ТРАНСПОРТНЫЕ СИСТЕМЫ
2.9.1 – Транспортные и транспортно-технологические системы страны, ее регионов и городов, организация производства на транспорте;
2.9.4. – Управление процессами перевозок;
2.9.6 – Аэронавигация и эксплуатация авиационной техники;
2.9.8 – Интеллектуальные транспортные системы

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Bird detection in the airfield area as a factor in ensuring ornithological safety of aircraft flights

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Abstract: The article considers the problem of ensuring ornithological safety of aircraft flights in the aerodrome area, where collisions with birds pose a serious threat that can lead to serious consequences in the form of an aviation accident or an aviation incident. Also, such collisions often lead to significant financial losses for airports, airlines, and insurance companies. The purpose of the study is to analyze the existing bird detection system in the aerodrome area, assess the quality of these systems and develop recommendations for improving the efficiency of using systems that ensure ornithological safety. The article considers various methods of bird detection: visual observation, acoustic systems, radar systems. An assessment of the effectiveness of the methods is given taking into account the accuracy, range and applicability in various conditions. The methods of statistical data analysis, analysis of the probability of occurrence of a dangerous factor are applied. The study revealed the need to use special ornithological radar stations with improved detection range and automatic target recognition, as well as the use of acoustic systems to detect birds in adverse weather conditions. The importance of continuous monitoring of the ornithological situation in the airfield area and timely decision-making in the event of a dangerous factor is noted. To effectively ensure ornithological safety of aircraft flights, it is necessary to implement a comprehensive system that combines modern detection technologies, automated warning systems and bird scaring methods developed for each airport. Further research based on this work should be aimed at developing more accurate and effective radars in terms of bird detection range and improving the methods of forecasting and identifying the likelihood of a dangerous factor and a risk factor.

Key words: ornithological flight safety, aerodrome, dangerous factor, risk factor, radar systems, acoustic systems, visual observation.

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Обнаружение птиц в районе аэродрома как фактор обеспечения орнитологической безопасности полетов воздушных судов

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Аннотация: В статье рассматривается проблема обеспечения орнитологической безопасности полетов воздушных судов (ВС) в районе аэродрома, где столкновения с птицами представляют серьезную угрозу, которая может привести к тяжелым последствиям в виде авиационного происшествия или авиационного инцидента. Также подобные столкновения часто приводят к значительным финансовым потерям аэропортов, авиакомпаний, страховых компаний.

Целью исследования является анализ существующей системы обнаружения птиц в районе аэродрома, оценка качества функционирования этих систем и разработка рекомендаций по повышению эффективности использования систем, обеспечивающих орнитологическую безопасность. В статье рассмотрены различные методы обнаружения птиц: визуальное наблюдение, акустические системы, радиолокационные системы. Дана оценка эффективности методов с учетом точности, дальности и применимости в различных условиях. Применены методы статистического анализа данных, анализа вероятности возникновения появления опасного фактора. В рамках исследования было выявлено, что необходимо использование специальных орнитологических радиолокационных станций с улучшенной дальностью обнаружения и автоматическим распознаванием целей, а также применение методов акустических систем для обнаружения птиц в сложных метеоусловиях. Отмечается важность постоянного мониторинга орнитологической обстановки в зоне аэродрома и своевременного принятия решений в случае появления опасного фактора. Для эффективного обеспечения орнитологической безопасности полетов ВС необходимо внедрение комплексной системы, сочетающей в себе современные технологии обнаружения, автоматизированные системы оповещения и отработанные для каждого аэропорта методы отпугивания птиц. Дальнейшие исследования, основанные на материале данной статьи, должны быть направлены на разработку более точных и эффективных с точки зрения дальности обнаружения птиц радиолокаторов, а также на совершенствование методов прогнозирования и выявления вероятности возникновения опасного фактора и фактора риска.

Ключевые слова: орнитологическая безопасность полетов, аэродром, опасный фактор, фактор риска, радиолокационные системы, акустические системы, визуальное наблюдение.

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Introduction

The main purpose of air transportation is to ensure flight safety. Flight safety consists of minimizing risks and preventing aviation incidents using modern technologies, inspections, controls and strict safety standards. Annually, the damage to global aviation from bird strikes reaches 1.2 billion US dollars. Therefore, it is necessary to develop a system of measures to detect and scare away birds in the airfield area. Studies have shown that in 45% of recorded cases of such collisions, birds enter the engine (engines) of the aircraft, which can lead to its failure, fire or surge, and in 12% of cases, they enter the radome or flight deck windows, which under certain conditions threatens to depressurize the aircraft. The main problem is the detection of birds at night and in bad weather conditions. At the moment, there are no absolutely reliable technical means for completely scaring away birds from the airspace and the territory surrounding the airfield [1]. The effective prevention of aircraft-bird strikes requires an integrated approach based on timely bird detection and bird awareness. This paper examines current bird identification and detection technologies and discusses their potential application at airports to reduce the risk of strikes.

