ENVIRONMENT PROTECTION

UDC 65.011.3:656.71:528.9 (045)
DOI: 10.18372/2306-1472.69.11058

Oleksandr Zaporozhets[1]
Inna Gosudarska[2]

THE AIRCRAFT ACCIDENT PROBABILITY MODEL IN THE VICINITY OF THE AIRPORT

National Aviation University
Kosmonavta Komarova avenue 1, 03680, Kyiv, Ukraine
E-mails: [1]zap@nau.edu.ua; [2]gil_@mail.ru

Abstract

This paper describes the results of processing and statistical analysis of accident data involving different types of Ukrainian-registered aircraft and including data from the CIS. The proportions of aircraft accidents both in Civil aviation of Ukraine and in Civil aviation of the Participants Agreement for different phases of flight have determined. The current models for assessing the probability of an aircraft accident in the vicinity of airports have analysed. The improved accident probability model is presented that allows for different categories of large and light aircraft to estimate the probability of the aircraft accident on the different phases of flight. The results of investigation the local aircraft crash risk at Kyiv Borispol international airport are presented.

Keywords: aircraft accident, airport, accident probability, ecological danger, environment, fatal aircraft accident, local aircraft crash risk.

1. Introduction

Basic factors that impact the formation of ecological danger in the vicinity of airports are probability of the transport events, such as aircraft accidents, moreover the fatal aircraft accidents which happened during take-off and landing phases of a flight, because each fatal aircraft accident lead to several adverse factors on environment in the vicinity of airports that are cause trouble. Today the aspects of technogenic impact on objects of the environment in the vicinity of airports should be important at both national and sectoral levels. New development within the areas around airports is lead to an increase the vulnerability of systems of human activities with regard to damaging technogenic factors. The destructive effects of high-speed the aircraft accidents are result the secondary consequences. The total affected area will be significantly enlarged due to secondary consequences. Accident consequence area in which leaking jet fuel and aircraft damage associated with the direct explosion due to jet blast (post-crash fire) are cause the dangerous effects on environment and people living, working or congregating in the vicinity of airports. Foremost priority is restriction the destructive effects on the different environment objects and reducing any potential hazard to human health from aircraft accident near civil airports.

2. Analysis of the research and publications

The current models for assessing the probability of an aircraft accident in the vicinity of airports were analysed. The «Method for determining risk and their acceptable levels for declaration of hazardous facilities» [1] is the most popular Ukrainian approach for assessing technogenic risk from hazardous facilities impact and their levels of safety that determines the procedure of analysis and risk assessment. This approach establishes the methodical principles as well as the criteria and level of acceptable risk including assessment of individual and social risks.

The NLR statistical model [2] estimates the probability of an aircraft accident for large aircraft with a maximum take-off weight greater than 5.7 tonnes (1, 2, 3 generations of aircraft) during take-off and landing phases of flight.

The U.S. Department of Energy (DOE) Standard DOE-STD-3014-2006 [3] describes an approach of risk analysis for hazardous facilities (close to a specific airport) due to aircraft accident. The DOE method defines a classification of aircraft according to their characteristics for assessing the probability of an aircraft crash. So, the approach provides crash probabilities for the following aircraft categories: for small aircraft with a maximum take-off weight of less than 20 tonnes; for large aircraft with a maximum take-off weight greater than 20 tonnes; for general aviation aircraft with a maximum take-off weight of less than 2.3 tonnes; for helicopter and military aircraft. The DOE method estimates the probability of an aircraft accident during take-off and landing phases of flight per year at an airport. This approach doesn't take into consideration the following types of accidents: take-off overruns and landing overruns.

The approaches for assessing the probability of an aircraft accident in the vicinity of airports are different because of the different selection criteria used. So, the results of the analysis have allowed to determine the necessity of improving the accident probability model in the vicinity of airports.

3. Task

The task is to improve the accident probability model in the vicinity of the airport which would have allowed for different categories of large aircraft (defined as being for aircraft with a maximum take-off weight greater than 4 tonnes) and light aircraft (defined as being for aircraft with a maximum take-off weight of less than 4 tonnes) to determine the aircraft accident probability on the different phases of a flight at and in the vicinity of airports during a period of one year.

