Prospects for the Introduction of Unmanned Aerial Vehicles for Fire Fighting in Russia: Innovations and New Opportunities

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Abstract: This paper examines the improvement of the functions of a fire safety system through the integration of unmanned aircraft systems (UAS). An analysis of the model range of modern UAS of domestic and foreign production for the needs of firefighting and rescue operations was carried out. Ways and methods of using these technologies in organizing fire extinguishing, including its subsequent expert study, are proposed.

1 INTRODUCTION

By their nature, fires are one of the most serious threats to human life and property. Conventional methods of firefighting and rescue operations can often face limitations in availability and safety, which affects the effectiveness of the work carried out. This can be especially true when working on high-rise buildings and other similar places. In the light of technological progress, unmanned aerial vehicles appear before us as an innovative solution that can expand the range of capabilities of fire services and increase the efficiency of firefighting.

The main purpose of this article is to consider the possibilities of introducing UAVs in Russia to fight fires and carry out various rescue operations. The concept of a new model range of UAVs designed to extinguish fires, their capabilities and functionality will be considered.

You need to know that in Russia, instead of the term unmanned aerial vehicles, the term unmanned aerial vehicles (UAS) is used. The very concept of UAS can be used for various classifications of aircraft, including drones for extinguishing fires. The BAS designation is used in accordance with many legal acts and regulatory documents in Russia.

The possibility of introducing such UAS will take firefighting capabilities to a new level, by ensuring the safety of both firefighters and victims.

The prospect for the development of UAS for firefighting already offers a wide range of possibilities, including work on the delivery of the necessary equipment, monitoring the situation in real time, photo and video recording. But it is worth noting that in order to ensure sustainable development of this area, it is necessary to conduct new research, develop direct cooperation between manufacturers and fire services, and improve the design of drones.

Reviewing and conducting research on the role of UAS in fire safety is an important contribution to the development of the emergency management industry.

2 REVIEW OF MODERN UAS

At the end of 2023, the opening of a research and production center for the creation of UAS was announced. The center's main priority will be the development of unmanned systems for various

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purposes, including fire extinguishing and fire reconnaissance. The concept of a number of drones designed for these purposes is already known. A total of six models were presented: “Perun”, “Cyclone”, “Rain”, “Storm”, “Thunderstorm”, “Drop”.

The “Kaplya” model will be a light reconnaissance drone with a take-off weight of 7.2 kilograms. It is assumed that up to four different modules can be connected.

Other drone models are proposed to be used for direct participation in firefighting. The main direction of their activity will be aimed at extinguishing fires in high-rise buildings. They will have a take-off weight from 36 to 180 kilograms. For example, the Cyclone is planned to be equipped with a connected hose for supplying fire extinguishing agents to a height and an emergency hammer for breaking windows.

The “Groza” model will carry a fire extinguishing bomb with a volume of 25 liters, and the “Storm” will already be equipped with two such bombs and have a mass of 105 kg. "Liven" will carry four fire extinguishing bombs at once, having a take-off weight of 36 kg. “Perun” is proposed to be equipped with a 20-liter powder fire extinguisher and will also have an emergency hammer for breaking windows.

All presented models are supposed to be built on the basis of a helicopter-type UAS with four or six main rotors.

For a deeper understanding, let’s look at ways to extinguish fires using UAS:

a. Spraying fire extinguishing agents: UAS may be equipped with special devices for spraying fire extinguishing agents, such as water and/or foam solutions. They can precisely deliver fire extinguishing agents to fires.

b. Carrying extinguishing agents: UAS can also be used to deliver extinguishing agents to the scene of a fire, especially in hard-to-reach or hazardous areas. For example, they can travel with fire extinguishers or special containers containing fire extinguishing agents, and then dump them directly into the burning zone.

c. Fire detection: UAS can be equipped with fire detection systems such as thermal imagers, infrared cameras, including black-and-white static images and electromagnetic radiation. They can scan large areas and quickly locate fires, even in situations where it might be difficult for humans to do so.

d. Coordination and Communication: UAS can be used to coordinate fire services. They can transmit real-time information, such as images and videos of a fire, to aid in rapid decision-making and effective coordination of firefighting efforts.

As we have found out, these UAS will have unique capabilities that will allow them to effectively fight fires in various hard-to-reach places, especially in high-rise buildings. They will provide the ability to deliver fire extinguishing agents to places where their supply was previously difficult or completely impossible.