Paper [2] provides data that since 2004 the total number of ornithological aviation incidents and accidents in the Russian Federation in relation to the USA, per 100 thousand takeoffs and landings, has been significantly higher. For the Russian Federation, this figure was 1.55 in 2004, and in the USA in 2008 – 1.16, i.e. the difference was 1.34 times, and in 2017 this difference was already 1.52 and 3.71, i.e. it increased by 2.44 times.

In other words, our gap in safety indicators in terms of ornithological support for flights from the United States is increasing.

Bird detection methods in the airport areas: review and efficiency analysis

The analysis of data presented in the works [2–6] indicates a significant increase in the number of bird strikes with civil aviation aircraft both worldwide and in the Russian Federation in recent years. This increase in ornithological incidents is brought about by a number of factors.

Firstly, there is a stable trend towards increased air traffic intensity in global civil aviation. Secondly, for various reasons, there is a natural increase in bird populations on a global scale. Thirdly, and this is especially important, a significant number of bird strikes were not officially recorded in the past.

Currently, both ICAO and the Federal Air Transport Agency impose mandatory requirements for recording all collision incidents, regardless of the consequences for the aircraft. According to the Federal Air Transport Agency letter No. AN1.02-3056 dated September 18, 2015, aerodrome operators are required to organize the recording and analysis of such cases, as well as to prepare and send reports on collisions, including incidents with aircraft of foreign operators, to the Flight Safety Inspection Department. Similar requirements for the filing of reports are also imposed on aircraft operators.

It should be noted that the most collisions (approximately 90%) do not lead to aviation incidents or accidents, much less accidents or disasters. However, there are well-known examples in aviation literature where bird strikes have had catastrophic consequences. One of the tragic examples of the negative impact of the ornithological situation on flight safety is the aviation accident that occurred on July 29, 2007, involving the Antonov-12 aircraft operating a flight route Domodedovo – Omsk – Bratsk – Komsomolsk-on-Amur. Just 20 seconds after rotation, a critical failure of both right engines occurred, caused by birds getting into the power units.

The crew took measures to stabilize the aircraft, but the loss of speed led to a crash landing into a forested area a minute after the engines had failed. The subsequent destruction and fire of the structure led to the death of all six crew members and one passenger on board.

To illustrate the dynamics of the growth in the number of bird strikes with aircraft in the Russian Federation, Figure 1, compiled by the authors based on the Federal Air Transport Agency data on statistics of birds and other animals strikes, shows the dependence of the number of such incidents in recent years compared to 2010.[1] If in 2010 about 50 collisions were recorded, then in 2023 this number increased to 1299, which corresponds to an increase of 26 times. At the same time, in 2023 compared to 2022, there was an increase of 38% (an increase of 1.38 times).

The document – FAR-331 (Federal Aviation Rules 331) states that for monitoring the ornithological situation at the airport, visual or radar observation aids should be used. It should be noted that currently, radar surveillance of the ornithological situation is not used at Russian airports due to the lack of appropriate ornithological radars. To ensure ornithological safety, a number of international airports use specialized real-time bird detection systems. In particular, Seattle/Tacoma International Airport and John F. Kennedy International Airport use radar stations to monitor bird movements. Amsterdam Airport Schiphol and Atlas International Airport have implemented the Harrier and MERLIN systems, respectively, to achieve comprehensive radar coverage. Additionally, San Francisco International Airport uses a high-resolution video surveillance system designed to track bird activity in the controlled area [7]. This may be one of the reasons why the number of ornithological incidents and accidents in the U.S. is significantly lower than in Russia, as the U.S. major airports (New York, Dallas, Seattle) use radar systems of the “Harrier” and “Merlin” types [8]. For information, we present the technical data of these radars:

Signal type – Pulse with Doppler.
Frequency range – centimeter.
Range resolution: 10 m or 20 m.
Number of frequency channels – 6.
Range – 8 km.
Azimuth angle – 360°.
Elevation angle – 45°.

In the Russian Federation, a radar station called “ENOT” has been developed, which is not essentially an ornithological station, although it is stated in the list of its detected objects that it provides: automatic detection of moving targets such as “bird”, “drone”, “airplane”, “person”, “car” in the presence of direct visibility.

The main tactical and technical characteristics of the “ENOT” station correspond to American analogues, but the maximum detection range of a typical target is only 2500 m, which is more

[1] Birds and other animals strikes FAVT. FAVT. Available at: https://favt.gov.ru/dejatelnostbezopasnost-poletov-stolknoveniya-ptici/ (accessed: 25.03.2025).