4. Analysis of aircraft accidents broken down by phase of flight

Most aircraft accidents occur during take-off and landing phases of flight and hence close to an airport. The annual report published by Boeing [4] containing an overview of statistical data related to the aircraft accidents per phase of flight in worldwide commercial operations shows that were a total of 407 worldwide aircraft accidents in the ten-year period 2004 to 2013 which resulted in 72 fatal accidents. On the basis of the analysis about the consequences of worldwide fatal accidents it was determined that the majority aircraft accidents happen during the take-off (24 %) and landing (55 %) phases of flight and the minority during the cruise (21 %). Table 1 shows the overall numbers of worldwide fatal accidents broken down by phase of flight for the ten-year period 2004 to 2013.

Table 1

Number of worldwide fatal accidents broken down by phase of flight for the period 2004 to 2013

Phase of flight		Number of fatal accidents	Percentage of fatal accidents
Take-off	Parked, load/unload, taxi	7	10
	Take-off roll	6	8
	Take-off, initial climb	4	6
Cruise	Climb	6	8
	Cruise	7	10
	Descent	2	3
Landing	Initial approach	6	8
	Final approach, landing	16	22
	Landing roll	18	25

Consequently, the take-off and landing phases of flight accounted for 79 % of the fatal accidents which related to the third party risk in the vicinity of airports.

The analysis of accident data in civil aviation of the Participants Agreement was performed for the period 1992 to 2013. Based on review, the chosen sources of data for this analysis were the accident reports published by the Interstate Aviation Committee [5] and the ASN Aviation Safety database [6] for worldwide aircraft accidents. There were a total of 552 accidents that formed the dataset involving different types of aircraft in the period 1992 to 2013 which resulted in 344 fatal accidents in civil aviation of the Participants Agreement.

It was defined that the total of 453 aircraft accidents (or 82.06 %) occurred during the take-off (23.3 %) and landing (58.76 %) phases of flight and 99 (or 17.94%) occurred during the cruise (shown in Table 2 and Figure 1).

The analysis of accident data in civil aviation of Ukraine was performed for the period 1992 to 2013. The analysis of the statistical data related to the accidents involving Ukranian-registered aircraft which happened in the period 1992–2013 has allowed to define that 58.52% of these happen in the landing phase and 23.7% in the take-off phase and only 17.78 % during the cruise (shown in Table 2 and Figure 2).

Table 2

Number of aircraft accidents and fatal accidents broken down by phase of flight for the period 1992 to 2013

Phase of flight		Civil aviation of Ukraine		Civil aviation of the Participants Agreement	
		Fatal accidents	Aircraft accidents	Fatal accident	Aircraft accidents
Take-off	Parked, load/unload, taxi	-	7	4	9
	Take-off roll	2	7	12	28
	Take-off, initial climb	7	18	66	92
Cruise	Climb	4	6	14	19
	Cruise	9	17	45	59
	Descent	-	1	19	21
Landing	Initial approach	8	13	72	103
	Final approach, landing	17	52	94	171
	Landing roll	1	14	18	50
Total		48	135	344	552

