ELECTRONICS

UDC 576.3(045)
DOI:10.18372/1990-5548.86.20563

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UNMANNED CONTROLLED COMPLEX FOR HIGH-QUALITY COMMUNICATION IN CONTEMPORARY EXTREME MEDICINE

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Abstract*—The general analysis was done of requirements for communication during of medical doctors work in extreme conditions, including locations of military activity. The tasks were determined – it was the need to create reliable stable mobile communication for their work; in the locations where there is no coverage, such communication can be organized using drones, and formation of complex of drones and ground base stations. So, the purpose was stated - to find solutions how to develop technologies to ensure high-quality communication with the use of unmanned aerial vehicles in extreme conditions in Ukraine. Numerous prototypes, including patents, were examined and analyzed. Several different schemes for organizing of mobile communications in cases where conventional wireless networks are vulnerable were observed (due to military operations, natural disasters, extreme situations). We have described some possibilities for the restoring of communications using a number of technological solutions based on the use of drones in extreme conditions. The possibility of software or hardware tools for replacing fixed base stations in wireless network with unmanned aerial vehicles were observed. It was proposed to use such tools in two ways: 1) either temporarily to replace fixed base stations with unmanned aerial vehicles; or 2) on permanent basis, f.e., in geographical locations where the terrain makes it difficult to place fixed base stations (impossible due to dangers of military operations, extreme situations, etc.) Such solutions can help to minimize also great damages of the war to our medicine, agriculture, nature in general.*

Keywords—Unmanned aerial vehicle; drone; construction; wireless networks; mobile communication; extreme medicine.

I. INTRODUCTION

In the Air Code of Ukraine, an unmanned aerial vehicle (UAV) is defined as a device whose flight control and monitoring are carried out using a special control station located outside the aircraft [1]. The Rules for the Operation of Unmanned Aircraft Complexes of the State Aviation of Ukraine state that an Unmanned Aircraft Complex (UAC) is not only an unmanned aircraft, but also the associated remote piloting points (ground control stations), as well as the necessary lines for operation and control. The complex may include several unmanned aircraft [2]. An unmanned aerial vehicle (UAV, drone) is an aircraft that flies and lands without the physical presence of a pilot on board. As it known, the civilian sphere of UAVs usage includes the following areas: law enforcement activities (patrol, analysis of traffic incidents, monitoring of mass events, tracking of criminals, identifying and eliminating of terrorist threats); monitoring and eliminating of the consequences of emergency situations (estimation of damage, determining the degree of contamination of territories, helping people in hard-to-reach places); medical care (transportation of medicines, blood, transplants, vaccines); functioning of agricultural complexes (monitoring crops, applying fertilizers and pesticides); environmental monitoring (radiation, fire prevention, oil, gas and chemical control); geodesy and oceanology (cartography, monitoring of sea waves, searching of mass aggregations of fish); shipping control (search of ships, monitoring of sea borders and compliance with fishing rules); delivery of wares; building; cinematography; journalism (reports about sports competitions, mass events, war events), and etc. [3] – [8].

II. Problem Statement

The development of technologies for production of various types of UAVs and their application is extremely intensive in our country in recent years. It is clear that the main reason for this is contemporary war in Ukraine, which stimulates both the invention and production of drones and related technologies. First of all, this applies to military technologies related to UAVs, but not only.

The economy of Ukraine has suffered great losses in recent years – cities, towns, fields and forests have been burned, large areas have been mined, which has caused enormous damage to both agriculture and wildlife. Restoring the damage is a large-scale task, and the technologies for using drones for this are able to successfully fulfill this noble mission. Drones technologies can be used in contemporary medicine with great successes too, especially in military field surgery, such work often has to be carried out under extreme conditions; the authors wrote about this in their previous publications [9]. In this sphere, as well as in the agricultural economy, ecology of Ukraine, this means carrying out work in large areas where communication is often absent or damaged. Below we will describe some possibilities for fulfilling the tasks set for the restoring of the communications using a number of technological solutions based on the use of drones in extreme conditions.

The ***purpose*** of this work was to find solutions how to develop technologies to ensure high-quality communication with the use of UAVs in extreme conditions in Ukraine. Such drone technologies can be used in extreme medicine, for the renovation of the contemporary economy of Ukraine, primarily agriculture, and improving of the environmental situation in the country.

The ideas of present work was based on the numerous foreign and domestic works -prototypes in this sphere, including patents [10] – [12]. Among them were the versions of previously developed UAV's modules [10] – [12]. The authors have long-year experience in the solution of some tasks in creation of information technologies for extreme conditions (among them - information systems) [13], development of actual mathematical approaches for such tasks solutions [14] – [16], and etc. Information about wireless and mobile communications, UAV complexes were supplemented from [17] – [24].

