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Analysis of communication possibilities of UAVs

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Abstract
The research focused on the description of the basic characteristics of UAVs. The UAV is an unmanned aircraft, the current use of which is diverse. The use of UAVs is limited by legislation that is regulated at the national level. Furthermore, the research focused on the description of UAV communication and communication protocols that are used. Communication protocols are directly dependent on the overall equipment of the UAV and its purpose. An important part is also the security of communication to prevent the possible loss of UAVs. The article also describes the communication between RPA and RPS for direct and indirect visibility using satellites.

Key words
communication, UAV, system, signal

Information
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1. Introduction

A UAV is considered a propelled airborne vehicle that does not carry a human operator. It uses aerodynamic forces to lift a device that can fly autonomously or be remotely controlled. Drones are replaceable means of re-use capable of carrying tracking, non-lethal or lethal payloads. Originally espionage and military drone technology has evolved over the last decade has become a commonly used cheap commercial technology, used by, for example, Amazon for delivery of packages [1-3].
This worldwide availability of cheap commercial UAVs along with the proliferation of sophisticated military UAVs leads state and non-state actors in armed conflicts to develop their own UAV capabilities to their tactical, operational, and strategic deployment.

Individual types of UAVs differ according to size, performance characteristics (endurance, range, maximum flight altitude, load capacity), flight speed, function, and purpose. In terms of functions, drones are gradually evolving into multifunctional aircraft. At present, these can still be divided into several categories:

- Objectives and baits - simulating enemy machines or missiles. Reconnaissance, gathering information from the battlefield.
- Combat drones - armed and capable of air attacks even in risky operations.
- Logistic - specially adapted for transport purposes.

Research and development used to develop UAV technologies. Civil and commercial design for specific purposes [3-5].

2. UAV/UAS general information

To better understand UA issues, it is desirable to focus on their classification, basic types, and characteristics. Unmanned aircraft can be classified according to several criteria, such as design, take-off weight, degree of autonomy, range, or size [6].

Most UAs can be divided into two groups in terms of their construction. These are fixed-winged and unmanned drones (multirotor systems). They are much smaller, e.g., hybrid UA or ornithopters. The UA with fixed wings is a designation for unmanned aircraft like traditional aircraft with fixed airfoils, such as gliders. They also use attached wings, which together with the forward movement create the lift necessary to stay in the air without the need for any other type of energy. For this reason, they are more energy-efficient than the second most common group, the UA with rotating wings. At the same time, they can cover even relatively long flight distances and develop a much higher speed. Their main disadvantage is the inability to hover over a particular place because they must be constantly on the move. Related to this is their further shortcoming. As movement is a condition of their flight, their operation requires launching devices and return, which can take up a considerable area [7-10].

UA with rotating wings (multi-copters) is a subgroup of motorized aircraft with rotating airfoils designed to create lift, which includes e.g., even a regular helicopter. Unmanned aircraft from this category are traditionally equipped with 4 rotors, which allow them to move or hover over a specific place, which guarantees them considerable popularity as pilots. On the other hand, this type of UA requires considerable amount of energy for its operation and is quite noisy [11].

Hybrid UAs represent a combination of fixed blades with rotors. The model e.g., Arcturus Jump uses rotors to take off and land and uses fixed wings to fly when it is already in the air.

Ornithopters or winglets are a small group of UAs that do not use rotors or fixed wings but sway surfaces and mimic the flight of birds or insects. The take-off weight is also a very important criterion for UA division. Take-off weight (or simply weight) is extremely important today, especially in the context of European law. States and Regulation No 1 of the European Parliament and the Council 216/2008 on common rules in the field of civil aviation. States also often use weight as the most common consideration for dividing UAs into different groups with different levels of regulation. Great Britain e.g., divides UA into "small, unmanned aircraft" (SUA) weighing up to 20 kg, "light UAS" up to 150 kg, and "UAS" over 150 kg, to which European law already applies. Germany divides UA by weight essentially into groups up to 0.25 kg, up to 2 kg, and over 25 kg. The Czech Republic has even decided to set up 4 UA categories by weight. Specifically, these are small UAs not exceeding 910 grams, up to 7 kg, up to 20 kg, and from 20 kg. EU law applies above 150 kg. The Netherlands divides UA into less than 4 kg, less than 25 kg, and less than 150 kg [12-13].

