**ISAE 2023**

The 6th International Symposium on Agricultural Engineering, 19th – 21st Oct 2023, Belgrade–Zemun, Serbia

# MAINTENANCE OF UNMANNED AERIAL VEHICLES (UAVs) IN AGRICULTURE

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**Abstract:** *In recent years, unmanned aerial vehicles (UAVs) have rapidly gained popularity in various industries, including agriculture, due to their wide application in agricultural production. The UAV is most often used for recording conditions in the field, monitoring the condition of crops, targeted application of chemical agents, yield assessment, etc. The efficient and reliable operation of UAVs applied in agricultural production depends to a large extent on the maintenance system. We divide UAV maintenance into two groups: maintenance before and after takeoff and maintenance due to unplanned situations. Both maintenance groups are crucial for preserving the working condition of the UAV with the aim of efficient operational work and extending the service life of the UAV itself. In this paper is shown the importance of regular UAV inspections, the importance of following the manufacturer's instructions, and the maintenance of key UAV components that require attention during regular maintenance. In addition to UAVs that are used for recording fields (terrain and crops), this paper also analyzes the maintenance of UAVs that are used for chemical protection of crops. By applying a timely and appropriate UAV maintenance strategy, we can expect maximum efficiency, reliability and safety of the UAV during their exploitation, as well as a longer working life - longer exploitation of the UAV.*

**Keywords:** *unmanned aerial vehicle (UAV), regular maintenance, crop condition, chemical protection, maintenance strategy, reliability.*

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## 1. INTRODUCTION

Unmanned aerial vehicles (UAVs) have become increasingly relevant in the field of agriculture due to their numerous application possibilities and advantages. These modern technical systems equipped with advanced technologies offer new ways to monitor and manage agricultural activities, improving the efficiency and productivity of agricultural production.

The use of UAVs in agriculture implies the use of advanced sensors and digital images that allow agricultural producers to obtain a clear picture of the condition of crops. Information obtained by using UAV, at the right time about the conditions in the field itself, is an important tool for implementing adequate agrotechnical measures, all with the goal of effective influence on increasing the realized yield [10]. Also, by comparing UAV reconnaissance techniques with other methods, it can be concluded that UAVs provide much cheaper, more up-to-date and more realistic data on crop condition. Due to their advantages, UAVs represent the best solution for monitoring the condition of crops on areas from 50 to 500 ha. [9]

The intensive development of software solutions and applications that are used both for their management and for the processing and use of the obtained data contributes to the wide application of UAVs to a large extent. Depending on its purpose, the UAV has different hardware and software equipment [7].

UAVs have the ability to, with adequate equipment, primarily multispectral cameras, create high-resolution digital field maps very quickly. To collect real information from the field, the precision of the UAV during the entire data collection process is important.

As UAVs continue to create changes in the agricultural industry, their role in increasing productivity and efficiency becomes increasingly important. However, in order to ensure the uninterrupted operation of these systems, it is necessary to establish adequate maintenance practices. [19] The goal of this paper is to present the importance and procedures of technical maintenance of individual components and systems that are used in modern UAVs.

The paper presents a review of existing domestic and foreign literature, UAV manufacturer's instructions, as well as the author's experience. The review was done to summarize and reveal the current solutions and ways of maintaining different types of UAVs, which are used for different purposes.

## 2. DIVISIONS OF UAVs

The division of UAVs can be done according to different criteria. According to the Directorate of Civil Aviation of the Republic of Serbia [1], based on the maximum take-off mass, UAVs are classified into IV categories:

I. unmanned aerial vehicles with a maximum take-off mass of 0.25 to 0.9 kg.
II. unmanned aerial vehicles with a maximum take-off mass of 0.9 kg to 4 kg (not including 4 kg).
III. unmanned aerial vehicles whose maximum take-off weight is from 4 kg to 25 kg (not including 25 kg).
IV. unmanned aerial vehicles whose maximum take-off weight is from 25 kg to 150 kg

UAVs of all categories have a limited range of 500 m, a maximum flight height of 100 m, and no speed limit. These restrictions are prescribed by the regulations, whereby there is a possibility of approval from the Directorate if it is necessary to fly at higher altitudes or at a greater distance.

UAVs can also be divided according to different construction characteristics into:

I. Unmanned aerial vehicles with a single propeller
II. Unmanned aerial vehicles with multiple propellers (becopter, tricopter, quadcopter, octocopter, hexacopter).

