Analyzing the Feasibility of Using the Sylvan Information System and Drones in Forest Fire Suppression in Yakutia

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Abstract: Special attention in the article is paid to the relevance of IT-technologies in the field of forest fire prevention and localisation. The author of the paper justifies the use of the forest fire countermeasures system "Sylvan" and the use of unmanned aerial vehicles. He considers them as a way to monitor and record forest fires. This paper will validate the effectiveness of using drones for forest fire suppression, which can determine the type of fire, its area and direction of fire development, as well as the area of the most intense burning. Determination of information needs of the system participants should be in the system of fire safety and fire suppression, because it is essential for the operation of the system. Insufficient information, its untimeliness, as well as falsehood increases the risk of loss of life and material objects, forces to act in conditions of uncertainty, and the decisions taken may be wrong. Improvement and introduction of the latest technical means make it possible to realise different forms of fire safety provision irrespective of the features of emergency circumstances.

1 INTRODUCTION

Yakutia is one of the most fire-prone regions of the country. The total area of forests is 256.1 million hectares (83.4% of the territory). According to the information, as of 20 October 2022, in 2022, 531 forest fires were registered in Yakutia on the area of 560 thousand hectares. Analysing this data with the indicators of the previous year, it becomes clear that in 2022 the number of fires decreased by 3 times, and the area covered by fire decreased by 14 times! As practice shows, such results have become possible, among other things, thanks to the use of information technology, which will be discussed in this article.

Modern information technologies have started to play an important role in ensuring fire safety. They provide a wide range of means for fire detection. Their process starts with detection and ends with fire extinguishing. Some of them, for example, the system from the company "Spark Cinema", work on the basis of artificial intelligence and are able to detect not only direct signs of fire, but also the preconditions for its occurrence, for example, overheating of electrical equipment.

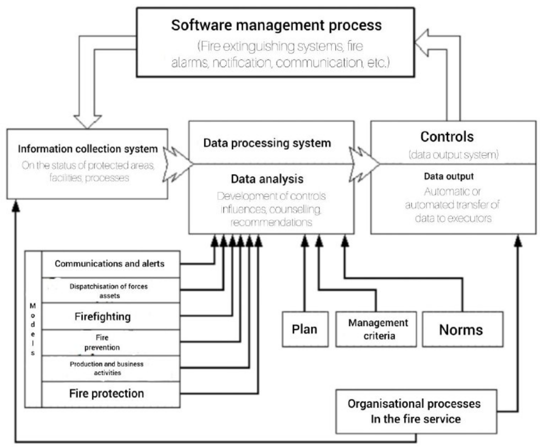

Figure 1: Structural diagram of automated software management.

IT technologies are already being used directly in firefighting. For example, modern automatic fire extinguishing systems can operate in an autonomous mode, analysing data from sensors and making decisions on the start of extinguishing.

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Large-scale projects in the IT industry are currently being implemented in Yakutia. The Far Eastern Federal District is a leader in high technology. It not only creates, but also implements promising, attention-grabbing projects that solve issues that exist not only in the republic, but also in the country itself.

In this article, I would like to make a special mention of a recent IT development by Yakut specialists. To create it and other control systems in the field of fire safety, the technologies discussed in Table 1 are used.

Table 1: Types of information technologies for creating control systems in fire safety.

Types of information technology	
System analysis	It identifies the characteristics of the facilities where fire safety must be assessed. The analysis helps to formulate the criteria for fire safety assessment and the main functional tasks to be performed by the control system. It includes computational experiments to simulate various scenarios of fire development, provides an opportunity to reproduce various calculated fire scenarios, etc.
Mathematical modelling	The emergence of powerful and affordable computing systems and the expansion of knowledge in the field of physics and chemistry of processes have made it possible to carry out modelling of processes occurring in fires with sufficient accuracy for practical activities. For modelling the development of fire hazards and determining the time of блокирования путей эвакуации используется combination of integral and zonal methods, or a bank of ready-made calculation models, and in case of analytical mode of system operation - field method. Decision support systems are implemented on the basis of mathematical modelling of CFP and evacuation development taking into account the evacuation conditions of the facility and analysis of calculation results using a database.
Database management systems	On the basis of DBMS the block of analytical processing is built, with the help of which reports are formed: on the process of evacuation of people, on blocking of evacuation routes, on getting evacuees into zones with maximum permissible values of fire hazards. Comparative tables of evacuation time and stages of fire development are also built to identify the danger of exposure of people to PFPs.
Operational analytical processing of data	The technology of operational analytical processing of multidimensional data (OLAP) provides high speed of work with data when performing analytical operations, visual presentation of results and prompt construction of reports. Multidimensional model allows to adequately represent the process of working with information objects, visually describe the main analytical operations and optimally build a physical data model for storing and processing queries.
Geographic information systems	Integration of geographic information systems (GIS) and OLAP-systems is possible. Such a combination contributes to increasing the visibility of presentation of the results of analytical data processing. As a result of integration OLAP-system acquires additional possibilities of visual representation of multidimensional data on geographical maps, GIS-tool for forming analytical queries for building thematic maps. The mechanism of dynamic connection of multidimensional data of OLAP-system to spatial information of GIS is based on cartographic data binding, which allows to establish correspondence between the results of operational analytical modelling and geographical objects.