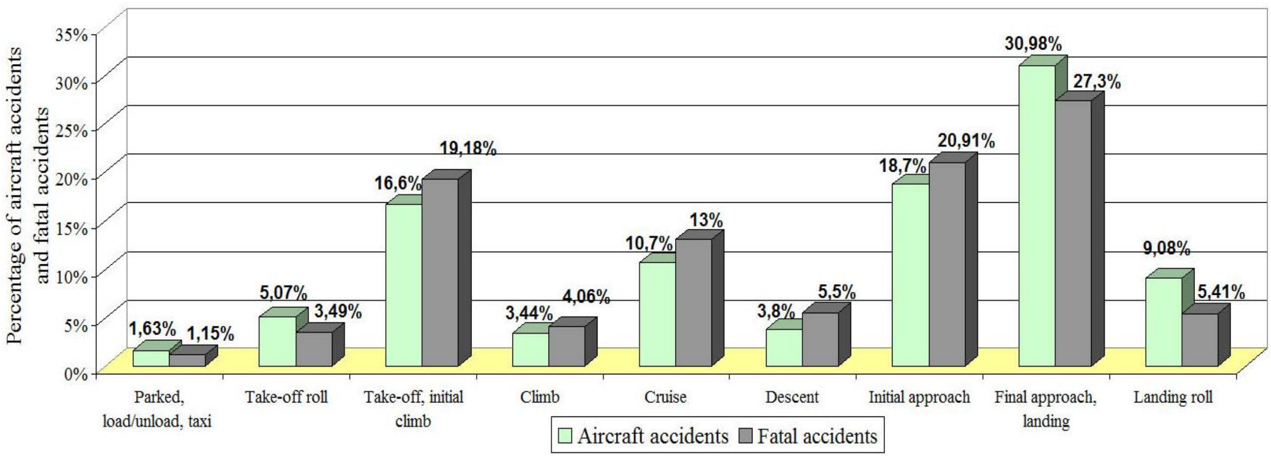

Fig. 1. Percentage of aircraft accidents and fatal accidents in civil aviation of the Participants Agreement during period 1992-2013

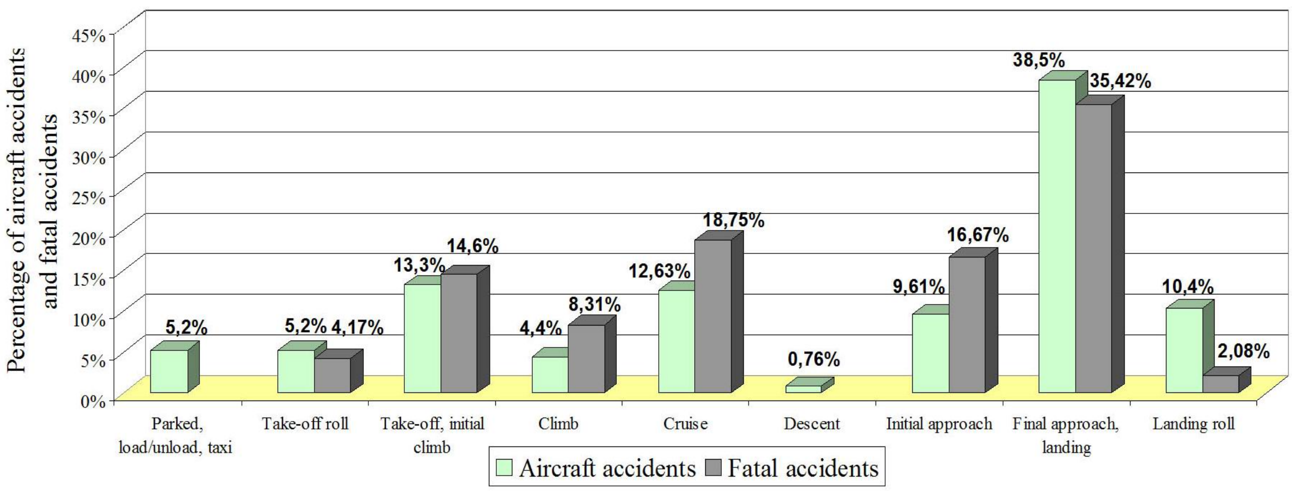

Fig. 2. Percentage of accidents involving Ukrainian-registered aircraft during period 1992-2013

The main sources of data for this analysis were accident reports published by the State Aviation Administration of Ukraine [7]. So, the results of the above analysis demonstrate that aircraft accidents tend to happen during the take-off and landing phases of flight and hence close to an airport which related to the third party risk in the vicinity of airports. In addition, the results of the analysis show that during take-off and landing phases account for a significant proportion of fatal accidents. It is implies the involuntary exposure to the risk of aircraft accidents for people living, working or congregating in the vicinity of airports.

5. Overview of the aircraft accident probability model

The accident probability model is the component of third party risk assessment model, which is used for calculating contours around area runway. This model is received further development which determines the crash probability per year for each flight phase (take-off roll, take-off, landing, landing roll) and for different categories of large aircraft (with a maximum take-off weight greater than 4 tonnes) and light aircraft (with a maximum take-off weight of less than 4 tonnes) in the vicinity of the airport.

The analysis of statistical data related to the aircraft accidents indicates the necessity of dividing aircraft into groups depending on date their elaboration and characteristics. Each main group is characterized by engine type of aircraft: jets, turboprops, piston engine.

It is assumed that jets divided into the following categories:

- western jets (such as the McDonnell Douglas DC-9, the Airbus Industrie A300 and the Boeing 767);
- executive jets (such as the Learjet 35/60 and the Canadair CL-600/601 Challenger);
- eastern jets includes aircraft that were produced in the USSR and CIS (such as the Yakovlev Yak 42/142, the Tupolev TU-134/154 and the Ilyushin IL-62).

