Problems and prospects for the development of unmanned aerial vehicles in Russia

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Abstract. Unmanned aerial vehicles are vehicles that can fly without a human pilot on board. Recently, unmanned aerial vehicles (UAV) have become widespread in the civil and military sectors, and the development of UAV is one of the promising trends in modern aviation. Drones have long ceased to be expensive and highly specialised and are in widespread use. They can be equipped with multiple cameras, gyrostabilisers, LIDAR and GPS to collect and transmit data in real time. Due to the demand for drones in various applications such as agriculture, search and rescue, wireless communications, surveillance and cargo transportation, several types of UAV have been invented with different sizes, weights, flight ranges, engine types, etc., optimized for specialized types of work. The deeper integration of drones into the transport system has the potential to relieve general strain in many companies and factories, reducing production and transport times, and facilitating faster response to emergencies. However, drones face a number of challenges related to flight logistics, collision avoidance, lack of necessary infrastructure, autonomous operation time and imperfect artificial intelligence.

1 Introduction

For some years now, drones have been changing the way many businesses operate. Initially, when range and payloads were significantly limited, drones were best suited to tasks that were expensive and impractical to perform using traditional methods and means. However, as UAV technology developed, the possibilities for their use rapidly expanded.

This development is still underway and it is already clear that in the coming decades unmanned aerial vehicles will play an increasingly important role in many sectors of the transport system, including both the transport of goods and people. UAV are no longer limited to the small aircraft typically used by photographers, tourists and hobbyists.

Unmanned aerial vehicles are expected to improve safety in some areas of work through automation (thereby limiting the degree of human interaction and possible human error associated with it) and create economic benefits through reduced costs and increased efficiency. This will lead to new business processes and opportunities.

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Although unmanned aerial vehicles have unique characteristics, they will need to fit into the existing air transport system to ensure safety for others and continuous monitoring. Realising the full potential of UAV will require new tools and ways of working, with the private sector playing a key role not only in the development of the drones themselves, but also in the development of the technologies themselves to support integration into the transport system.

1.1 Relevance

The relevance of the study is based on the fact that in today's world, robotic technology is increasingly being used to replace humans, and drones are no exception. The technology, developed for military purposes, is slowly making its way to the consumer market, so many companies decided to keep up with the trends. Since UAV is versatile, it can be applied in almost any field: from delivery and aerial photography to border protection and security. The extensive capabilities of drones have attracted many companies around the world.

1.2 Literature review

This paper reviews and studies the works of foreign authors who study the possibility of introducing unmanned aerial vehicles in various fields of activity. A significant number of works are devoted to studies in the field of UAV infrastructure development, environmental and economic impact [1-10]. In the works of Ravil I. Mukhamediev, Adilkhan Symagulov, Yan Kuchin detail the variations of UAV application, listing and describing many options for their use, as well as describing the momentum from the introduction of drones in different areas [2].

Exploring the potential of UAV to combat the new coronavirus infection COVID-19, a group of authors represented by Vinay Chamola, Vikas Hassija, Vatsal Gupta, Mohsen Guizani cite DragonFly drone capable of monitoring temperature, heartbeat and cough in humans to detect infections [6]. However, it is worth noting that this development is not relevant at the time of 2022, due to the decline in the number of diseases around the world.

Kirill Kolosov, Alexander Miller, Boris Miller describe the possibility of integrating drones with existing airfields and airports, as well as the use of a unified navigation system to avoid collisions [7]. Nourhan Elmeseiry, Nancy Alshaer, Tawfik Ismail in their work describe in detail the further development of UAV, possible new applications and prospects [9].

The above mentioned authors describe in great detail various aspects of unmanned aerial vehicles, coming to the same conclusion: UAV is a new vehicle, but has a huge potential for development, despite the obvious shortcomings in the form of relatively short operating time and lack of full automation.

1.3 Problem statement

The review of scientific papers has shown that the main problems hindering the development of drones are:

1. lack of necessary infrastructure for the safe use of UAV;
2. lack of mass production for commercial use;
3. artificial intelligence at this stage of UAV development does not allow the vehicles to be used completely free from humans;
4. the state is more interested in developing UAV for military purposes than for commercial ones.

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1.4 Aim, objectives and hypothesis

The aim of the study is to analyse the problems and prospects of drones and their impact on the economy.

The objectives of the study are:
- analysis of the current state of unmanned aerial vehicles;
- classification of drone types according to their characteristics;
- identification of factors constraining the development of UAV and description of possible solutions;
- market analysis and formulation of prospects.