In addition to the above, which have just begun their production, some UAS are already in service in Russia. They are mainly divided into aircraft, helicopter and combined UAS. The most common and accessible helicopter-type devices, such as DJI Phantom 3. It gained popularity due to the high-resolution camera, which was initially installed out of the box in the UAV gimbal. Thanks to it, UAVs can be used for exploration and reconnaissance of terrain

Also, for a deeper understanding of the types of UAVs, it is worth delving into their classification. It is usually customary to classify them according to four parameters: mass, time, altitude and flight range.

Table 1: Classification of UAS.

	Weight, kg	Flight time, h	Flight altitude, km	Flight range, km
Ultralight	To 10	1	1	100
Lungs	Up to 50	2-3	3-5	100-350
Average	Up to 1000	10-12	8-10	350-1200
Heavy		24+	20	1200+

For the full use of UAS, it is necessary to carry out its certification. In Russia, UAS certification is carried out in accordance with laws and regulations that establish requirements for the safety and quality of aircraft. In total, to comply with all standards it is necessary to obtain three types of certifications:

a. Certification of compliance with technical standards in the field of safety and quality of aircraft. This certification is carried out in accordance with the requirements of the Federal Air Transport Agency Rosaviation and other competent authorities to ensure that the UAS meets the minimum safety and quality requirements.

b. UAS type certification is based on test results, evaluation of the design and

manufacturing process of the UAS itself. The purpose of this certification is to confirm that a specific model meets established safety and quality requirements. After successful completion of certification, a certificate is issued that contains information about the certified BAS model.

c. UAS operator certification is conducted to evaluate the qualifications and knowledge of the operator who will operate the UAS during firefighting and various rescue operations. The operator must undergo training and education, as well as pass examinations and practical tests. After successfully completing all stages of training, the operator receives the appropriate certificate.

The review shows significant potential for the use of firefighting UAS to improve the efficiency and safety of firefighting and rescue operations. Further developments in technology will improve the functionality and navigation of these UAS, leading to more effective deployment in a variety of firefighting scenarios.

3 STATISTICS ON THE USE OF UAS IN RUSSIA

Currently in Russia, drones are not used to directly extinguish fires. However, a lot of research is being carried out aimed at designing UAVs of this type. The issue of operational use of UAS in all fires with the establishment of local airspace restrictions also remains problematic.

Statistics show that in 2020, unmanned aircraft of the Russian Ministry of Emergency Situations carried out more than 7.7 thousand flights. During 2,100 flight hours, almost 12 thousand square kilometers of territory were inspected, more than 90 fires were identified over an area of over 2 thousand square kilometers, and 270 objects were inspected.

Unmanned aerial vehicles were used to conduct search operations and rescue people lost in forests and hard-to-reach areas. 37 people were found and rescued, including 16 people in the Volga River delta.

A conclusion about the relevance and effectiveness of the use of UAS in fires and emergencies can also be made based on the statistics of their use given below. For example, in the Main Directorate of the Russian Ministry of Emergency Situations of the Nizhny Novgorod Region, in 2023, unmanned aircraft specialists carried out 558 flights (Picture 1). This unit is armed with 6 helicopter-type unmanned aerial systems.

As we can see, a large proportion of flights are for training sorties. This is due to the training of qualified specialists, as well as maintaining constant readiness to respond. Specifically in the selected unit, training flights are organized weekly.

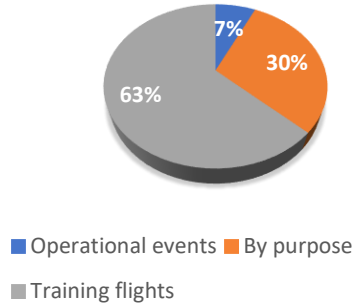

Figure 1: Flight statistics of the Main Directorate of the Ministry of Emergency Situations of the Nizhny Novgorod Region.

Below we consider statistics on the use of UAS, directly related to operational events and missions for the purpose of the UAS. Operational events refer to sorties to conduct reconnaissance while extinguishing various fires and conducting search operations. Search and rescue operations account for 15 sorties per year. Firefighting sorties – 25 per year (Picture 2).

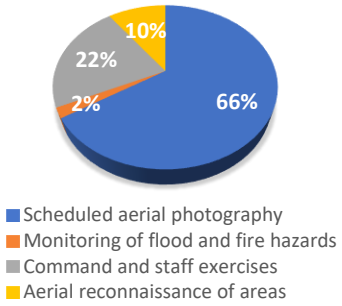

Figure 2: Detailed statistics of UAS flights by their intended purpose.

Thanks to flights from these categories, there are enormous opportunities for carrying out various preventive measures aimed at reducing the consequences of floods, floods, and so on. In this way, it is possible to limit budget expenditures on preventive measures, as well as avoid material damage to the population.