2D and 3D graphics	2D - graphical environment is necessary to generate input data on fire hazardous objects. 3D - graphic environment helps to visualise the results of modelling, e.g. the process of evacuation of people and the spread of fire hazards.

2 SYLVAN SOFTWARE FOR FIGHTING FOREST FIRES

The Sylvan system, developed by Smart Unit LLC with the participation of employees of the State Budgetary Institution of the RS(Ya) "Avialesookhrana", the Ministry of Emergency Situations and volunteer movement, in 2022 helped Yakutia to detect new fire hotspots and extinguish forest fires twice as quickly. The advantages of using the forest fire information system include:

1. Reduction of response time by 5 times.
2. rapid detection of thermal anomalies (within 30 minutes).
3. Generation of over 30 types of reports, analytics and dashboards in automatic mode.
4. Possibility to create a register of citizens' appeals.
5. Calculation and tracking of readiness of means and forces.
6. Data update every 30 minutes.

This unique kind of programme combined mapping services for wind direction, deployment of forces and means, as well as climate services and accounting systems that were previously used by operational firefighting services such as EDDS, EMERCOM, 112, Avialesokhrana, municipalities and the operational headquarters of the district management. For comparison, previously, seven different applications were used to detect a natural fire in Yakutia, but now there is only one system.

The hardware and software complex, which consists of many modules, provides a complete picture of the current forest fire situation. It contains information on the area of fires, the number of resources involved, access to analytical data for the day/past dates, the register of aerodromes, records of air raids, readiness of forces and means. This data allowed to halve the response time to fires of any complexity and five times reduce the time to analyse the situation and actions. In addition, the system maintains the dynamics of each fire by day: changes in fire class, area, edge, human resources and equipment involved. The programme is available to all interested agencies - the operational headquarters, the Ministry of Ecology, the Ministry of Emergency Situations, the prosecutor's office, and municipal administrations. Compared to 2021, which was the most difficult year in history, forest fires in 2022 became 6.5 times less, and the area covered by fire decreased by 30 times. The downward trend continues in 2023. For example, on 21 June 2023, there were two forest fires on the territory of the Republic of Sakha covering an area of 1903 ha (Table 2).

Table 2: Types of information technologies for creating control systems in fire safety.

Region	Number of fires		
RS(Ya)	2022	2023	%
	199	217	+8,3

The mapping subsystem is implemented on the SMART software platform and was introduced in May 2022. After successful implementation, today it is used by more than 150 organisations, including specialists from the Aviaforestry, Ministry of Ecology, and municipalities of the republic. The development solved a problem of many years - it enabled agencies of different levels to interact with each other.

After the programme detects by satellite thermal spots with suspected fires, a ground unit or an air monitoring group immediately goes to the place. For its successful operation, data from six different sensors is collected. Today, the Smart Unite team is working on updating the programme, namely on the introduction of a lightning detection system and monitoring of thunderstorms.

The mathematical model of forest fire forecasting from the Synet Spark Foundation has small similarities with the development of Smart Unite. It can predict the development of an active fire for a certain period of time, taking into account the type of landscape, relief, and wind direction. The principle of its work is based on satellite observations, as well as data from international monitoring and scientific services. To build the forecast, the OpenWeather service is used, which receives information on wind speed and direction from a convolutional neural network.

The declared accuracy of the data is from 90 to 100% with an error of 1%. Even the darkness of a particular area is taken into account. On the map you can compare the forecast and already active fires with the help of a layer of actual "forecast" perimeters, which reflect the areas occupied by thermal points, from the beginning of the fire season to three days ahead of the selected date. Archived forecasts for 2020-2022 are publicly available. Figure 2 shows archived data for 12 July 2023.

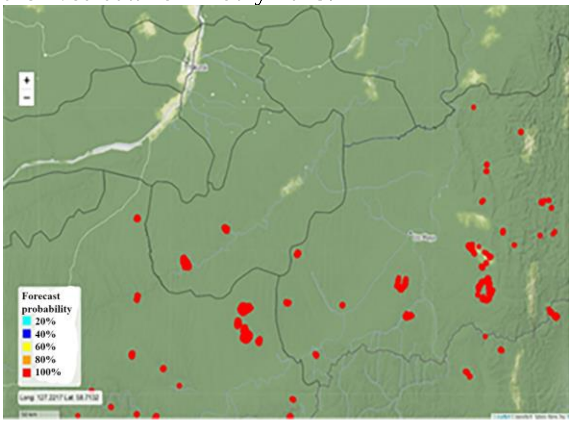

Figure 2: Archived data from the start page of the Yakutia Forest fire forecast website.