Hypothesis can be formulated as follows: it is to be expected that a deeper introduction of drones will significantly reduce the burden on the transportation system and other areas of commercial activity. However, there are challenges to the successful use of UAV, such as: non-ideal artificial intelligence, complete or partial lack of infrastructure, reluctance of states to invest in commercial drones, and lack of factories for mass production.

2 Methods

Relevant material from various sources was selected as a basis for writing this paper. According to them, an analysis of the problem was carried out, ways to solve it were identified and conclusions were drawn. Empirical-theoretical research methods were used, in particular the method of analysis, the method of analogy, the method of comparison and induction. In order to analyse the current state and implementation of drones, materials were found in different sources. Based on the analysis of the data obtained, problems were identified and analysed, solutions were identified and conclusions were drawn.

3 Results

One of the first manned helicopters with four main rotors, which in practice could bounce off the surface and hover above the ground, was created and tested by the Russian-American aircraft designer Georgi Botezat in 1922. The construction of Botezat's helicopter was a cross-shaped truss made of steel pipes, all the spans of which were wrapped with swan wire. At the ends of the truss were four six-bladed propellers, each with a diameter of six metres. A 180 hp rotary engine was housed in the central part of the hull. The propellers moved in pairs in different directions. The weight of the helicopter was 1700 kg.

The new round of drone development came in 1935. Engineers in Britain created a reusable unmanned aerial vehicle. It was called the QueenBee. The model of the Fairy Queen biplane was taken as the basis. After reconstruction and modification, the drone could be controlled remotely from a seagoing vessel at a distance of up to 5km. Its maximum horizontal flight speed was up to 170 km/hour. Codenamed DH82B, it was used by the Royal Navy and Royal Air Force as a target practice drone until 1947. By the beginning of the Second World War radio-controlled unmanned vehicles were already in mass production. Especially the Target type. One such UAV was the famous QQ-2 radio planner. The first operational model of which appeared in 1939. The Radio Plane was the most produced drone. A total of 14,000 were produced.

Since 2016, a huge number of start-ups have formed, with companies raising money to develop and manufacture their own drones. Many of them are forced to withdraw from the market due to lack of necessary funding, strong competition, etc. One such representative is Amazon. The company planned to deliver packages using quadcopters, but after 9 years of design, development and testing, the idea was abandoned. In 2021, Amazon fired and reassigned more than a hundred employees who were working on the drone delivery project.

However, there are those who have been able to get their projects off the ground. The most prominent example is Zipline: the company specialises in delivering medicines to rural areas in Rwanda with agreements with the Rwandan government. Zipline transports blood products to 21 transfusion clinics. However, the global market leader is the Chinese company DJI, which controlled around 70% of the market in 2015. The company has managed to establish itself as a premium and reliable brand, and has expanded beyond China, contrary to stereotypes about the short-lived and unreliable nature of Chinese technology. Drones are likely to increase productivity and create a new direction for manufacturing and technology, which will create new jobs. In the more distant future, they could also eliminate jobs in parts of the transport sector altogether.

Traditional aviation has significant impacts on the environment, but these impacts are generally well understood and a number of policies, regulations, standards and operational procedures have been developed to address these impacts. The environmental impacts of free-flying aircraft have received relatively little attention. The huge differences in the size and characteristics of drones make it clear that mitigation measures developed for traditional aviation are unlikely to be sufficient to manage the environmental impacts of drones and new approaches, regulations and standards will be needed. Çetin E., Cano A., Deransy R., investigating the implementation of mitigation measures when using UAV conclude "more than 70% of the mitigation measures are found to be achievable in a short or medium timeframe" [1].

The available research shows that drones can potentially reduce overall energy consumption and hence the amount of emissions emitted by vehicles. On the other hand, there are clear environmental concerns associated with UAV deployment. These relate to the effects of noise and vibration, as well as light pollution, which have a negative impact on nature and humans. As Swedish researchers Ravil I. Mukhamediev, Adilkhan Symagulov and Yan Kuchin "Polluted air, water, and soil increase risk of coronary heart disease, lung cancer, cerebrovascular disease." [2].