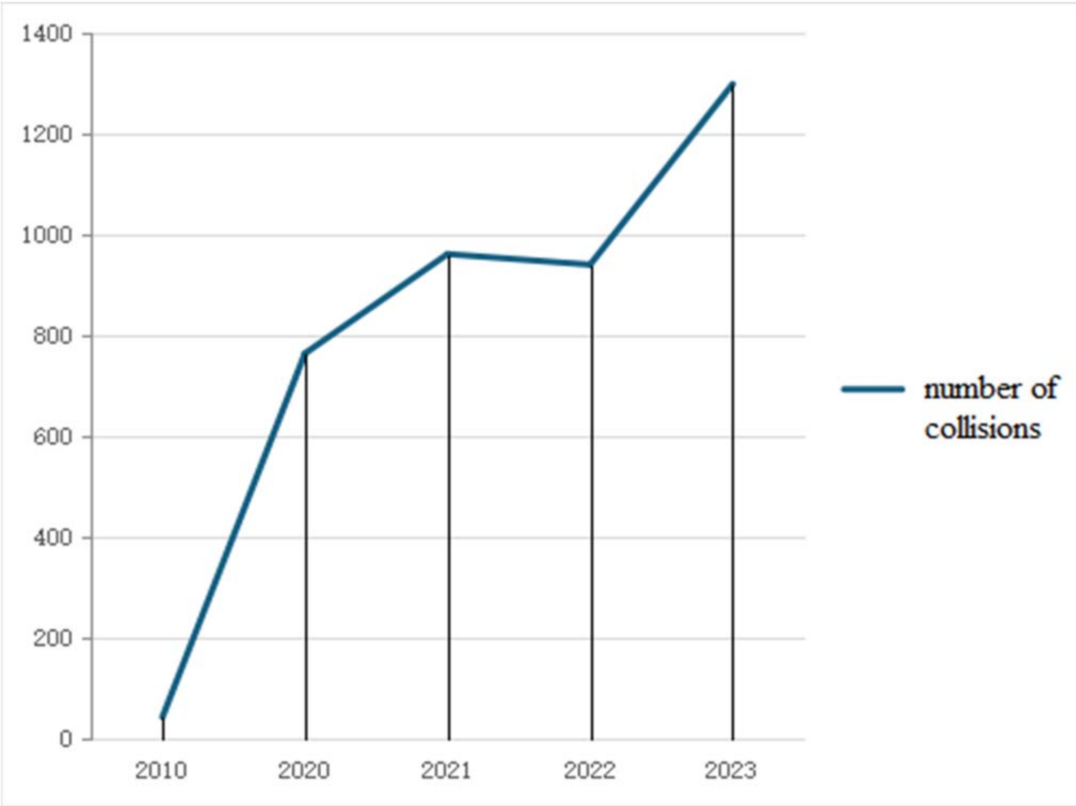

Fig. 1. Number of bird strikes with aircraft in the Russian Federation by years

than 3 times worse than American models. Taking into account the assigned task: the detection of birds – the range of detection of the "ENOT" system does not correspond at all to the concept of an "ornithological" radar.

Thus, it is necessary to solve the problem of using special ornithological radars at airports in the Russian Federation with complex ornithological conditions [9]. In this case, the concept of ornithological radar should include the function of identification and classification of detected birds.

Based on long-term analysis, certain patterns have been identified that characterize the threat posed by birds. More than 70% of all collisions occur during the day, with the most dangerous altitudes being up to 100 m (52–80% of all collisions). About 47–57% of collisions occur during the descent and landing stages, and 30–47% during the takeoff and climb stages. A striking example was the recent crash of the South Korean Boeing. According to the official preliminary investigation report, on Sunday, December 29, 2024, at about 04:30 (local time), a passenger flight of Jeju Air (HL8088, B737-800) took off from Suvarnabhumi International Airport in Thailand with 181 passengers on board, including 6 crew members and 175 passengers. At 08:54:43, HL8088 first contacted the Muan International Airport control tower for landing clearance. The tower cleared the aircraft to land on runway 01. As HL8088 approached the runway, the tower warned the crew to be careful of birds at 08:57:50. A few seconds later, HL8088 due to a bird strike, the aircraft issued a Mayday distress signal, which is used only in critical situations when the crew understands that the lives of people on board are in danger. As HL8088 was flying over the left side of RWY 01, it turned right and approached RWY 19 to land on it after aligning with the runway centerline. The aircraft belly-landed without landing gear extended, veered off the runway, crashed into an embankment, and caught fire. As a result of this accident, four crew members and 175 passengers were killed, and two crew members were seriously injured. According to the report, the cockpit voice recorder and flight data recorder stopped recording four minutes before the accident. The pilots noticed a flock of birds while approaching Runway 01, and a surveillance camera captured HL8088 approaching the flock of birds during the go-around. Both engines were sent for examination, and feathers and blood stains from birds were found on each of them. The samples were sent to specialized organizations for DNA analysis, and a local organization identified them as belonging to Baikal teals (a duck family). Following the crash, South Korean officials said they would install bird-detection cameras and thermal imaging cameras at all airports in the country. The new equipment is said to help determine the size and trajectory of birds from a distance, allowing air traffic controllers to respond more quickly to threats and mitigate the risk [10]. Thus, the weight of the bird directly affects the degree of collision hazard for aircraft; the heavier the bird is, the higher is the risk of damage. Even a small bird, the size of a duck, is capable of breaking through a three-centimeter glass of the aircraft cockpit. International aircraft design standards require the stability of the cabin, engines, fuselage and wing to the impact of a bird weighing up to 1.8 kg, a collision with a flock or large birds, such as geese, ducks (up to 5 kg), can lead to serious damage, including engine destruction and deformation of the fuselage, wing, empennage. These requirements are set out in the airworthiness standards (AS) 35, which are harmonized with the relevant sections and appendices of the US AS FAR-35 with amendments up to and including 35-8 and with the requirements of the European airworthiness standards CS-P with amendment 1.[2]

