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Risk prevention strategies of aircraft with wildlife strike

Abstract. The paper presents a set of problems of the complexity of observing strikes of aircraft with wildlife. The study was carried out on the choice of a group of birds with the most significant in terms of the number of species and strike damage. The development of a metric for observing the fuzziness of strike events is aimed at resolving the problem in interpreting data, incomplete, inaccurate information in strike reports. The set of problems consists in the extreme complexity of observing, fixing and registering the facts of strike, identifying groups and types of wildlife, which is required to develop strategies for the ecological balance of aviation and wildlife. Risk prevention strategies of aircraft with wildlife strike are developed.

Keywords: aircraft, wildlife, strike, flight safety, avian safety, risk, strategies

Introduction. This paper analyzes modern studies of strike of aircraft with objects of wild nature (Wildlife) or air-terrestrial animals: birds, bats, terrestrial mammals, reptiles (Bird/Other Wildlife Strike). The study was carried out on the choice of a group of birds with the most significant in terms of the number of species and strike damage. The task of strike risk calculations establishes the possibility of reducing uncertainty, fuzzy event structure and creating metrics and calculations for risk management. In the subject of interaction of aviation with wildlife under study, all aircraft are considered: airplanes, helicopters, drones. The flight time starts from taxiing, takeoff run to the end of the landing run. Therefore, strike occur with air-terrestrial animals. The use of low-noise aircraft in commercial aviation is expected to reduce the ability of the wildlife to recognize a strike hazard. Aircraft at greatest risk are light, low-altitude, high-speed, single-engine aircraft. The damage from strikes differs greatly from the speed of the aircraft and the mass of the body of the wildlife [1, 2]. Airport operators use many methods to reduce the likelihood and severity of strike risks, such as fencing off take-off and landing areas, local observations for compiling eBird databases, movement monitoring, and species identification. However, these measures are not very effective in relation to the observation of migratory movements of the wildlife. Information about the location of the RBP based on expert observations and meteorological observation radars provides information on the resident and transit types of the wildlife. Radar observations provide information on the types of schooling, body weights of the wildlife, eBird data are based on the registration and reporting of previous strikes [3].

Content of the Problem. The International Civil Aviation Organization (ICAO) establishes aircraft flight safety requirements for the prevention of strike risks in the territories and near airports by fencing territories, displacement measures, scaring away and liquidations, that is, to the detriment of the safety of the airborne flight. Statistics based on the registration, recording and analysis of strikes are considered incomplete, since a significant part of the events is not recorded [4]. Real number of strikes are several times more registered. Aircraft crews and ATC services do not have volumetric information and at low altitudes. The set of problems consists in the extreme complexity of observing, fixing and registering the facts of strike, identifying groups and types of wildlife, which is required to develop strategies for the ecological balance of aviation and wildlife.

Strike Risk Prevention Strategies. At present, the aviation world community has established the following strategies and measures to prevent the risks of aircraft strike with wildlife.

Strategy 1. Increasing the strength of the aircraft. Design and construction of aircraft elements with protection against damage and destruction. Designing different characteristics of windshields and engines inlet nozzles using high-strength materials and coatings that eliminate the worst-case scenarios of accidents. Certification of the airworthiness of the aircraft and structural elements with respect to strike with the wildlife is carried out by national and international aviation administration [5, 6]. The European Aviation Safety Agency (EASA) establishes strength certification for fuselage structures, windshields and engines of wide-body commercial aircraft [7] against impact kinetic energy requirements, which is defined by (Eq. 1):

$$E_{kin} = 1/2 \cdot m \cdot (v)^2, \quad (1)$$

where (m) is mass, (v) is speed.

The kinetic energy certification criteria are set by EASA for large aircraft in the following values (table 1).

Table 1 – Certification criteria

Components	Kinetic energy criteria
Windshield	$E_{kin} = 1/2 \cdot 1{,}8\,kg \cdot (v_{ref})^2$, v_{ref} - cruising speed at the corresponding route altitude
Hull	$E_{kin} = 1/2 \cdot 1{,}8\,kg \cdot (0{,}85\,v_{ref}2438\text{ m})^2$, at the altitude 2438 м
Engine	$E_{kin} = 1/2 \cdot m_{bird} \cdot (102.9\text{ m/s})^2$, m_{bird} – bird body mass

Strategy 2. Aircraft space freedom. Otherwise, remove the wildlife from the aircraft space. Design and organization of the aircraft movement space, minimizing strike with wildlife. This strategy is being implemented in the following areas. (1) Organization of space. Airport fencing within five miles or greater distances of habitats and land use, wetlands, dredger containment sites, municipal solid waste landfills, and nature reserves that attract wildlife. (2) Regulatory actions. Development of regulatory documentation for ornithological flight safety. Formation of a database of

strikes, statistical analysis, participation in investigations. Evaluation of the bird hazard of airfields, development and evaluation of the effectiveness of specialized means of protection against wildlife. (3) Ornithology. Organization of airport ornithological services, technical and biological means of scaring away birds in their habitats, formed by instincts over millions of years of evolution. The most productive is the content of the states of the "bird police" of hunting birds - saker falcons, golden eagles, pygmy eagles to "patrol" the sky over the airport. Creation of uncomfortable living conditions for wildlife. Extermination of insects, worms, cleaning of natural bird feeding areas near takeoff and landing areas, acoustic and bioacoustic installations, light signals, pyrotechnics, radio-controlled models of predators for scaring away, scarecrows, traps for trapping birds of prey, chemical means.

Strategy 3. Wildlife space freedom. Otherwise, remove the aircraft from the wildlife space. Preservation of the wildlife habitat outside the aircraft movement space. Visual and radar observations, notification of airports about dangerous ornithological conditions. Designing airfields and take-off and landing areas, taking into account the historical areas of bird settlement and accounting for their migration. Development of a strike risk avoidance model based on Geographic Information System (GIS), integrating data on geographical regions of habitat, migration and feeding of various bird species, the U.S. Bird Avoidance Model (BAM). The analysis of numerous studies reliably establishes that the absolute number of aircraft strikes with wildlife occurs near the earth's surface during departure and arrival up to a height of 1000 meters. The implementation of strike avoidance is based on a comparison of the trajectory of the aircraft and the wildlife, similar to the Airborne Collision Avoidance System (ACAS | TCAS), in which the space is structured into danger segments: caution, warning, strike. Unlike ACAS |TCAS, which displays the exchange of distance information between aircraft, the strike avoidance system displays information from radars of the distance between the aircraft and the wildlife to make decisions about maneuver, departure or approach delay and landing. Departure and arrival delays are related to runway and airport capacity calculations. Radars do not provide altitude information to calculate Closest Point of Approach (CPA) for comparison with Predicted Bird Position (PBP) and Actual Bird Position (ABP). The distance between PBPs when the aircraft reaches the CPA is called the CPA distance (dCPA).

Conclusion. The events of aircraft strikes with wildlife have a high frequency, extremely complex structure, and fuzzy content. These circumstances determine the complexity and costs of their observation and development of risk prevention measures. As the intensity of flights around the world increases, the total number of strikes will increase. The descriptions and structure of the subject area in this paper can be used as an approach for the development of manuals and manuals on ornithological flight safety management. The content of the work is based on the choice of a group of birds, which is recommended to be used when choosing other groups.

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