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3. Methodology

The term communication does not mean only standard voice communication but is basically all communication resp. all data and information transmission that takes place between the aircraft itself and other ground or satellite equipment.

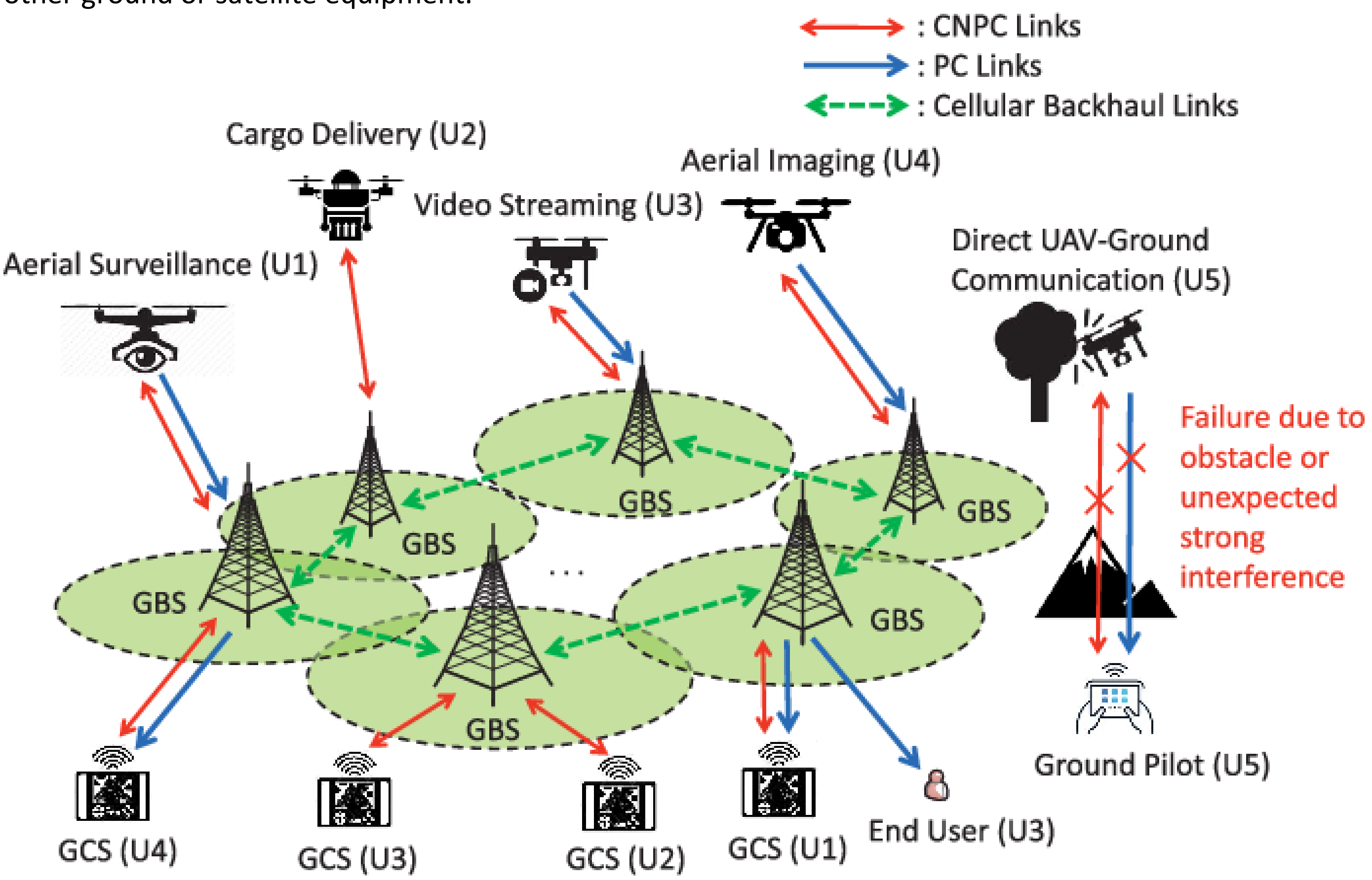

Figure 1. UAV communication [14]