A major engine failure can be seen in a serious incident that occurred on March 1, 2025, in Newark, New Jersey. The FedEx Boeing 767 cargo plane made an emergency landing nine minutes after takeoff. The emergency landing was caused by an engine fire caused by a bird strike. Figures 2–3 show the aftermath of the collision.

Fig. 2. Destroyed engine as a result of a bird strike

Fig. 3. Destroyed engine nozzle because of a bird strike

Airports are required to use the radar to determine the size and dimensions of birds, which are generally proportional to their weight [11]. Determining the size of a bird from radar echoes

[2] Order of the Federal Air Transport Agency No. 785-P dated 02.11.2022 On approval of the Airworthiness Standards of propellers NLG 35. ConsultantPlus. Available at: https://www.consultant.ru/document/cons_doc_LAW_434288/ (accessed: 25.03.2025).

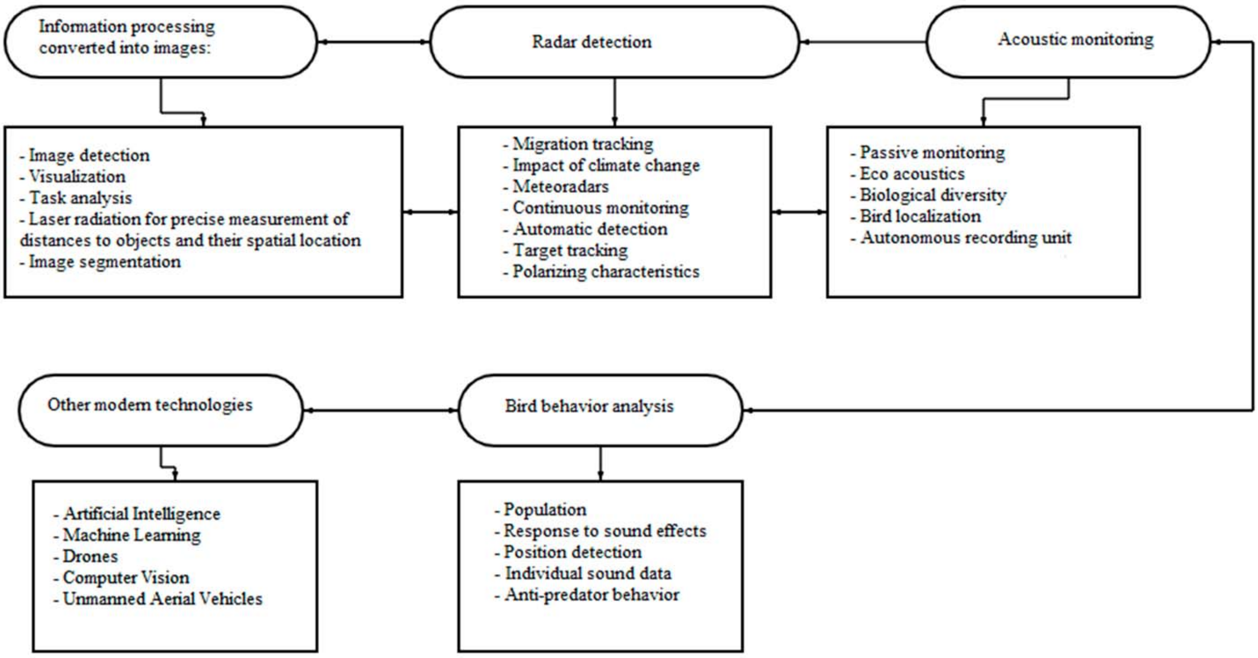

Fig. 4. Block diagram of a set of automated means for monitoring the ornithological situation

can quantify the level of bird strike hazard, thereby providing airports with guidance on how to deal with a bird strike threat.