The turboprops divide into the following two groups based on date their designed and entered service: aircraft developed and entered service in and after 1970 (such as the BAe Jetstream 41, the Dornier 328, the SAAB 340 and the Shorts 360) or aircraft developed and entered service before 1970 (such as the Fairchild F27 and the Convair 580). Such grouping was based on the assumption that different engine types have different levels of reliability (piston engines have higher frequency of failure than jet engines). So, these groups have different statistical characteristics.

In order to estimate the crash probability the aircraft were classified on the different categories according to:

- flight and technical characteristics;
- data on passenger aircraft movements (PAX) or non passenger aircraft movements (NP);
- date aircraft designed and entered service.

The full breakdown of aircraft by categories for assessing the probability of an aircraft accident is as follows:

- category 1-4 western jets (*L1–L4*);
- eastern jets (*SU*);
- turboprops aircraft developed and entered service in and after 1970 (*T1*);
- turboprops aircraft developed and entered service before 1970 (*T2)*;
- executive jets (*EJ*);
- light aircraft (*LT*);
- miscellaneous (*MC*).

Aircraft grouped in categories 1-4 are western jets that divided into date their developed and entered service (such as the Boeing 727, the BAe 146 and the Fokker 100). Aircraft grouped in category “light” are piston engine aircraft with a maximum take-off weight of less than 4 tonnes (such as the Cessna 172/177, the Pilatus BN-2A Islander and the Piper PA23 Aztec/Apache). Aircraft grouped in category “miscellaneous” are unclassified aircraft types that are not included in any mentioned above categories (such as helicopters the Mi-8/9 and the Giles G-200).

Such separation is made for estimating the probability of fatal accident for each aircraft category per movement in the airport and the operational reliability of each aircraft category. By the practical method [8] it is possible to estimate the fatal accident probability P_i for each aircraft of i category per million movements:

$$P_i = \frac{n_i}{N_i} \cdot 10^6 ,$$

where n_i is number the fatal accidents of the aircraft of i category;

N_i is number movements the aircraft of i category for analysed period.

The analysis of data shows the fatal accidents of the first generation western jets (category 1) happened frequently in compare with modern western jets (categories 2-4), and therefore have higher accident probability. Similarly the high values of fatal accident probability have eastern jets and executive jets. The accident statistics indicates the fatal accidents of the jet aircraft types to happen seldom in compare with turboprops and piston-engine aircraft.

It is assumed that aircraft grouped in category "miscellaneous" which mainly includes helicopters and unclassified aircraft types, as in the case of aircraft grouped in category "light", it is considered that they have highest the probability of fatal accident. Table 3 shows a summary of the probability values P_i of fatal accidents for the aircraft of *i* category.

Table 3

Probability of fatal accident in 2003

Aircraft category	Probability of aircraft accident per million movements
Large aircraft	
L1 (PAX)	1.113
L2-L4 (PAX)	0.148
L2-L4 (NP)	0.444
SU	0.874
EJ	2.23
T1 (PAX)	0.288
T1 (NP)	0.864
T2	0.782
MC	3.27
Light aircraft	
LT	3.27

The probability values P_i of fatal aircraft accident (Table 3) are based on worldwide fatal accident statistics of the aircraft of *i* category and number movements N_i the aircraft of *i* category.

The numerous factors which influence on safety aspects of global civil aviation are similar in civil aviation of Ukraine [7]. Hence the probability values P_i of fatal aircraft accident (Table 3) used to estimate the probability of fatal aircraft accident in the vicinity of airports in Ukraine.

As shown in Table 1 and Table 2, the number of aircraft accidents was grouped into three main flight phases and so the proportions were determined. The proportions of worldwide accidents which happened in mostly during take-off and landing phases of flight are very similar both in Civil aviation of the Participants Agreement and Civil aviation of Ukraine. The results of the comparison (Table 4) show that the majority of aircraft accidents happened during the take-off and landing phases and the minority during the cruise.