Today's air traffic is very dependent on traditional voice communication, which forms a substantial part of the transmission of very important information. Currently, voice communication is used to pass instructions between air traffic controllers and pilots, is used to pass information to ensure aircraft separation, permitting, meteorological warnings, and much other important information. It helps to ensure safe air traffic and to ensure the continuity of air traffic. However, it turned out that such a classic communication is impractical in areas with very heavy traffic because it fails to transmit enough information in a sufficiently fast time and thus places an excessive burden on air traffic controllers. Therefore, there was later more massive use of Data Link, which in many cases, communication is significantly speeded up and partly prevents mistakes in verbal communication and incomprehensibility in some cases.

UAS and communication are extremely interconnected, and this follows from the fact that each drone still has to communicate with its control station at the same time, and vice versa. Today, such communication is carried out exclusively by radio waves at different frequencies. UAS aircraft, like any other manned aircraft, use many types of communication. They communicate with ground-based navigation equipment, ATC, other aircraft, satellites, and many other devices, and in addition with the said control station. In general, communication is thus, divided into three parts and together referred to as C3 - Command, Control & Communication. Today's air communications and frequency spectra are subject to legislation that describes the technical background in detail. Legislation dealing with this topic includes, for example:

- RTCA DO-258A / ED-100A
- RTCA DO-178B / ED-12B
- ARINC 622-4, ARINC 618-6
- Boeing ATS SR&O D926T0280
- MIL-HDBK-514
- EUROCAE ED-23C
- JAA Administrative & Guidance Material
- EASA.2008.OP.08.
- FAA AC 25.1309-1A-FAA AC 27-1B
- FAA AC 29-2C, FAA AC 20-115B, FAA AC 20-140

4. Results and discussion

The connection of the UAS of the aircraft and the control station can be realized in two basic ways. Both as a direct connection between RPA (drone) and RPS (control station) or as an indirect connection between RPA and RPS. Both connection methods have their advantages and disadvantages.

4.1 RPA and RPS connection for direct radio visibility

As the name suggests, the connection directly means that the RPS + antenna is directly connected to the RPL by the data link, and the signal thus propagates directly from the RP antenna to the RPA itself. The range of the radio link for direct visibility is in the range of 50 to 500 km.
This value has such a large variance because the direct range depends on many factors. As with some known navigation devices, this radio range depends on the transmitting power of the antenna, the radio frequency used, the surrounding terrain, the weather, the signal processing itself, and many other factors. If all the right technologies and procedures are used, it is not a problem to achieve the above the upper limit, i.e., up to 500 km from the control station or its antennas which, however, is usually connected to the station by a cable line and placed within a few tens of meters.
In case we need to increase the radius of operation of the UA, there is a variant where it is possible to use multiple control stations, called in this case translation stations that extend the range of the signal transmitted by the main control station. This method is possible to cover a huge area while retaining almost all the benefits of direct radio communication.

4.2 Connection of RPA and RPS for indirect radio visibility by satellites

This type of RPA and RPS connection is realized by data transmission using satellites The advantage over the previous method is that satellites today cover almost all parts of the Earth, or at least most of the inhabited area, and thus can control the drone almost anywhere in the world and from anywhere. This method has no specific range, but the aircraft must move in space with sufficient satellite signal coverage, which is not a problem today. It follows from the nature that this method is especially suitable for UAS that have long-range and endurance.