In order to make sure that drones really have many advantages, let's try to look at a specific application scenario and highlight them. Based on application experience, many disadvantages and advantages have been identified in the use of BAS. Let's consider the problem of aerial photography using drones to identify them.

Table 2: Advantages and disadvantages of aerial photography using UAS.

Advantages	Flaws
High resolution pictures	Limited shooting area
Survey results instantly or within the shortest possible time after landing	Difficulty in obtaining the necessary permits for flights
Ability to track one object and hover over it	Expensive
Spot photography in hard-to-reach places	Light payload weight
Possibility of installing additional monitoring equipment on the drone	The number of flights directly depends on the operator

At the moment, the unmanned aviation system of the Russian Ministry of Emergency Situations includes about 400 UAS units. It is being actively improved in order to update the fleet and equip units with modern multifunctional UAS. It is planned to introduce new units of unmanned aircraft, which will be equipped with mobile control points - all-terrain vehicles capable of providing mobility and autonomy.

Based on experience and achievements in the field of firefighting aviation and the use of UAS, the Russian Ministry of Emergency Situations continues to develop and improve a system for training professionals to work with unmanned aircraft systems. It includes retraining of specialists, retraining for modern UAS and advanced training of employees.

Drones are equipped with thermal imaging cameras and other sensors that can detect and transmit information about hot spots, smoke and heat sources. This allows you to quickly respond to a developing situation and direct fire brigades to where they can effectively take extinguishing measures.

Another important aspect of the use of drones is their ability to quickly and safely inspect emergency situations, including hard-to-reach and dangerous areas. Drones can monitor the edges of a fire, assess environmental characteristics, and help determine the best firefighting strategy.

The Russian government and the Russian Ministry of Emergency Situations are actively interested in the possibilities of using firefighting drones and are allocating financial and scientific resources for the further development of this area. Research is underway to determine the optimal design and functionality of firefighting drones, as well as the development of algorithms and software for automatic fire detection and classification.

The prospects for the use of firefighting drones in Russia are very encouraging. It is expected that in the coming years, not only research will be carried out, but also demonstration tests of firefighting drones for direct firefighting. This will strengthen the capabilities of fire services and ensure more effective firefighting, saving lives and reducing property losses.

The statistics provided support successful examples of the use of UAS in real-life situations. These data highlight the importance of using UAS for fire suppression, especially in high-rise buildings, and confirm their important role in ensuring the safety and effectiveness of fire extinguishing.

Statistical data is an important tool for assessing the effectiveness of the use of firefighting UAS and determining further prospects for the development of their use in Russia. They serve as the basis for decision-making and further improvement of technologies and methods for using firefighting UAS.

4 DEVELOPMENT PROSPECTS AND FURTHER APPLICATION

Considering the prospects for the development of firefighting unmanned aerial vehicles in Russia, we will consider areas of innovation and improvement, as well as the further use of these technologies.

Technical improvements and new functionality are key aspects of the development of firefighting UAS. Further progress in the field of neural networks, artificial intelligence and autonomous navigation will allow the development of aircraft software that will ensure the effective use of drones. This may include the development of algorithms for automatic detection and classification of fires, improving the accuracy of navigation and identifying potentially hazardous materials.

In addition to firefighting, UAS can be used in other areas. For example, they can be used to transport necessary equipment and materials to the scene of an incident. There are already similar examples, but these are more like experiments.

Collaboration between UAS manufacturers and fire services plays an important role in the development of this field. Fire departments should

actively participate in the development of requirements and safety standards for the use of UAS in combat emergency situations. These agencies can also provide valuable statistical data to improve the functionality and adapt the UAS to real-life situations.

Future applications of UAS could potentially be expanded to other areas, such as automated fire monitoring and control, and disaster response. It is important to continue research and development in this area to maximize the potential of UAS and significantly improve the efficiency and safety of firefighting and rescue operations.

5 CONCLUSION

Progress in firefighting UAS development promises new capabilities, including the use of autonomous navigation systems, artificial intelligence and other innovative technologies. Further improving the functionality, reliability and accuracy of their actions based on the collected data will improve the effectiveness of fire suppression and maximize the protection of lives and property.

Key factors in the development of firefighting systems are further research and cooperation between manufacturers, fire services and scientific institutes. It is also important to ensure that the UAS is certified and meets all necessary safety regulations to ensure that the UAS is reliable and effective in real-world use.

The use of UAS in the field of fire safety in Russia represents a significant step in the field of fire safety. Further development of this technology and maximum use of its potential will allow us to more quickly protect lives and property, as well as improve the effectiveness of firefighting and rescue operations. In-depth research and close collaboration with practitioners and the scientific community will contribute to the development and application of firefighting UAS to ensure safety in fires and emergencies.

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