Table 4

Comparison of accident data broken down by phase of flight

Phase of flight	Percentage of world-wide fatal accidents	Percentage of aircraft accidents in Civil aviation of the Participants Agreement	Percentage of aircraft accidents in Civil aviation of Ukraine
Take-off	24	23.3	23.7
Cruise	21	17.94	17.78
Landing	55	58.76	58.52

These results have evidenced the potential threat of technogenic events related to phases of flight during take-off and landing (Table 4) which may cause the dangerous consequences for people living, working or congregating in the vicinity of airports.

6. Estimating the probability of an aircraft accident and the results

In order to estimate the probability of an aircraft accident per movements P_A at an airport during a period of one year are needed to calculate as:

$$P_A = \frac{(N_1 \cdot P_1 + N_2 \cdot P_2 + \ldots + N_{14} \cdot P_{14})}{N} = \frac{\sum_{i=1}^{i=14} N_i \cdot P_i}{N},$$

where N is total number of movements per year at an airport;

N_i is number movements the aircraft of *i* category during a period of one year at an airport;

P_i is probability value the fatal accident of the aircraft of *i* category (Table 3).

The total number of movements N is defined as the sum of the movements N the aircraft of *i* category departing and arriving at an airport during a period of one year:

$$N = N_1 + N_2 + \ldots + N_{14} = \sum_{i=1}^{i=14} N_i .$$

Because the aircraft accident risk is different at separate airport, so local aircraft crash risk is investigated for a specific airport, taking into consideration all departures and arrivals of each airline at the airport including each group and category of aircraft by reason their difference in the probability values of fatal aircraft accident.

The local aircraft crash risk is calculated for Kyiv Borispol international airport in Ukraine. Using the appropriate data about all airlines [9] (including each group and category of aircraft) the result of this calculation for Borispol airport is 1.51 crashes per million movements.

The probability of an aircraft accident differs significantly between flight phases. The proportions of the four types of aircraft accidents were estimated which create the potential ecological danger in the vicinity of airports. The analysis of data is based on a review of accident reports published by National Transportation Safety Board [10], UK Civil Aviation Authority [11], UK Air Accidents Investigation Branch [12], the Federal Aviation Administration [13], the Bureau d'Enquêtes et d'Analyses [14] and etc. [15]. It was based on position information from 583 worldwide accidents which happened within runways and in the vicinity of airports related to phases of a flight:

- takeoff phase, which includes the takeoff roll and the initial climb,
- landing phase, which includes the landing approach and the landing roll.

Also the chosen sources of data for this analysis were the ASN Aviation Safety database [6] for worldwide accidents and the Transportation Safety Board of Canada database [16]. The preferred source of data on aircraft accidents was the ADREP (the International Civil Aviation Organization) database [17]. Following a review of available data sources involving accidents in the vicinity of airports related to phases of a flight, so the aircraft accidents were divided into:

- take-off accidents from flight,
- take-off overruns,
- landing accidents from flight,
- landing overruns.

Corresponding to data set the proportions were found where:

- 20 % take-off fatal accidents from flight,
- 8 % take-off overruns,
- 52 % landing fatal accidents from flight,
- 20 % landing overruns.

Accident data involving Ukranian-registered aircraft were collected. The time period 1992 to 2013 was chosen to analyse and to determine the proportions accidents involving Ukranian-registered aircraft related to phases of a flight in the vicinity of airports. There were a total of 135 accidents involving different types of Ukranian-registered aircraft, which resulted in 48 crashes. This information was obtained from accident reports published by national organisation (the State Aviation Administration of Ukraine) [7] and international organisation (the Interstate Aviation Committee) [5]. The ADREP (the International Civil Aviation Organization) database [17] was used for more detailed analysis of aircraft accidents. Corresponding to dataset the proportions accidents involving Ukranian-registered aircraft were found where:

- **19 %** take-off fatal accidents from flight,
- **8 %** take-off overruns,
- **60 %** landing fatal accidents from flight
- **13 %** landing overruns.

In order to estimate the probability of an aircraft accident for different phases of a flight (as mentioned above phases of a flight: the takeoff roll and the initial climb, the landing approach and the landing roll) is needed take into consideration proportions of aircraft accidents which create the potential ecological danger in the vicinity of airports.

Considering the proportions of accidents involving Ukranian-registered aircraft related to phases of flight, it is suggested to estimate the probability of an accident involving Ukranian-registered aircraft for different phases of a flight. As a result, the accident probability in phase of take-off roll P_{TR} related to Ukranian-registered aircraft is estimated:

$$P_{TR} = 0.08 \cdot P_A \cdot N_D ,$$

where N_D is number of departures.

