Литература:

1. *Новиков Д.А.* Теория управления организационными системами. – М.: МПСИ, 2005. – 584 с.

2. *Ткаченко В.А.* Система управления промышленной безопасностью с позиций теории систем / Труды XII международной конференции «Проблемы управления безопасностью сложных систем». – М.: РГГУ, 2004. – С. 432-437.

DOI: 10.25728/iccss.2022.26.90.065

Plotnikov N.I.

Estimation of accident hazard and magnitude of aircraft with wildlife strike damage in aviation safety vs avian safety

Abstract: This paper analyzes modern studies of strike of aircraft with objects of wildlife or air-terrestrial animals: birds, bats, terrestrial mammals, reptiles (Bird/Other Wildlife Strike). The probabilities of actual damages and risks are calculated. The solution to the problem of calculating strike risks is carried out in the development of a relational matrix that contains data by parameters, indicators in selected scales. The results of the work are presented as algorithms for optimizing the mutual protection of the aircraft and the wildlife.

Keywords: aircraft, wildlife, strike, hazard, magnitude, estimation

Introduction. 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. Real number of strikes are several times more registered. According to the US Federal Aviation Administration (FAA) estimates from 1991-1997 to the present, about 20% of strike that actually occur are recorded. Full statistics of strike observations is not maintained for various reasons: a) most of the strike are not critical, in the absence of damage to the aircraft, they may not be detected; b) lower priority of expenditures invested in security for this factor; c) a representative statistical sample of observations is preferred to complete statistics; d) insufficient formation and requirements for voluntary registration and accounting of the legal framework. In this paper estimation of accident hazard and magnitude of aircraft with wildlife strike damage in aviation safety vs avian safety of civil aviation (CA) has been completed. Methods of resource modeling of organizational objects are used [1].

Estimation of Strike Damage. Critical parameters are determined with the highest values of the "number of strikes" indicators, as well as the data "number of strikes with damage", established by expert and experimental means. In studies, it was statistically established that the highest frequency of strikes occurs with birds of 0.5-2 kg. It has been experimentally determined that the most striking mass of a bird is determined to be 2.7 kg. In the identified 33 bird species, a correlation (R2 = 0.82) was established between the average body weight and the probability of aircraft injuries: for every 100 grams of weight, the probability of injury increases by 1.22% [2]. It was revealed that the main danger is in the event of a strikes of the wildlife in the windshield and in the aircraft engines. A large bird breaks the windshield at speeds of over 500 km/h and this can have fatal consequences for the life of the pilot and catastrophic destruction of the aircraft. The impact force of a bird weighing 400 grams at an aircraft speed of 700 km/h reaches 20 tons. The risk of a pilot's death increases sharply at a speed of 400 km/h. Getting into the engine can lead to failure and disaster. The peculiarity of the consequences of strikes is that they can be either immediate or delayed. If destruction does not occur immediately, then destruction is possible during climb under the action of intra-cabin pressure and continued destruction of mechanical damage from high-speed air pressure in flight. An assessment has been made: the critical values of the indicators in the above matrix are highlighted in bold.

Aviation Safety vs Avian Safety. The solution of the problem of flight safety of aviation safety vs avian safety is similar to the solution of the problem of avoiding aircraft strikes in air traffic control. However, there is an important difference: in the strike avoidance problem, the motion of the aircraft is considered to be deterministic, which is possible for a formalized description, while in the problem of strikes between the aircraft and the wildlife, the motion of the wildlife is stochastic, the description of which is formally impossible. Observation parameters aircraft and wildlife are general and specific for each object.

Damages assessment. The following data are used to estimate and calculate the environmental damage caused by the wildlife in strikes with aircraft, the conditions and assumptions are accepted. Under the damages of the wildlife is meant the death of objects, since there is no statistical record of injuries. Wildlife data with aircraft damage is used as evidence of the damage and death of the wildlife. The calculations use statistical data on the ratios (coefficients) of strikes on the number of aircraft flights [3]. For certified commercial aviation airports for the years 2000-2020, the number of recorded strikes (hence, dead wildlife) per 100,000 flights is 21.29, including strikes with aircraft damage 1.25. According to the data of [4], the number of strikes that have occurred is five times more than the number taken into account, that is, 106.45 dead objects per 100,000 flights. In the behavior of the flocking parameter of birds, an indicator of 10-100 individuals is taken as statistically the most verifiable. For the sake of calculation, let's assume that 10 individuals from the flock die in each strike. For further calculations, the data of [3] are extrapolated to the global scale.