A set of automation tools for monitoring the ornithological situation at the airport

In order to improve the efficiency of ensuring ornithological flight safety in the aerodrome area, it is necessary to develop and implement a set of automated means for monitoring the ornithological situation, which is an integrated system for collecting, processing, analyzing and visualizing information on the presence and movement of birds. A set of automated means for monitoring the ornithological situation ensures continuous monitoring of the ornithological situation in real time, timely notification of airport services and aircraft crews about potential collision threats, and also provides analytical data for the development and implementation of effective risk management measures. Figure 4 shows a set of automated means for monitoring the ornithological situation in the form of a block diagram.

Processing information converted into images. Identification of bird species in the proposed system is carried out by analyzing images obtained using cameras, including thermal imaging [12]. The process consists of extracting relevant features from the image and then comparing them with reference data obtained as a result of preliminary training of the systems. The accuracy and speed of recognition directly depend on the volume and quality of the sample.

Key steps in the process of classifying bird images include object detection, feature extraction and image segmentation [13]. These steps are the subject of scientific research aimed at improving the accuracy and speed of target detection.

Feature extraction, which includes the analysis of morphological characteristics, appearance, and color parameters, is a preliminary processing stage aimed at identifying the most significant elements of an image. Researchers have found that identifying differences in the color of birds and the background color of the natural environment is particularly difficult, requiring the use of highly accurate image segmentation methods [9]. Image segmentation is a complex and labor-intensive task in digital image processing and is an actively developing area of research in the field of object recognition.

Radar detection: The advantage of radar bird detection over other methods of detecting bird images is due to several factors:

1. Radars are capable of detecting birds at significant distances, reaching dozens of kilometers, which allows for early detection of bird flocks and taking measures to prevent collisions with aircraft.
2. Radars can provide continuous monitoring, operating around the clock, regardless of time of the day or lighting conditions.
3. Modern radars are capable of detecting birds in conditions of limited visibility, such as fog, haze, and rain.
4. Modern radar systems are equipped with automatic target detection and tracking systems, which allows tracking the movement of birds in real time.
5. Modern radars that use the polarization characteristics of the signal are able to distinguish the size and type of bird, providing more detailed information about the ornithological situation.

The above factors are extremely important for solving the problems of ensuring flight safety, but it should be noted that for high-quality work it is necessary that radar data be integrated with other systems, such as automatic information transmission systems in the aerodrome area, bird scaring systems, meteorological systems, which will allow the creation of a comprehensive system for ensuring ornithological safety.

However, at present, there is no way to obtain accurate information about bird species using radar detection in civil aviation. Despite significant advantages, there is a number of disadvantages and difficulties in implementing radars with the required characteristics to fully ensure flight safety in the airfield area [14]. Firstly, the cost of such installations is very high, so it will not be possible to install such radars in every airport in the Russian Federation in the foreseeable future. Secondly, there is a high probability of a false signal when various interferences occur, such as insects, weather conditions, drones, buildings, trees. Therefore, a radar is often used to study bird migrations and detect birds in the airfield area at night.

To mitigate the dependence on meteorological conditions, the ornithological radar must have a function of switching between the centimeter and millimeter range. The most complex interference situation arises at the input of the radar receiving devices due to the impact of interfering reflections from hydrometeors. This is due to the wide variety of different meteorological formations (fog, hail, rain of varying intensity, snowfall, etc.) [9]. At the same time, the level of signals from interfering reflections from hydrometeors can change significantly over time (change in the intensity of meteorological formations), in space (wind influence), i.e. it has a clearly expressed stochastic nature.

When strong interference occurs, the orientation angle of the polarization plane of the electromagnetic wave changes β_p, and in this case, the probability of correct detection will be presented in the following form [15]:

$$P_{cd} = 1 - F(h_0 - \sqrt{\frac{2E}{N_0}} \cos \beta_p). \quad (1)$$

In formula (1) $h_0 = \sqrt{2}h / \sqrt{N_0 E}$; F(x) is the Laplace function; h_0 is the detection threshold; $(2E/N_0)$ is the signal-to-noise ratio; β_p is the orientation angle of the plane of polarization of the electromagnetic wave; $\cos(\beta_p)$ is the cosine of the orientation angle of the plane of polarization.

According to this ratio, it is easy to see that an increase in the angle β_p according to the presented ratio leads to a deterioration of detection parameters. At a fixed signal/noise ratio, a decrease in the probability of correct detection (P_{cd}) is observed in the range from 1.1 to 1.7 times. Such a loss of sensitivity of the radar system can be qualified as the occurrence of a dangerous factor.

Doppler weather radar is more resistant to interference because the interference can be distinguished and removed during analysis. Refinement of radar echo signal is a prerequisite for improving detection and identification capabilities. Due to its wider detection range, Doppler weather radar can analyze bird information while obtaining weather information. Therefore, it is widely used to study the impact of weather conditions on bird migration and to develop bird migration forecast models by combining artificial intelligence training and other methods.