Noise is a key factor that, without proper regulation, can be a serious obstacle to the integration of drones into society. Although most UAV do not produce exhaust emissions, this does not mean that there is no harm from them. The emissions of UAV compared to conventional modes of transport will depend on the specific use case. All of the above is confirmed by Spanish scientists Ender Çetin, Alicia Cano, Robin Deransy, Sergi Tres and Cristina Barrado "Actions are needed to disseminate the benefits of drones as environmentally friendly vehicles". [3]

To summarise, UAV have a positive impact on the environment rather than a negative one. They will help to reduce air pollution as most of the vehicles are powered by electricity and eliminate the emission of exhaust gases. However, they can have a negative impact on wildlife by creating visual disturbances. These impacts need to be taken into account when building infrastructure.

Drones, as a relatively new technology, still do not have a single universally accepted classification. As of 2022, it is common to categorise them according to their main characteristics: take-off weight, range and payload. The characteristics of all types of UAV are shown in Table 1 below.

Table 1 shows the main characteristics of all types of UAV. It can be seen that both electric motors and internal combustion engines are used as engines. UAV differ in take-off weight, payload volume and range, which allows UAV to be used in different scenarios.

As of early 2022, unmanned aerial vehicles (UAVs) are actively used in a wide variety of sectors:

1. agriculture. In the US, the Environmental Protection Agency is already using unmanned aerial vehicle technology to manage livestock and monitor crops. In the future, farmers and growers will be able to use UAV to strategically monitor and spray their crops;
2. delivery. Anything that can be carried by a postman can also be delivered by drone. Food, medicines, birthday gifts, etc.;
3. search and rescue operations. Drones visit places that people cannot access. They are the ideal solution for dangerous search and rescue operations as well as delivering relief supplies to remote locations and areas of natural disasters;
4. logistics. Heavy Unmanned aerial vehicles (UAV) replace trucks for delivering food and moving goods between warehouses and other locations.

Table 1. UAV characteristics.

Type of UAV	UAV class		Take-off weight, kg	Payload, kg	Range of action, km	Engine type
Airplane	Micro and mini UAVs		up to 5	up to 1	25-40	Electric motor
	Light UAVs	short range	5-50	1-10	10-120	Electric motor
		medium range	50-100	5-30	70-250	Electric motor, internal combustion engine
	Medium UAVs		100-300	20-50	150-1000	Internal combustion engine
	Medium - heavy UAVs		300-500	45-150	70-300	Internal combustion engine
	Heavy UAVs	medium range	500-1500	60-250	70-300	Internal combustion engine
		long range	>1500	>300	1500	Internal combustion engine
Helicopter	Mini UAV		up to 5	up to 1	5	Electric motor
	Light UAVs		5-50	1-30	5-100	Electric motor
	Medium UAVs	short range	50-300	20-50	50-100	Internal combustion engine
		medium range	30-500	50-150	100-400	Internal combustion engine
	Heavy UAVs	medium range	500-1500	120-150	150-400	Internal combustion engine
		long range	more than 1500	more than 200	400-1500	Internal combustion engine

UAV can also be useful in bridge design and inspection, as noted in a study by Aliyari M., Ashrafi B., Ayele Y.Z. "UAV deployment in bridge inspection could potentially save time and money" [4].

Chinese researchers Jia J., Cui W., Liu J.in their study "In recent decades, using remote sensing for automatic classification and mapping of infrastructure is valuable for avoiding manual identification, which is time-consuming and laborious" [5] note that the wide range of sensors that can be loaded on board enable the collection of important data that can be used for monitoring and responding to emergencies. The ability to remotely control UAV helps reduce risks to people and shield them from life-threatening tasks.

Alphabet plans to deliver over-the-counter medicines via UAV in Australia after a year and a half of test flights.

Researchers at the University of South Australia, in collaboration with Canadian commercial UAV manufacturer DraganFly, have developed a one-of-a-kind drone capable of identifying people with infectious respiratory diseases in response to an outbreak of a new coronavirus infection. As Chamola V., Hassija V., Gupta V. and Guizani M. note in their paper. "These drones are to be installed with a specialized sensor and computer vision system that can monitor people's temperature and heart rates" [6]. It is also expected that these drones will be able to detect people sneezing and coughing in public places.

Drones are likely to require a smaller and simpler ground infrastructure than aircraft or helicopters, which provides some flexibility in airfield design and layout, especially if they serve drones with UAV (vertical take-off and landing) capability. Unmanned aerial vehicles will also require high-capacity charging and refuelling stations. For both passengers and cargo, secure loading/unloading facilities as well as a waiting/storage hall are required. Thus, depending on cargo and regulations, a port of call for small drones could be a common rooftop, a car park, or small UAV stations.