Currently, about 40 million commercial aviation flights take place in the world every year [5]. Calculations:

Damage to the wildlife: (40000000 flights) / (100000 flights) x (21.29 counted (106,45) strikes) x (10 birds) = 85160 (425800) counted (occurred) dead birds annually.

Aircraft damage vs wildlife damage: (1.25 / 100000 flights) = 0.0000125 vs (21.29 (106.45) / 100,000 flights) = 0.0002129 (0.0010645). Ratio: 0.0000125 / 0.0002129 (0.0010645) = 17032 (85.16).

Otherwise, the damages of wildlife exceed the damages of aircraft by 17 (85) times.

Human victims vs death of birds. Between 1988 and 2020, more than 293 people died in strikes around the world [3], on average, 9 people per year. Calculation: 85160 (425800) counted (occurred) dead birds / dead people (9) = 9 462 (47 311).

Otherwise, the victims of the wildlife exceed 9462 (47311) times the human victims. Almost 50000 birds die yearly in strikes between aircraft and wildlife per one human fatality. Let's summarize the calculations by comparing the annual number of casualties and damage to aircraft per 100000 flights with the estimated number of human fatalities (table 1).

Table 1 – Strike damage

	Damages	Number	1 / 2	1 / 3	Probability
1	Wildlife	85 160 (425 800)		9 462 (47 311)	P = 10-5 (10-4)
2	Aircraft	21,29 (106,45)	17 (85)		P = 10-8
3	Human fatalities	9			P = 10-8

The performed calculations can be performed in more detail. First, separately perform calculations for groups, types of wildlife, for geographical scales. Calculations should take into account the CA data. For 100 000 CA flights, the number of strikes is 1.52, including 0.28 strikes with aircraft damage. Strikes with damage account for about 6-7 percent in commercial aviation, and 18 percent in CA of the total number of recorded strikes. The total number of birds in the world is estimated at about 100 billion individuals. From here, it is possible to structure and calculate the size of environmental damage.

Conclusion. Calculations show that damage indicators do not depend on the number of species in groups. Due to their weight, damage from strikes with terrestrial mammals is five times greater than from strikes with birds. The development of a metric for observing the fuzziness of events makes it possible to calculate the probabilities of actual damages and strike risks. In the statistics of all accident causes, the events of strikes with the wildlife in this work are calculated by the probability of casualties for every 10-8 flights. Yearly almost 50000 birds die in strikes between aircraft and wildlife per one human fatality. A matrix and algorithms for observing and calculating strikes have been developed. Experimental studies have been carried out, which confirm the main results of statistical studies. It satisfies the need of airlines and airports to actively manage measures to protect flights from strike events and reduce the risks of accidents. Consumers are flight departments of airlines, ornithological services of airports, emergency rescue services.

References:

1. *Plotnikov N.I.* (2021) Methods of resource modeling of organizational objects. Lecture Notes in Intelligent Transportation and Infrastructure. Advances in Air Traffic Engineering Selected Papers from 6th International Scientific Conference on Air Traffic Engineering, ATE 2020, October 2020. – Warsaw, Poland, Springer Nature Switzerland AG. – P. 116-130
2. Federal Aviation Administration. (2020) 14 CFR 91.7 – Civil Aircraft Airworthiness; Federal Aviation Administration: Washington, DC, USA, 2020.
3. *Dolbeer R.A., Begier M.J., Miller P.R., Weller J.R., Anderson A.L.* (2021) Wildlife Strikes to Civil Aircraft in the US, 1990-2020, FAA Report 27. – p. 141.
4. *Allan J.R., Bell J.C., Jackson V.S.* "An Assessment Of The World-wide Risk To Aircraft From Large flocking Birds" (1999). 1999 Bird Strike Committee-USA/Canada, First Joint Annual Meeting, Vancouver, BC. Retrieved from [https://digitalcommons.unl.edu/birdstrike1999/4]
5. Retrieved from [https://www.un.org/en/observances/civil-aviation-day].

DOI: 10.25728/iccss.2022.33.65.066

Чинакал В.О.

Применение встраиваемых интеллектуальных компонентов в системах улучшенного мониторинга сложными промышленными объектами

Аннотация: Рассматриваются вопросы разработки и применения встраиваемых интеллектуальных компонентов (ВИК) в систему усовершенствованного мониторинга AMS+ (AMS+ - Advanced Monitoring System Plus) сложного промышленного объекта. ВИКи обеспечивают автоматизацию решения задач ситуационного анализа обработки данных об изменениях ключевых технологических параметров (КТП) непрерывных производств и состояния технологического оборудования (СТО). Разработана структура распределенной системы ВИК с использованием продукционных моделей