Acoustic monitoring. Acoustic signals are one of the key methods used by environmental specialists to assess bird biodiversity. Researchers in this field often use separate autonomous recording devices to record sound signals. The large memory capacity of digital recorders used for acoustic monitoring allows long recording periods, and the recorded data is used for subsequent studies and reassessment. The recorded bird sounds data usually requires preprocessing operations such as bias correction to ensure accurate results. Acoustic monitoring can be used for a wide range of purposes, including bird identification, monitoring bird species diversity, and monitoring during night bird migration. Acoustic signals emitted by birds during different ecological processes (mating, reproduction, migration, etc.) are usually different, which makes acoustic monitoring of birds more challenging and at the same time presents high research value.

The three main methods described above are often used in combination with each other or with some other technical means, such as Machine Learning, Artificial Intelligence Training, Unmanned Aerial Vehicle (UAV) detection, and computer vision processing. Bird behavior highlights the adaptive process in which birds tend to give different responses to stimuli when faced with external influences.

Visual observation is limited by many factors and cannot meet the need for obtaining accurate information about birds.

Other modern technologies. Modern technologies such as Artificial Intelligence (AI), Machine Learning (ML), Computer Vision (CV) and Unmanned Aerial Vehicles (UAVs) have great potential to significantly improve the efficiency of ensuring ornithological flight safety. They allow automating and optimizing the processes of detection, identification, forecasting and scaring birds away, thereby reducing the risk of collisions with aircraft. For example, ML allows processing a large volume of data received from acoustic and radar signals. AI can help develop forecasts based on available statistics. UAVs can be used both for monitoring and for prompt scaring birds away. The possibility of using each of these systems requires additional scientific research, but the effectiveness of these systems is obvious.

Analysis of bird behavior. The adaptive nature of bird behavior is determined by their ability to form various behavioral reactions in response to changing internal (physical) and external (environmental) conditions. These reactions cover a wide range of actions, including communication, strategies for protection from predators, methods of obtaining food, and the manifestation of rhythmic processes at the moment of influence of various systems.

To eliminate incidents involving collisions of birds with aircraft, means for repelling or destroying birds from the general list given in [5] are used:

1. Bioacoustic installations. 2. Gas guns. 3. Rattles. 4. Mirror balls. 5. Laser Repellers. 6. Nets. 7. Dummies imitating dead birds. 8. Chemical methods. 9. Radio-electronic and electromagnetic methods. 10. Specially trained birds and dogs. 11. Radio-controlled models. 12. Unmanned aircraft.

An analysis conducted by various authors [2, 5] showed that for various reasons the first 8 methods are ineffective due to the rapid habituation of birds to the corresponding impact. The 9th method is currently undergoing experimental testing and cannot yet be definitively recommended for use. The 10th method is quite difficult to apply and for obvious reasons cannot be recommended everywhere.

From the above, it follows that the use of radio-controlled models and unmanned aircraft is advisable as the primary means of scaring birds away from airfields. The study [5] examined various means of scaring birds and, regarding the possibility of using radio-controlled models, the following was said: "this method has not received wide application due to the difficulties of controlling the models and the need to have a specially trained specialist at the airfield."