As technology advances, drones will become safer and more reliable. As of 2022, they are undergoing a revolutionary change. Russian researchers Kolosov K., Miller A., Miller B., believe that "The integration of data from various sensors is fundamental in the navigation of unmanned aerial vehicles [7]. The use of various sensors provides a comprehensive integrated observation of all-round objects.

As of 2022, the most promising technology is fully autonomous UAV. The Australian group of researchers represented by Taha Elmokadem and Andrey V. Savkin, studying the issue of full autonomy of UAV cite the following in their work: “Being completely able to carry out missions/tasks with minimum human interaction is an ultimate goal for unmanned aerial vehicles. Different levels of autonomy can be achieved towards that goal depending on the complexity of tasks and whether a fully autonomous solution exists or not for that specific application.” [8].

Urban terrain is the predominant use of UAV, so collision avoidance is a priority task that needs to be developed as soon as possible. This is due to a non-optimised artificial intelligence that is unable to properly analyse the surrounding terrain. Nourhan Elmeseiry, Nancy Alshaer and Tawfik Ismail point it out in their article "Collision avoidance for UAVs is a great challenge, as it is essential to avoid accidents with any obstacle. Obstacles can be moving or stationary, and UAVs may crash with them. [9]

Russia is mostly interested in developing and purchasing drones as military equipment rather than for commercial use. Domestic UAV are widely used for homeland security purposes, as well as for Arctic exploration, search and rescue and major fire prevention.

As of November 2021, the number of military UAV in Russia was over 2,000. Short-range drones are important tools for domestic and border monitoring, and the Ministry of Defence's orders for their production are increasing every year. Alharbi A., Poujade A., Malandrakis K. emphasize in their study: "The growing use of Unmanned Aerial Vehicles (UAVs) operations will require effective conflict management to keep the shared airspace safe and avoid conflicts among airspace users."[10]. The most sought-after Russian UAV are the surveillance drones shown in Table 2.

These drones are mainly tactical drones, their low weight does not allow for the installation of additional equipment and to be used as combat units.

"The Eagle-10 is a unique domestic development with the ability to broadcast a target to engage all combat vehicles. The technology is extremely effective, as confirmed in their research paper by researchers Huang H., Zhao X. and Zhang X. "In terms of missile precision attack control, proportional guidance law was first applied to the design of the missile guidance and control system and proved to be a simple and effective method." [11].

Table 2. Domestic unmanned aerial vehicles.

Name	Developer	Units produced	Purpose	Tasks to be solved
Aileron-3	CJSC "ENIX"	>200	The complex is designed for round-the-clock aerial optical-electronic reconnaissance	Visual search of exploration objects in real time; detection and recognition of intelligence objects; determination of the exact location of objects; aerial photography
Orlan-10	"Special Technolo gy Center"	>1000	Monitoring of extended and local objects in an accessible area, including during search and repair work	Broadcast of the target for destruction by all combat vehicles (self-propelled guns, tanks, infantry fighting vehicles, air defense vehicles) connected to the ESU TK
Orlan-30	"Special Technolo gy Center"	Is unknown	Conducting reconnaissance and maintenance of artillery firing in the optical and infrared ranges	Determination of projectile deviations from the target and calculation of corrections when shooting to kill
IRKUT-10	Irkut	Is unknown	Terrain monitoring in various weather conditions	Provision of real-time reception and transmission of television and thermal imaging signals to Earth

Although most drones are used directly for military purposes, it is also worth mentioning land-based drones. As of February 2022, testing of passenger drones is still sparse and does not go beyond single test drives. The computer software that drives the unmanned vehicle uses artificial intelligence algorithms. As University of London researchers Katie Inder, Varuna De Silva and Xiyu Shi note in their paper, "Currently, training autonomous vehicles that autonomously navigate environments requires extensive training mileage." [12].

The global crisis caused by the new coronavirus infection COVID-19 has led to a significant increase in unemployment, slowed supply chains and reduced demand for goods. However, some drone companies have been able to benefit, including through the medical use of commercial drones.

Aeronet predicts that by 2025 there will be over 100,000 unmanned aircraft in the skies over Russia, with a global market of over $200bn, of which Russia's share will range from $35bn to $40bn. The Russian market potential is extremely large, with Aeronet estimating the market will expand to 2.5 million devices by 2025.

Based on data provided by "Drone Industry Insights", the drone market will almost double in 5 years, showing an average annual growth rate of 13.8%. The analysis shows that despite emerging challenges, the commercial drone industry will tightly consolidate and remain resilient.