III. Problem Solution

A. The idea of using drone technologies for extreme conditions

In general, the idea of using drone technologies in the conditions described above concerns systems and methods for at least one relay drone, which is used to transmit information between the base station and the working drone. It is clear that the formed systems of working drones and relay drones, the system and methods may differ for various types of relay drones. Such drones can be controlled singly or in a group; and also transmit information between the base station and the working drone.

In modern terminology, the notion "drone" includes any unmanned vehicle, UAV, remotely piloted aircraft (AC), and etc. Today, a drone can be called a single- or multi-rotor helicopter (quadcopter, etc.), or a fixed-wing aircraft. Currently, drones are known also in the form of other types of unmanned vehicles (water vehicles, tracked or wheeled ones, etc.).

Constructing a network of repeater drones, then here we can use a set of repeaters (links) between a base station and a working drone controlled by the base station. Repeater drones can amplify the signal of communication channel or communication signal between a base station and a working drone in the network. For example, repeater drones can amplify the communication channel. In this case, they act as nodes that relay the communication between a working drone and a base station. The communication signals at each node are amplified to compensate the decrease in signal strength at a certain distance. Simultaneously this system needs a path with a direct line of sight between the working drone and the base station. Repeater drones and base stations can use a communication protocol to initiate interaction with worker drones and repeater drones.

Base stations and/or relay drones may receive information about the location and then transmit signals in the direction of available worker drones and / or relay drones. Such signals may serve as control signals. These control signals may be transmitted to the available relay drones or worker drones via omnidirectional antenna or directional antenna calibrated to the location of the available relay drones or worker drones. Data signals may be generated in response to the control signal; and in turn they may be intended for reception by the base station. Available relay and worker drones may interact with base stations and / or other relay drones. During such interaction, the information about location may be transmitted so that the base station or relay drones may also send a control (or data) signal to the relay or worker drones. Sometimes a drone can be used as a relay drone (while relaying communications) or as a working drone (with data collection to return to the base station), or as both ones.

Repeater drones can be used to maintain broadband communication between a working drone and a base station, even if the components of such a system are mobile (base station, working drone, repeater drone). This can also happen if there is no direct line of sight between the working drone and the base station (they are separated). In the case of such separation, the communication between the components can be maintained by the repeater drone. In turn, the repeater drone can also be mobile or stationary, maintaining a line of sight connection between the working drone and the base station.

B. A mobile communications network organized with the support of UAVs

Mobile networks can exchange by information (data, including telephony and non-telephony data) between mobile devices, such as smartphones, as well as between devices with fixed location (devices of different types: mobile, computing or telephony ones). Typically, a mobile network unites few geographically distributed fixed radio base stations, each of which serves for a limited surrounding geographic area; such an area is called a "cell" usually. The base stations are often directly connected to each other, and have constant power supply.

The mobile device uses the network to establish a radio connection with the nearest base station or with the base station to which the strongest radio signal can be transmitted. If for some reason the connection with the nearest base station is unavailable, the mobile device can connect to a more distant base station, which is located more distantly. This creates opportunities for the exchange of information between the mobile device and the base station. Mobile communication networks can exchange by various types of information, including emergency calls, or calls to eliminate the consequences of natural disasters, other emergency situations, etc.

C. Vulnerability of mobile networks and the use of UAVs

Practice has demonstrated that mobile networks that include only stationary base stations are quite vulnerable. Such stationary base stations can be destroyed (fully or partially) or disabled as a result of military operations, natural disasters, and other extreme situations.

In order to reduce the vulnerability of conventional wireless networks, the authors are considering the possibility of software or hardware tools to replace fixed base stations in a wireless network with unmanned aerial vehicles. Such tools can be used 1) either temporarily to replace fixed base stations with UAVs; or 2) on a permanent basis, for example, in geographical locations where the Earth surface makes it difficult to place fixed base stations, because this is impossible due to the dangers of military operations, etc. (Fig. 1).

Sometimes such methods allow to be put into service in short periods of time, f. e., in periods like minutes or hours. In some realizations, connections to certain mobile devices may be organized basing on two or more UAVs for further reducing the reliance on fixed base stations. In all such cases abovedescribed techniques and models of information network organization with UAvs usage are quite useful in various practical spheres: medicine, agriculture, nature protection, and so on.