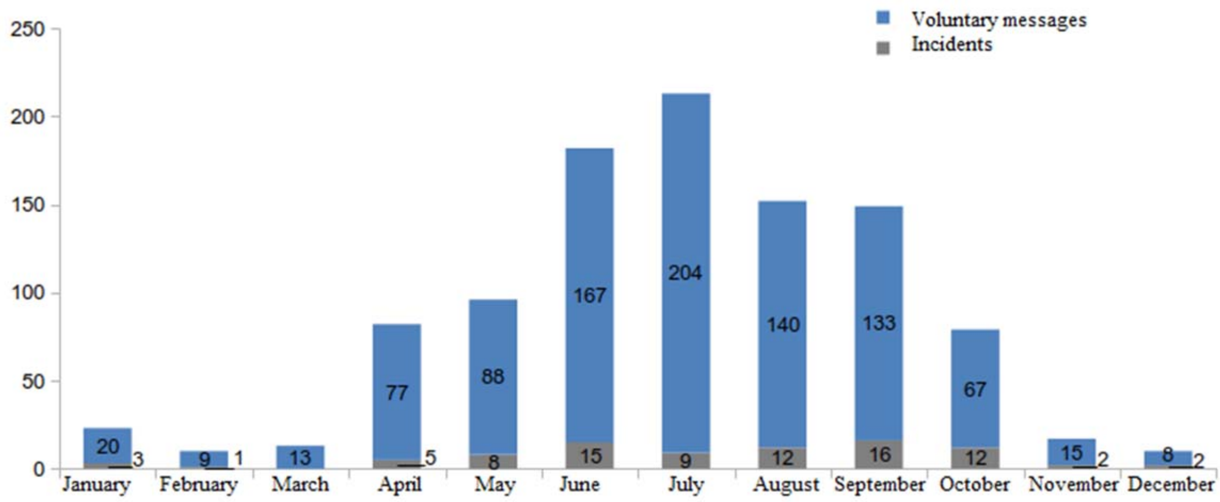

Fig. 5. Number of aircraft collisions (threats of collisions) with birds in 2022

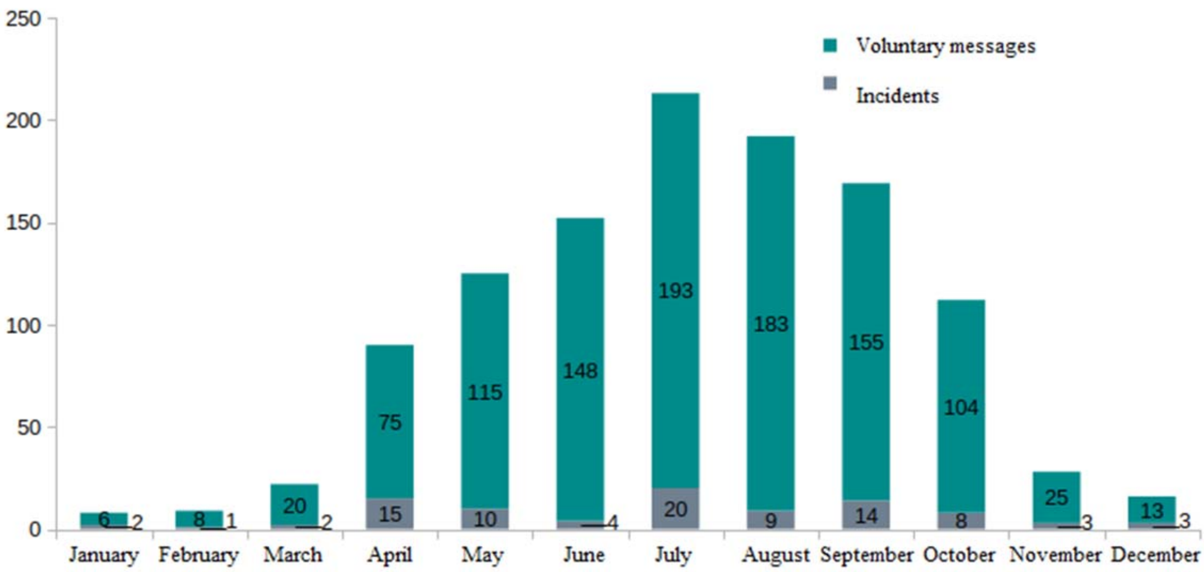

Fig. 6. Number of aircraft collisions (threats of collisions) with birds in 2023

However, the very concept of ensuring ornithological safety at airports implies the presence of specialized ornithological services staffed by trained personnel [3].

Airports are a central object in scientific research aimed at finding methods and ways to prevent bird strikes [16–18]. However, the geographical and ecological environment around the airport is complex and diverse, including various types of habitats such as wetlands, forests and agricultural lands, leading to a large number of birds that are difficult to monitor [19]. The likelihood of incidents related to aircraft collisions with birds is influenced by various factors, such as flight maps and airport locations, weather conditions at airports, the season and time of day, types of aircraft in operation, the effectiveness of the ornithological support system at airports, as well as the knowledge and qualifications of aviation personnel in the field of ornithological flight safety. In general, birds pose the greatest threat to flights in summer, as their populations increase at this time of year due to reproduction. The annual peak of collisions occurs in July (Figure 5–6). The risk to flight safety increases during this period [6].