Fig. 1 Bicopter [14]

Fig. 2 Tricopter [15]

Fig. 3 Quadcopter [16]

Fig. 4 Hexacopter [17]

Fig. 5 Octocopter [18]

## 3. TECHNICAL MAINTENANCE OF UAVs

Technical maintenance of UAVs is crucial to ensure their optimal performance, accuracy and longevity of application. UAV technical maintenance can be divided into two groups: planned and unplanned maintenance. Scheduled maintenance is performed before take-off and after landing, while unscheduled maintenance is that which is performed due to unexpected and unplanned situations, such as breakdowns.

### 3.1. Pre-takeoff and post-landing maintenance

Planned maintenance is a set of measures that include a visual inspection, before take-off and after landing, where it is necessary to pay attention to the elements that are most exposed to damage during the flight. In most cases, damage occurs if the UAV does not have elements to rely on during landing, but instead lands directly on the ground. During such landings, damage to UAV propellers occurs to the greatest extent. For this reason, it is necessary to pay extra attention to this group of elements and replace them in order to complete the mission without any problems. During the visual inspection, it is necessary to pay attention to electrical lines that may be mechanically damaged.

As the battery is one of the main components, it is necessary to check whether the battery is charged before each take-off. According to the manufacturer's instructions, the batteries are charged up to 100%. Batteries must never be left completely discharged, because in this way the batteries lose their functionality. Before each flight, it is necessary to take into account the weather conditions on the ground [3,4,11]. Research has proven that air temperature (extremely high and low values), wind speed and precipitation negatively affect UAV durability, maneuverability, aerodynamics and navigation sensors. [4,6]. Therefore, small-sized UAVs are not capable of flying in difficult weather conditions such as strong winds. Some of the manufacturers clearly emphasize the limits of wind strength within which it is possible to fly [12].

It is necessary that the operator during the mission itself takes into account all the changes that occur and reacts accordingly. It primarily refers to the possible existence of obstacles (eg trees), monitoring of weather conditions, sound and visual effects that give signals about the state of the battery or a malfunction. It is also the operator's duty to follow legal regulations and follow the rules related to no-fly zones (near borders, airports, military facilities...).

After completing the mission, it is necessary to repeat the process as at the beginning and perform a detailed inspection of the UAV and make sure that no damage has occurred. Batteries on UAVs that will not be used for a while must be charged at least to 70%, because even if they are not used, their charge capacity decreases over time.

The recommendation of the manufacturers themselves [5] is that, in addition to regular inspections before take-off, some subsequent checks should also be carried out, every 10 hours of flight or after longer storage of the UAV. Scheduled maintenance at authorized service centers varies depending on the manufacturer, but is usually done after every 100 hours of flight. If the UAV is often used in bad weather conditions, such services need to be performed more often. Maintenance in service centers is a condition for extending the warranty against some major defects.

### 3.2. Unplanned UAV maintenance

Unplanned maintenance[8] implies noticing damage in time and taking certain steps in order to repair the damage as quickly as possible. Diagnostics and identification of the fault itself on the UAV can be a long process, especially when there are frequent changes to the computer part of the UAV itself. Based on that, as well as based on the location where the maintenance is performed, the same authors provide an overview of the division of unplanned maintenance. The division itself implies maintenance in the field, maintenance in the workshop and in the service. Thus, the primary repair site is the field where the flight mission is performed, where it is possible to perform minor repairs and replacement of parts. It is also possible to eliminate minor operational program errors that do not require more time. The same malfunctions and errors, if they require more time, can be done in the operator's workshop. While maintenance in authorized service centers implies repairs of components that cannot be repaired by the operator, and are necessary for the operation of software systems. An entire team of experts works on the removal of demanding repairs in authorized service centers, while minor repairs in the field can be performed by one operator.

The most common reasons for unplanned maintenance are engine failures, failure of control components during flight or loss of UAV connection. In those cases, the operator can no longer control the UAV, and that is when the UAV falls and is damaged. Also, damage to the UAV occurs due to non-functioning sensors for avoiding objects. The main goal of installing these sensors in modern UAVs is to reduce the possibility of damage and autonomy [24]. These sensors allow UAVs to detect in time and avoid obstacles during the flight, so they are

considered as a very important component of UAVs. This type of failure leads to situations that can pose a great danger to living beings and objects in the immediate environment. Reducing the risk of UAV malfunctions requires a combination of preventive measures, proper maintenance, and the responsibility of the person operating the UAV.