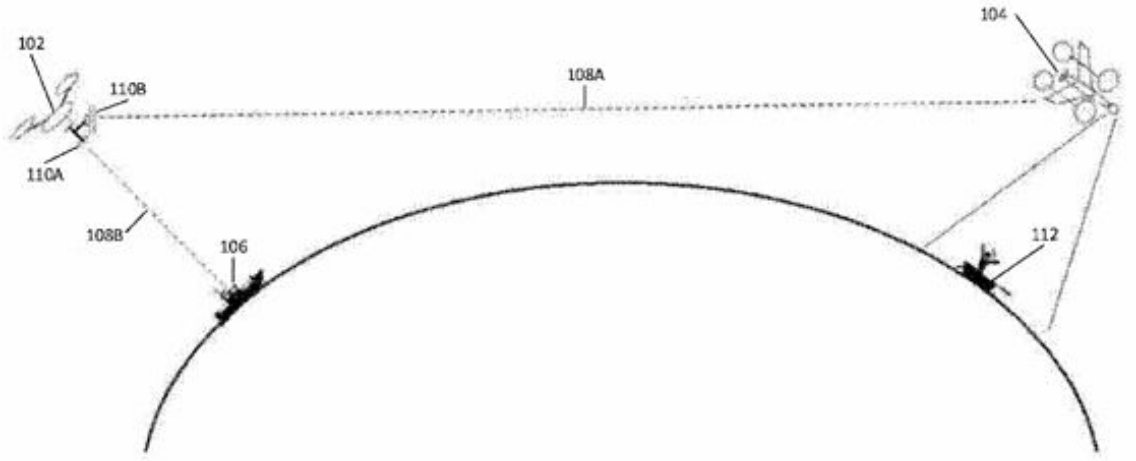

Fig. 1. The system that includes few components: base station, working drone, repeater drone (details see text) [10], [11]

IV. CONCLUSIONS

Several different schemes for organizing of mobile communications in cases where conventional wireless networks are vulnerable were observed in present article; for example, due to military operations, natural disasters, and other extreme situations. In the paper we have described some possibilities for the restoring of communications using a number of technological solutions based on the use of drones in extreme conditions. The possibility of software or hardware tools for replacing fixed base stations in a wireless network with unmanned aerial vehicles were observed. It was proposed to use such tools in two ways: 1) either temporarily to replace fixed base stations with UAVs; or 2) on a permanent basis, for example, in geographical locations where the terrain makes it difficult to place fixed base stations, because this is impossible due to dangers in this area (military operations, other extreme situations, etc.) From our point of view such solutions can help to minimize step-by-step great damages of the war to our agriculture, wildlife, nature in general. Possibility to organize medical care, sometimes surgical operations close to areas of military activity also need organization of reliable high-quality connections – and drones technologies are able to solve these problems too. Restoring the war damages is a large-scale task, and technologies for using drones for this are able to fulfill successfully this noble mission.

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Received August 18, 2025

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В. М. Шутко. Б. Д. Москаленко, О. М. Ключко, Я. Г. Волжин. Безпілотний керований комплекс для забезпечення якісного зв'язку у сучасній екстремальній медицині

Проведено загальний аналіз вимог до послуг зв'язку під час роботи лікарів в екстремальних умовах, включаючи місця проведення військових дій. Були визначені завдання – необхідність створення надійного стабільного мобільного зв'язку для їх роботи; в місцях, де немає покриття, такий зв'язок може бути організований за допомогою дронів, та формування комплексу дронів та наземних базових станцій. Отже, була поставлена мета – знайти рішення щодо розробки технологій забезпечення високоякісного зв'язку з використанням безпілотних літальних апаратів (БПЛА) в екстремальних умовах в Україні. Було розглянуто та проаналізовано численні

прототипи, включаючи патенти. Розглянуто кілька різних схем організації мобільного зв'язку у випадках, коли традиційні бездротові мережі є вразливими (через військові дії, стихійні лиха, екстремальні ситуації). Описано деякі можливості відновлення зв'язку за допомогою низки технологічних рішень, заснованих на використанні дронів в екстремальних умовах. Була розглянута можливість використання програмних або апаратних засобів для заміни стаціонарних базових станцій у бездротовій мережі безпілотними літальними апаратами («БПЛА»). Було запропоновано використовувати такі засоби двома способами: 1) або тимчасово замінити стаціонарні базові станції на БПЛА; або 2) на постійній основі, наприклад, у географічних місцях, де рельєф місцевості ускладнює розміщення стаціонарних базових станцій (неможливо через небезпеку військових операцій, екстремальних ситуацій тощо). Такі рішення можуть допомогти мінімізувати також великі збитки війни для нашої медицини, сільського господарства, природи загалом.
Ключові слова: безпілотний літальний апарат; дрон; конструювання; бездротові мережі; мобільний зв'язок; екстремальна медицина.

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