The accident probability in phase of landing roll P_{LR} related to Ukranian-registered aircraft is estimated:

$$P_{LR} = 0.13 \cdot P_A \cdot N_A ,$$

where N_A is number of arrivals.

The accident probability in phase of initial climb P_{TA} (generally speaking, take-off accident) related to Ukranian-registered aircraft is estimated:

$$P_{TA} = 0.19 \cdot P_A \cdot N_D .$$

The accident probability in phase of landing approach P_{LA} (generally speaking, landing accident) related to Ukranian-registered aircraft is estimated:

$$P_{LA} = 0.6 \cdot P_A \cdot N_A .$$

7. Conclusions

The data on accidents involving Ukranian-registered aircraft and including data from the CIS during period 1992-2013 has been collected. The analysis of aircraft accidents broken down by phases of flight is presented. The proportions of aircraft accidents both in Civil aviation of Ukraine and in Civil aviation of the Participants Agreement for different phases of flight have been determined. The analysis of the statistical data related to the accidents in civil aviation of the Participants Agreement has allowed to define that the 58.76 % of these happen in the landing phase and the 23.3 % in the take-off phase and the minority during the cruise (17.94 %). The analysis of data involving Ukranian-registered aircraft shows the accidents tend to happen during the take-off (23.7 %) and landing (58.52 %) phases and hence close to airports which create the potential consequences in form of secondary effects on the ground (i.e. ecological damages). It was found that the majority of aircraft accidents happened in the vicinity of airports forming third party risk. The results of investigation have allowed to underline that there are probability of technogenic event during take-off and landing phases of flight and the potential threat for different environment objects within the areas around airports.

The current models for assessing the probability of an aircraft accident in the vicinity of airports were analysed. Based on result of researches, it was proposed the improving of the accident probability model which has allowed for different categories of large aircraft with a maximum take-off weight greater than 4 tonnes and light aircraft with a maximum take-off weight of less than 4 tonnes to determine the accident probability on the different phases of a flight (such as take-off roll and initial climb phases, landing approach and landing roll phases) in the vicinity of airports.

Using the appropriate data about all airlines (including each group and category of aircraft) the local aircraft crash risk has been calculated for Kyiv Borispol international airport. The result of investigation for Borispol airport is 1.51 crashes per million movements.

References

[1] Ministry of Labour and Social Policy of Ukraine (2003), “Method for determining risk and their acceptable levels for declaration of hazardous facilities”, Order no 637, 192 p.

[2] Pikaar A., Weijts J., M. de Jong (2000) *An enhanced method for the calculation of third party risk around large airports with application to Schiphol*. Netherlands, NLR, 104 p.

[3] *Accident analysis for aircraft crash into hazardous facilities* (Standard DOE-STD-3014-2006). U.S. Department of Energy, 215 p.

[4] *Statistical Summary of Commercial Jet Aircraft Accident 1959–2013*. Washington, Boeing Commercial Airplanes, 26 p.

[5] The Interstate Aviation Committee, Aviation Accident Reports until 2013 “Civil aviation flight safety level of the contracting states of the Agreement on civil aviation and use of airspace”, available at: http://mak-iac.org/en/rassledovaniya/bezopasnost-poletov/.

[6] *ASN Aviation Statistics*. Available at: http://aviation-safety.net/statistics.

[7] The State Aviation Administration of Ukraine, Annual Safety Reports until 2013 “Analysis of aviation safety level and identification of potential accidents associated with the Ukrainian-registered aircraft”, available at: http://www.avia.gov.ua/documents/Bezpeka-aviatsii/Bezpeka-polotiv/.

[8] Sakach R.V., Zubkov B.V., Davidenko M.F. (1982) *Bezopasnost poletov* [Aviation safety]. Moscow, Transport Publ., 239 p.

[9] *Flight information 2013*. Kyiv Borispol international airport. Available at: http://kbp.aero/.

[10] *Aviation Accident Reports*. U. S. National Transportation Safety Board. Available at: http://www.ntsb.gov/investigations/ reports_aviation.html.

[11] *Aviation Safety Reviews*. UK Civil Aviation Authority. Available at: http://www. caa. co.uk/application.aspx.