In the test version of the Yakutian service, current and forecast wind speed values are collected at 40 points evenly distributed across central Yakutia with a time step of 3 hours. Local authorities highly appreciated the project and intend to support its further development. According to project manager Timur Alekseev, in the future it is planned to make the system more accurate and also provide forecast data on fires in other regions of Russia.

3 USE OF UNMANNED AERIAL VEHICLES IN FIGHTING FOREST FIRES

During the first 10 days of August 2023, 152 forest fires with a total area of 156,354.4 hectares were extinguished, including 14 forest fires with a total area covered by fire of 51,933 hectares. In order to preventively detect forest fires and eliminate them, the first flights of BAS drones were conducted in early July 2023. The experiments confirmed that the drones, which are equipped with thermal imaging cameras, help paratroopers and paratroopers to scout the situation as accurately as possible, as well as to build the most effective plan of action. At the same time, drones are used for systematic monitoring of territories. This is especially important during the time of year when fires are most possible - in summer during dry weather. UAVs for monitoring forest fires have a great advantage over large aircraft. Firstly, it is operational efficiency - reconnaissance can be launched as needed per day. Secondly, UAVs are able to "see" fire sources even through significant smoke screens. Thirdly, flights are hundreds of times cheaper than manned aviation. The use of drones is expected to be an alternative to aviation when aircraft are unable to go out on air patrols due to low cloud cover.

There is usually only a short period of time between when a fire starts and the loss of control of the situation. Drones provide an opportunity for firefighters to observe the area from a bird's eye view, further helping rescuers to understand where the fire is moving, predict the further development of the situation, and correctly assess the scale of the disaster. UAVs fly lower than helicopters and provide a more detailed picture of the situation, can manoeuvre in a limited or dangerous space, where no aircraft pilot would dare to go.

In some cases, drones and firefighting helicopters can even be used in tandem to cover as much terrain as possible. The 360-degree images from the scene provide invaluable information on property damage to more quickly assess the situation and expedite insurance payouts to victims. The GPS receiver and RTK stations, with which the vast majority of modern drones are equipped, present the overall picture down to centimetres of the sensing results in a special mapping system. Coordinates are determined, locations of emergency services, machinery, equipment are identified, general condition and changes in the concentration of substances in the air are calculated, external factors are assessed, taking into account weather and other changes. Computer systems and autonomous stations also make it possible to control unmanned systems from afar, promptly regulating the actions of fire and rescue services.

4 CONCLUSION

It is becoming evident that information technologies make it possible to quickly mobilise additional forces and resources to extinguish forest fires, which so often occur in Yakutia. Thanks to them, response times are reduced and losses are prevented.

Recently, neighbouring regions have shown interest in the Silvan system. The programme developers have held talks with representatives of Khabarovsk Krai, Primorye, Karelia, Magadan, Irkutsk and Amur Oblasts, as well as Egypt, Madagascar, Mongolia and Turkey. Representatives of industrial, energy, communications and agricultural enterprises have also actively started to join in for continuous monitoring of their facilities -

industrial territories, communication lines, gas and pipelines. The Republic also signed an agreement with the Skolkovo Institute of Science and Technology on the use of models for predicting the direction of fire based on artificial intelligence. There are plans to introduce such a complex throughout the entire territory of the Far Eastern Federal District. The Yakutia Innovation Development Fund and Rostelecom will provide support in scaling up the IT development.

The authorities of the Sakha Republic are actively promoting the improvement of competences of UAV operators and training of new ones. In January this year, a special training centre was opened in the republic, where 1,060 students will be trained between 2023 and 2025. It should be said that Yakutia is included in the number of regions where the all-Russian strategy for the development of unmanned aviation will be developed in pilot mode.

After analysing the fire danger of forests, it turns out that IT in fire safety in Yakutia is an integral part of modern life, which help to save forests and reduce the cost of fire suppression. Drones, different information systems, some of them discussed in this article, not only improve the quality of fire supervision, but also reduce the number of accidents, loss of life at fires. They can be used to further prevent the spread of fire in forest areas, as well as to improve the efficiency of communication, signalling, special equipment, etc.

A number of activities aimed at developing the sphere of information technologies within the Republic of Sakha are planned for today in order to successfully pass the next fire seasons. The main conclusion of this work suggests that the perennially burning forests of Yakutia are one of the country's problems that need the help of IT specialists and all those who care about them.

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