Use of unmanned aerial vehicles for automated forest fire patrols in the Republic of Sakha (Yakutia)

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Abstract. Within the framework of this article, the possibility of using unmanned aerial vehicles in forests is considered. The specific object of research is the territory of the Republic of Sakha in Yakutia of the Russian Federation. The choice is explained by the size of this region - it is the largest in the country. The relevance of this article is explained by the description of the experience and principles of using UAVs in the regions of Russia. The paper also provides statistics on fires over the past 4 years, demonstrates all the main fire centers, as well as the principles of their distribution. To solve this problem, it is proposed to use several models of unmanned aerial vehicles. Each of them has certain positive and negative properties. At the same time, the article contains a calculation of the total number of drones to ensure constant monitoring of the environment. The material contains an economic justification for the use of specific aircraft in comparison with aircraft models. The conclusion contains a description of a specific model of the drone, which makes it possible to ensure the greatest efficiency of the complex of reconnaissance measures to detect fires in the region under study.

The problem of forest fires is becoming increasingly important in the Republic of Sakha (Yakutia). Continuous monitoring of fires requires the use of a significant amount of material resources. Thus, to solve the problems of this industry, more and more cases are beginning to use unmanned aerial vehicles (UAVs) [1]. They are used for civil and military purposes. The most prominent representative is a quadrocopter [2].

In the period from 2017 to 2020, more than 2,000 forest fires were recorded on the territory of Yakutia. The fire destroyed a significant amount of plant and animal fauna, which led to enormous damage to the environment. An extremely difficult situation began to form in the central part of the republic.

Today, monitoring techniques that use space images and images from unmanned aerial vehicles (UAVs) are of particular relevance in the study of natural-territorial complexes. Their use allows obtaining the most relevant information about objects on the earth's surface, as well as structuring and combining data on the state of the environment based on data obtained from images [3].

According to media reports, unmanned aerial vehicles are actively used to organize work to prevent and eliminate forest fires in various regions of the Russian Federation. The importance of their use in the future is constantly emphasized.

For example, in 2020, specialists from the Tyumen air base received the DJI Mavic 2 Enterprise and Zala 427 - 08T drones. All of them were purchased within the framework of the "Conservation of
Forests” program. The same drones were equipped with video surveillance cameras and thermal visors, which made it possible to detect fires [4].

![Figure 1. Statistics of forest fires 2017 - 2020 in the Republic of Sakha (Yakutia).](image)

In 2015, when the Far East was burning in the Khabarovsk Territory, Supercam S350 drones were purchased. The Governor and Chairman of the Krai Government gave a positive assessment of the use of drones. The significant savings that are achieved through the use of drones instead of helicopters were also highlighted. The head of the forestry department of the Khabarovsk Territory noted that an hour of using a helicopter costs 150 thousand rubles, while almost the entire amount is spent on fuel. In turn, the drone flies using the energy of the batteries [5].

In 2021, specialists from the Krasnoyarsk Territory for the first time will use drones for the first time to monitor the fire situation in the Krasnoyarsk Territory [6].

A special fire safety regime was introduced in the Voronezh region from April 15, 2021. With the help of drones, they will monitor its observance, as well as catch violators. At the moment, the regional Ministry of Emergency Situations has 12 drones [7].

Based on these statements, we can conclude that drones are in high demand in the Russian Far East.

There is a set of strict requirements for a UAV:

- High flight range;
- Availability of various kinds of cameras and sensors with high sensitivity;
- Relatively low mass and long flight time;
- High reliability;
- Easy to operate;
- Low cost [8].

Given our territorial characteristics, it is extremely important that the UAV meets all these requirements. The problem is that the republic is divided into 34 ulus. Each of them has an average area of over 50 thousand km. An important feature is the fact that the climatic features should not lead to a dead end in the use of UAVs. This implies that they will be used as a means of round-the-clock monitoring of the forest. When carrying out calculations, it turns out that with the current number of drones, this is quite a feasible task that can be carried out in the next couple of months. In the near future, drones will become one of the main means of fighting forest fires.

What you need to know to solve this problem:

- Determine the area of each district of the Republic of Sakha (Yakutia);
• Determine the total number of UAVs that are needed to monitor territories;
• Determine the list of requirements for the UAV, taking into account the geographical and climatic characteristics of the region.
• Determine the economic requirements to meet these goals.