[12] *Annual Safety Reports*. UK Air Accidents Investigation Branch. Available at: http://www.aaib.gov.uk/publications/annual_safety_reports.cfm.

[13] *Accident and Incident Dates*. Federal Aviation Administration. Available at: http://www.faa.gov/data_research/accident_incident .

[14] *Annual reports*. Bureau d’Enquêtes et d’Analyses. Available at: http://www. bea.aero/en/rapport.annuel/index.php.

[15] *Annual Safety Reviews*. European aviation safety agency. Available at: http://easa.europa.eu/communications/general-publications.php.

[16] *Aviation Statistics.* Transportation Safety Board of Canada. Available at: http://www.tsb.gc.ca/eng/stats/aviation/index.asp.

[17] *ADREP ICAO.* Request 198/80 (USSR). Available at: http://www.icao.int.

Received 6 June 2016.

О.І. Запорожець[1], І.Л. Государська[2]
Модель оцінки ймовірності авіаційної події в околиці аеропорту
Національний авіаційний університет, просп. Космонавта Комарова, 1, Київ, Україна, 03680.
E-mail: [1]zap@nau.edu.ua; [2]gil_@mail.ru

В статті описані результати обробки та статичного аналізу даних про АП ЦА України і ЦА держав-учасників Угоди. Встановлена тенденція виникнення авіаційних подій за етапами польоту ПС ЦА України і ЦА держав-учасників Угоди. Виконано аналіз існуючих моделей оцінки ймовірності авіаційної події в околиці аеропорту. Виконано аналіз існуючих моделей оцінки ймовірності авіаційної події в околиці аеропорту. Запропоновано подальший розвиток моделі оцінки ймовірності авіаційної події, яка дозволяє для запропонованих категорій важких і легких повітряних суден визначати ймовірності катастрофи в околиці аеропорту на різних етапах польоту. Представлено результати дослідження локального ризику виникнення катастрофи повітряного судна в околиці аеропорту ДП МА «Бориспіль».

Ключові слова: авіаційна подія; аеропорт; довкілля; екологічна небезпека; ймовірність події; катастрофа повітряного судна; локальний ризик катастрофи повітряного судна.

А.И. Запорожець[1], И.Л. Государская[2]. **Модель оценки вероятности авиационного происшествия в окрестности аэропорта**
Национальный авиационный университет, просп. Космонавта Комарова, 1, Киев, Украина, 03680.
E-mail: [1]zap@nau.edu.ua, [2]gil_@mail.ru

В статье описаны результаты обработки и статического анализа данных про авиационные происшествия гражданской авиации Украины и гражданской авиации государств-участников Соглашения. Установлена тенденция возникновения авиационных происшествий за этапами полета воздушных судов гражданской авиации Украины и гражданской авиации государств-участников Соглашения. Выполнен анализ существующих моделей оценки вероятности авиационного происшествия в окрестности аэропорта. Предложено дальнейшее развитие модели оценки вероятности авиационного происшествия, которая позволяет для предложенных категорий тяжелых и легких воздушных судов определять вероятности катастрофы в окрестности аэропорта на различных этапах полета. Представлены результаты исследования локального риска возникновения катастрофы воздушного судна в окрестности аэропорта ГП МА «Борисполь».

Ключевые слова: авиационное происшествие; аэропорт; вероятность события; катастрофа воздушного судна; локальный риск катастрофы воздушного судна; окружающая среда; экологическая опасность.

Zaporozhets Oleksandr (1956). Doctor of Engineering. Professor.
Director of Institute of Environmental Security, National Aviation University, Kyiv, Ukraine.
Education: Kiev Institute of Civil Aviation Engineers (1978).
Research area: development of models and methods of information provision for environment protection from civil aviation impact.
Publications: 210.
E-mail: zap@nau.edu.ua

Gosudarska Inna (1979). Candidate of Engineering.
Department of Safety of Human Activities, National Aviation University, Kyiv, Ukraine.
Education: National Pedagogical Dragomanov University, Kyiv, Ukraine (2002).
National Aviation University, Kyiv, Ukraine (2004, 2008).
Research area: methods of third party risk assessments in the vicinity of the airports, ensuring ecological safety of airports.
Publications: 26.
E-mail: gil_@mail.ru