that there are a number of advantages and disadvantages in each type of UAV used as an aerial platform for relaying radio communications. However, taking into account the requirements for the repeater, the most preferred type of UAV is a tethered quadrocopter-type UAV or an airplane-type UAV that does not require specially equipped platforms for takeoff and landing. At the same time, it is preferable to use Tier III standard relay equipment with an operating range of 134-176 MHz, a transmitter output power of no more than 25 watts and a mass-dimensional characteristics of 2-3 kg. An analysis of the VHF signal relay equipment allowed us to conclude that at present the BARYS KZTE-R VHF repeater from BARYS is the most optimal variant of the relay equipment for its further refinement and adaptation for use on both quadcopter and aircraft types of UAVs.

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Ұшқышсыз ұшу аппараттарының базасында сигналдарды қайта тарату құралдарын құруға әсер ететін кейбір жағдайлар мен факторлар туралы

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Аңдатпа. *Мақала бағдарламаның ЖТН BR21882279 «Байланыстың қашықтығы мен тұрақтылығын арттыру үшін ұшқышсыз ұшу аппараты (ҰҰА) базасында шағын габаритті байланыс ретрансляторын әзірлеу және дайындау» тақырыбы бойынша ғылыми зерттеу аясында әзірленді. Авторлар ұшқышсыз ұшу аппараттары (ҰҰА) базасында сигналдарды қайта тарату құралдарын әзірлеуге және жасауға әсер ететін жағдайлар мен факторларды зерттейді. Осындай жүйелерге қойылатын техникалық, пайдалану және нормативтік талаптардың қысқаша талдауы, сондай-ақ әртүрлі жағдайлардың олардың тиімділігі мен мүмкіндіктеріне әсері қарастырылады. Әзірлеушілер байланыс ретрансляторының пайдалы жүктемесі үшін әуе платформасы ретінде пайдаланатын аэродинамикалық ұшқышсыз орналасулардың кейбір түрлері қарастырылады, ұшқышсыз ұшу платформаларының оң және теріс қасиеттеріне қысқаша баға берілді. Жұмыстың ҰҰА негізіндегі ретрансляциялау жүйелерін әзірлеушілер мен пайдаланушылар үшін, сондай-ақ байланыс және телекоммуникация мамандары үшін практикалық маңызы бар.*

Кілт сөздер: *ұшқышсыз ұшу аппараты (ҰҰА), ҰҰА базасында байланысты ретрансляциялау жүйесі, байланыс желілері, дрондар, жерүсті станциялар, радиоэлектрондық күрес, байланыс желісі, сигнал жиілігі.*

О некоторых условиях и факторах, влияющих на создание средств ретрансляции сигналов на базе беспилотных летательных аппаратов

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Аннотация. *Статья разработана в рамках научного исследования по теме программы: ИРН BR21882279 «Разработка и изготовление малогабаритного ретранслятора связи на базе беспилотного летательного аппарата (БПЛА) для увеличения дальности и устойчивости радиосвязи». Авторы исследуют условия и факторы, влияющие на разработку и создание средств ретрансляции сигналов на базе беспилотных летательных аппаратов (БПЛА). Проведен краткий анализ технических, эксплуатационных и нормативных требований к таким системам, а также рассматривается влияние различных условий на их эффективность и возможности. Рассматриваются некоторые типы аэродинамических компоновок беспилотников, используемых разработчиками в качестве воздушной платформы для полезной нагрузки ретрансляции связи, проведена краткая оценка положительных и отрицательных свойств БПЛА-платформ. Работа имеет практическую ценность для разработчиков и пользователей систем ретрансляции на базе БПЛА, а также для специалистов в области связи и телекоммуникаций.*

Ключевые слова: *беспилотный летательный аппарат (БПЛА), ретрансляция связи на*

базе БПЛА, сети связи, дроны, наземные станции, радиоэлектронная борьба, канал связи, частота сигнала.

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