Some of the steps to minimize the chance of causing malfunctions are:

- Regular maintenance: which includes routine visual checks (previously explained) and taking care of the cleanliness of the UAV. Moisture, dust or other small impurities can cause damage to components or sensors [20].
- Updating the software according to the manufacturer's instructions to ensure that there are the latest applications with the correction of potential errors.
- UAV calibration which is a procedure in which it is ensured that the sensors are accurate and work properly [21]. This is very important to do when flying in new locations. This enables the improvement of flight stability, performance and safety of the UAV
- Checking the strength of the GPS signal. A strong GPS signal improves flight stability and enables real-time tracking [22].
- Use of quality batteries and proper battery charging.
- Monitoring of weather conditions because strong wind, rain or extreme temperatures put stress on the UAV components which directly affects the performance of the UAV during flight.

By following these UAV maintenance guidelines and performing routine maintenance, the likelihood of UAV malfunctions can be significantly reduced. This also ensures a longer operational life of the UAV [23].

## 4. MAINTENANCE OF UAVs USED FOR CHEMICAL PROTECTION OF PLANTS

Today's conditions of agricultural production require increasing control over the use of pesticides, so chemical protection by means of UAVs is therefore increasingly applied. By having adequate sensors and cameras, UAVs have the ability to detect various weeds, diseases and insects and thus apply variable chemical protection. In this way, the use of pesticides in quantities greater than necessary is prevented, thereby increasing the success of the controlled use of pesticides [13]. The maintenance of these UAVs does not involve major differences compared to the maintenance of UAVs for field imaging, the maintenance of which was previously explained.

Before flying, there are a number of factors that must be analyzed because their influence on the effective use of chemical protection is very significant. Some of those factors are related

to climatic parameters such as: air temperature, air humidity, wind speed and wind direction. The effectiveness of the use of chemical protection also depends on another group of factors, which include: speed and height of application of chemical protection. Indicators of the quality of chemical protection, i.e. drift, droplet size, droplet distribution, determine the height and speed of movement of the UAV during the performance of chemical protection.

What is done within the scope of the visual inspection itself refers to certain elements. It is checked if something interferes with the operation of the propeller or the engine. The UAV battery level as well as the remote control, which must be fully charged, are also checked, followed by a check of all other elements. If it happens that an element is not in good condition or is broken, it is replaced in order to complete the mission without causing damage.

Special attention is paid to the system for the application of chemical agents. Before the actual chemical treatment, it is necessary to do a trial test where there will be no working fluid but only clean water. In this way, the operation of nozzles, pumps and sprayer hoses is initially checked. The manufacturers of these types of UAV [2] also warn about the frequent problems of the system for the application of chemical agents, and provide a series of recommendations that must be followed. One of the measures that can be applied is the avoidance of powdery chemical agents that can lead to clogging of the nozzles and the use of filtered water for preparing the working fluid.

After the finished treatment, when the tank is empty, it is necessary to fill the tank with clean water and take off in order to wash the tank and other components such as nozzles to prevent damage to the system and other processes that may be caused by the chemicals that were applied during the chemical treatments. The operator must wear adequate equipment, which will protect him from the possible harmful effects of the chemical agent.

## 5. CONCLUSION

In order for UAVs to be used adequately, it is necessary to service and prepare them for each flight in the prescribed manner and according to the manufacturer's instructions. Carelessness of the operator can lead to more serious consequences, from those that are material to those that can lead to injury to the operator as well as living beings and objects in the immediate environment. By implementing a comprehensive maintenance strategy, UAV operators can ensure the continuous and efficient operation of their UAVs. Planned maintenance plays a vital role in preventing unforeseen failures and optimizing the performance of UAVs applied in agricultural production. Regular inspections and routine servicing help identify and address potential problems before they escalate. It also saves money in the long run because early detection of minor defects avoids complete repairs that require

more money. This proactive approach ensures that UAVs remain technically sound and adequately perform the technological operations for which they were designed

In the future, drone maintenance is expected to be highly automated, with advanced artificial intelligence systems. With which diagnostics will be carried out in real time as well as predictive maintenance, in order to ensure optimal performance and safety.

**Acknowledgement:** Paper is a part of research financed by the Ministry of Science, Technological Development and Innovation Development of the Republic of Serbia and agreed in decision no. 451-03-47/2023-01/200009 from 03.02.2023.

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