However, the disadvantage of the indirect connection is the considerable delay in the data transmission between the aircraft and the control station. This complicates and even prevents direct control of the aircraft by the operator in real-time. Therefore, this method of indirect radio control is mostly used only in conjunction with semi-automatic or fully automatic UAS. Those if management intervention is needed such as collision avoidance, prompt response to the pilot's instructions, aircraft landing and the like can cope on their own. Of course, such UASs must be equipped with a powerful S&A system and a high degree of automation. This system, however, despite the advanced technology, is used today in such a way that the RPA is in the phase of landing, takeoff, or flight in the unseparated area controlled by a direct connection which was mentioned above. Indirect connection is mainly used for long-haul flights and at high altitudes. It is popularly used at the military UAS.

4.3 Communication architectures

Aviation communication architecture is composed of all devices that somehow participate in data transmission in aviation. These include many types of ground equipment, AFTN (Aeronautical Fixed Telecommunication Network) transmitters, satellites, all involved in air traffic, and the like. The architecture itself consists of a system of interconnection between individual devices of the entire air communication network. It discusses how data is transmitted between these devices. The analysis of this communication architecture and the design of a new one also stands in the way of the integration of UAS controlled spaces which would include data transmissions associated with UAS operations. Thus, it is mainly a completely new type of connection, namely the aircraft with the control station and the entire UAS system with all other necessary components of the communication network.

4.4 Data connections and their security

The data link must transmit several different types of information between aircraft and other air traffic controllers. In addition, in the case of UAS, there is an extremely important and data-intensive connection between the control station and the drone itself. The data connection is one of the largest areas to be addressed in the integration of UAS into controlled airspace, as there is little experience with it in the past regarding UAS operations together with piloted operations. Several issues need to be resolved, regarding the already mentioned data transmission architecture, the choice of suitable frequencies, the provision of data links, their reliability, and the like. This task is addressed in detail by the RTCA (Radio Technical Aviation Commission) in document DO-344 issued by the SC-203 group, which, however, is not publicly available for free. The issue of UAS was also discussed at the WRC-2012 World Radiocommunication Conference of 2012, where issues concerning UAS frequency allocation and data communication security were discussed.

Data connections used in aviation, like all other parts of the system, are subject to controls and it is important that they can ensure sufficient integrity and continuity. As mentioned, each data transmission must have a sufficient range of the radio signal, which depends mainly on the power of the transmitter, on the antenna itself, on the frequency used on the terrain type, and on the weather. Adequate signal quality, adequate data transmission delay, and sufficient performance must also be ensured. In any case, data protection and security must be ensured. As we are talking about drones, protecting control data is extremely important, because if a third party was allowed to monitor this data, it could eventually take control of the UAS.

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Although the data is encrypted during long-term monitoring, it is possible to arrive at their encryption sequence signal decipher. This must be prevented and there are several methods, many of which are still used today in GPS systems and the like.

5. Conclusion

Aviation, as the fastest growing mode of transport in recent decades, has made tremendous advances, one of which has been the invention of the Unmanned Aerial / Aircraft System (UAS). The first mentions of drones go quite far back in history, around 1903. However, the first UAS in the form we know them today began to be used in practice since the 1990s for military purposes. Their use was, of course, limited to certain areas and bases, and was used mainly for border monitoring and to ensure the security of facilities, or as training targets for weapons tests. Later, over time, the potential of these facilities began to expand rapidly and the UAS found a wide range of applications in various fields. Today, we already know dozens of tasks that the UAS can perform very effectively, such as aerial photography, area and vegetation research, signal transmission and broadcasting, forest fire monitoring, borders, the state of the environment, protection of certain areas, flight tests and research, filming, even experimental handling of consignments and the like. There are several different types of UAS in terms of their dimensions, weight range of operating altitudes, in-flight speeds, and other differences. Their potential commercial use is very interesting, while in some cases they allow a significant increase in efficiency and cost reduction while maintaining a high level of security. However, for the potential of the UAS to be fully exploited, it is necessary to address a very wide-ranging issue concerning the legislation and technical capabilities of the UAS itself and the CNS equipment. UAV and communication are interconnected, and this follows from the fact that each drone still must communicate with its control station, and vice versa. Today, such communication is carried out exclusively by radio waves on different frequencies.

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