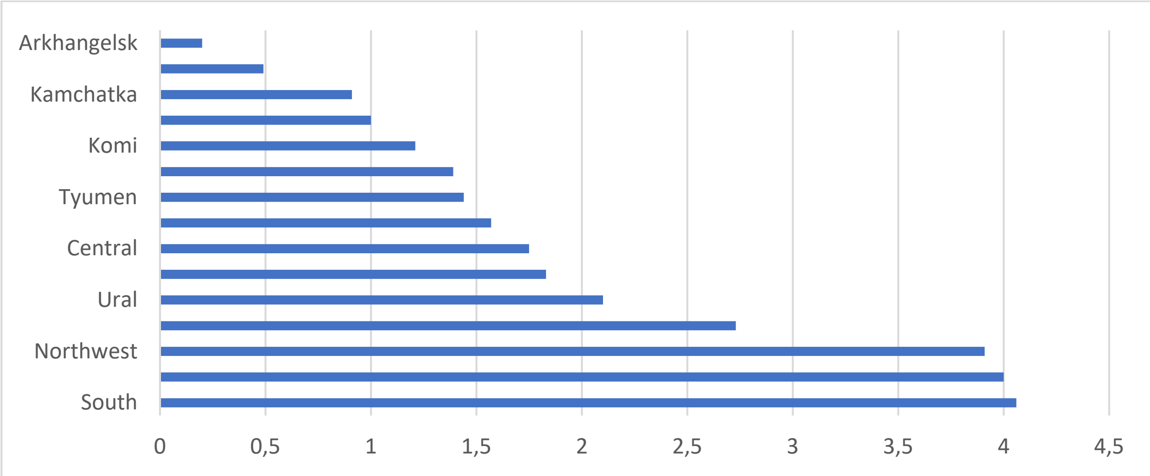

Fig. 7. Distribution of the relative number of incidents (Number of incidents per 100 thousand takeoffs and landings at airports (their areas)) associated with collisions with birds by local agencies of the Federal Air Transport Agency

The inconsistency of risk is also noted by territorial principle [4]. Analysis of the Federal Air Transport Agency data showed that the leader in the number of incidents per 100 thousand takeoffs and landings at airports (their areas) related to collisions with birds is the Southern Interregional Territorial Administration [20] (4.06 incidents) (fig. 7).

Airports find it difficult to analyze the overall situation with birds in the subzones, which complicates obtaining accurate data about birds to ensure flight safety. Therefore, detecting birds in the vicinity of the airport is of particular importance.

Most of the bird detection radars used at major airports around the world are marine radar systems with a horizontal detection range of 5 to 20 km, which cover a wide range and can detect birds that cannot be tracked visually and provide high-resolution images of bird movements. Airport bird detection radar systems can provide airport operators with information on bird activity in clear weather, so that bird scaring measures and control plans can be organized in advance.

Once again, it should be noted that radar systems cannot detect birds in the rain due to precipitation reflections. Some ground obstacles (such as buildings) and air interferences (such as insects) will affect the radar's ability to detect and track birds, leading to an inability to accurately perceive this phenomenon. At the same time, radar systems are expensive and currently widely used mainly in European and American countries. Therefore, it is necessary to create comprehensive systems for detecting and identifying birds in the airfield area, as well as using methods to scare away and protect aircraft from collisions with them.

Conclusion

Based on the above, a conceptual model for the widespread implementation of systems that ensure ornithological flight safety is proposed.

The proposed model divides the ornithological situation control zone in the aerodrome area into small, medium and large. The small zone is defined as the area in which an aircraft performs the following flight stages: taxiing, takeoff and landing, and is located within 8 km from the aerodrome perimeter. The medium zone covers the airspace at a distance of 8 to 50 km from the aerodrome perimeter and includes various natural objects that attract birds (e.g. lakes, wetlands, agricultural lands, forests). The large zone is an area from 50 km to the maximum range of the Doppler weather radar. The longest range of a Doppler weather radar can reach 460 km. For example, the radar meteorological stations of the NEXRAD network in the USA have a beam width of 1° and observe a large area in a cycle lasting from 4.5 to 10 minutes.

In the small zone, the priority is to determine the ornithological situation in real time. Visual observation is supplemented by data from bird detection radars, information processing and its transformation into images. In the middle zone, airspace monitoring is carried out primarily using radars, with data integration and analysis to track bird trajectories and promptly develop recommendations. Each mid-zone object can be equipped with acoustic monitoring equipment that provides timely data transmission and analysis, allowing for advance (several hours ahead) forecasting of risks associated with bird activity. In the large zone, it is advisable to use Doppler radars to obtain information on bird migrations and subsequent forecasting of the ornithological situation for the coming days. The generated forecasts can serve as a guide for planning measures to manage ornithological risks and scare birds away on the airfield territory.

Ensuring ornithological safety is impossible without integrating various methods of bird detection: visual observation, use of radars, analysis of statistical data. Only a combined approach, taking into account the strengths of each method, allows to obtain the most complete picture of the ornithological situation in the airport area.

Systematic monitoring of ornithological activity in the airport area, including collection and analysis of data on bird species, their numbers and behaviour, will enable reliable forecasts of potential collision risks. Effective bird detection is not only a guarantee of flight safety, but also a key factor in improving the efficiency of airport operations and ensuring comfortable conditions for all air traffic participants.

The study confirms that effective detection of birds in the aerodrome area is a critical element in ensuring the ornithological safety of aircraft flights. An analysis of existing detection methods, from traditional visual observations to modern radar systems, revealed both their advantages and serious limitations. The problem is especially acute in southern regions, in conditions of poor visibility and difficult meteorological conditions, as well as when it is necessary to detect birds at a significant distance from the runway.

Despite existing measures, bird strikes continue to pose a serious threat, resulting in material losses, flight delays and accidents. This highlights the need for continuous improvement of bird detection technologies and methods.

The further direction of scientific work should be the development of specialized radar systems designed specifically for the tasks of ornithological protection of airfields.

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