Russia is expected to continue increasing the number of drones for military purposes and importing them from abroad. In the future, civilian drones in the form of monitoring systems and delivery vehicles should be expected.

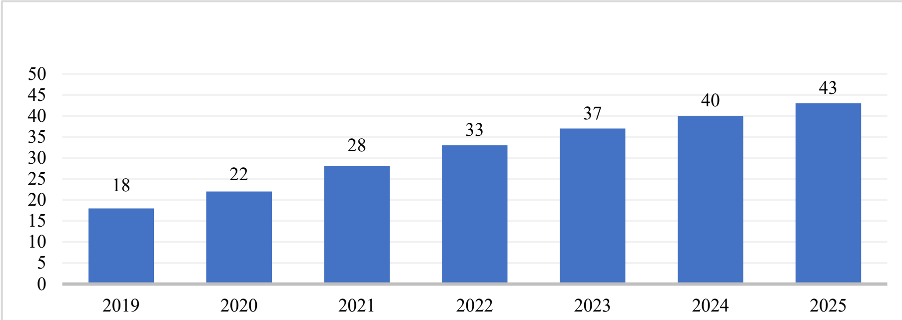

Fig. 1. The projected volume of the drone market until 2025, billion dollars according to the analytical agency "Drone Industry Insights"

4 Conclusions

Although Russia has made some progress in the development and use of UAV, the country still lags behind the US, China and European countries. Despite the attractiveness of the technology, engineers have to revise and refine some aspects of the aircraft. Mass production of low-cost drones needs to be ramped up to match price and commercial operation, and work needs to be done to fine-tune infrastructure and integrate drones into the existing transportation system. In this study, statistics and analysis have been reviewed and the following challenges have been identified:
1. technology is not perfect, artificial intelligence does not allow drones to operate fully autonomously;
2. extremely limited number of companies manufacturing UAV;
3. drones are more popular in military activities than in civil society.
Based on the above-mentioned problems, the following suggestions for solutions are offered:
1. UAV artificial intelligence needs to be upgraded to take into account territorial and weather conditions. This will not only reduce the number of accidents but also make the work of the command posts easier. Engineers are refining the AI every day and tests are being conducted;
2. The number of companies making UAV is extremely low. The government needs to invest in new technology and get engineers involved. With the growing interest in drones and the market not crowded with competitors, export of drones can attract both investment and money into the budget;
3. Russia is exclusively interested in military UAV, completely ignoring the consumer market. A number of countries already use commercial drones to simplify some tasks in industries, search and rescue operations, etc. Mass production requires government investment similar to that received by military specialists for development of combat and reconnaissance UAV.

References

1. E. Çetin, et al., Drones **6(2),** 28 (2022). DOI 10.3390/drones6020028.
2. R.I. Mukhamediev, et al., Applied Sci. **11(21),** 10171 (2021). DOI 10.3390/app112110171.

3. E. Çetin, et al., Drones **6(2),** 28 (2022). DOI 10.3390/drones6020028.
4. M. Aliyari, B. Ashrafi, Y.Z. Ayele, Structure and Infrastr. Eng. **18(3),** 412-428 (2022). DOI 10.1080/15732479.2020.1858878.
5. J. Jia, W. Cui, J. Liu, Frontiers in Env. Sci., 734 (2022). DOI 10.3389/fenvs.2021.778598.
6. V. Chamola, et al., Ieee access **8,** 90225-90265 (2022). DOI 10.1109/access.2020.2992341.
7. K. Kolosov, A. Miller, B. Miller, Remote Sensing **12(23),** 3849 (2020). DOI 10.3390/rs12233849.
8. T. Elmokadem, A.V. Savkin, Sensors **21(18),** 6223 (2021). DOI 10.3390/s21186223.
9. N. Elmeseiry, N. Alshaer, T. Ismail, Aerospace **8(12),** 363 (2021). DOI 10.3390/aerospace8120363.
10. A. Alharbi, et al., *Rule-based conflict management for unmanned traffic management scenarios* in 2020 AIAA/IEEE 39th Digital Avionics Systems Conference (DASC). IEEE, p. 1-10 (2020). DOI 10.1109/DASC50938.2020.9256690.
11. H. Huang, X. Zhao, X. Zhang, Comput. Intell. and Neurosci. **2022** (2022). DOI 10.1155/2022/8235148.
12. K. Inder, V. De Silva, X. Shi, Remote Sensing **11(23),** 2723 (2019). DOI 10.3390/rs11232723.