Calculation of the total number of UAVs to ensure continuous monitoring:

\[ N = (A \times n_1) + (B_1 \times n_2 + B_2 \times n_2) + (C \times n_2) \]

where,
- \( N \) - total number of UAVs for the territory of Yakutia
- \( A \) - areas with a minimum probability of a forest fire
- \( n_1 \) - total number of UAVs required for large area monitoring
- \( n_2 \) - total number of UAVs required for small area monitoring
- \( B_1 \) - territories (May - September) by the occurrence of a forest fire with a large area
- \( B_2 \) - territories (May - September) by the occurrence of a forest fire with a small area
- \( C \) - territories with a later (July - August) forest fire

\[ N = (13 \times 1) + (8 \times 1 + 10 \times 2) + 4 \times 2 = 49 \text{ pcs.} \]

![Figure 2. The location of the UAV on the map of the Republic of Sakha (Yakutia).](image)

\[ I = (R + T) \times N \]

Where,
- \( I \) - the total amount of money for the purchase of a UAV
- \( R \) - UAV price for 1 piece
- \( T \) - average price for delivery, thousand rubles
- \( N \) - total number of UAVs for the territory of Yakutia

\[ I = (R + T) \times N = (870 + 5) \times 49 = 42.875 \text{ million rubles.} \]

Calculation of the ratio of fuel consumption for aviation and consumption for UAVs:

Data:
- Aircraft A - 21 "Solo" is considered.
Fuel for one run - 496.7 liters.
The average price for 1 liter of aviation gasoline is 85 rubles.

UAV:
The average cost of a battery is 25,000 rubles. The minimum application period is from 100 flights.

Payment:

\[ N = H \times L \]

Where,
\( N \) - fuel consumption for 1 flight in monetary terms, rubles.
\( H \) - total volume of the aircraft tank, liter.
\( L \) - cost of aviation gasoline per liter, rubles.

\[ N = H \times L = 496.7 \times 85 = 42220 \text{ rubles}. \]

Based on the data, 49 unmanned aerial vehicles are required for the Republic of Sakha (Yakutia). This requires 42.875 million rubles. They can be obtained both from the federal budget and from the republican budget.

Positive and negative qualities of unmanned aerial vehicles:

**Figure 3.** DJI Matrice 300 RTK with Zenmuse H20T Gimbal.

**Benefits:**

- Designed for monitoring, patrolling, searching for sources of ignition;
- Flight altitude up to 7000 m.
- Stability in the temperature range from -20 to +50 C.
- Notifications about changes in weather conditions;
- Reserve stocks of the battery;
- Backup compass systems;
- Able to make an emergency landing;
- Low cost;
- Full protection from rain, dust and snow.

We can conclude that the ZALA 421 - 16E UAV is the best of all the others. It has a long range and flight duration. But it should be borne in mind that ZALA 421 - 16E has low reliability and an expensive price. Therefore, the DJI Matrice 300 RTK RTK is the best option.

**Conclusion**
The use of UAVs is an advanced concept for our republic. In most cases, they are used for entertainment purposes. The use of UAVs in the future allows the following advantages to be provided:

- No need to use aviation in forest fire reconnaissance;
- Ease of organizing fire-prevention measures in case of detection of a forest fire;
- Ability to detect a forest fire in advance and prevent its development. The UAV can significantly reduce the likelihood of further escalation of the fire and its development.
- All reconnaissance takes place remotely, which ensures a safe distance. There is no need to send pilots on risky missions. There are many cases where planes have practically crashed due to fire.
- Ability to interact with aviation. The UAVs will analyze the state of a forest fire and identify the strongest fire zones, and fire aviation will extinguish them. At the same time, the number of flights will decrease and extinguishing will become more accurate. For example, the cost of fuel for Be - 200 for one call is more expensive than for other types of fuels. And so you need to make the most of this moment.

Based on the data I analyzed, the DJI Matrice 300 RTK is most suitable for Yakutia. This UAV has all the qualities for fighting fires in the Republic of Sakha Yakutia, taking into account its geographic and climatic conditions. And for the economy of our republic, the cost of UAVs to fight forest fires will be significantly less.

Each region is recommended to purchase a DJI Matrice 300 RTK UAV of this brand, which costs 875,000 rubles.

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