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ICAO AVIATION OCCURRENCE CATEGORIES SIGNIFICANTLY AFFECTING AVIATION SAFETY IN POLAND FROM 2008 TO 2015

Summary. Poland, as a member of the EU, is represented within the ICAO, by the European Aviation Safety Agency. However, this does not relieve our country from the responsibility of developing a state safety programme (SSP). The need to set up such a programme, which has to be specific to every country involved in aviation operation, was introduced by the ICAO's Annex 19. One of the important points in Annex 19 is: "5.2.1 Each State shall establish and maintain a safety database to facilitate the effective analysis of information on actual or potential safety deficiencies obtained, including that from its incident reporting systems, and to determine any actions required for the enhancement of safety". The Polish Civil Aviation Authority, along with other databases, manages the European Coordination Centre for Aviation Incident Reporting Systems (ECCAIRS). The authors (who are specialists dealing with exploitation processes in aviation) have conducted a laborious processing of the data contained in the ECCAIRS database, analysing them based on various criteria: aviation occurrence categories (as defined by the ICAO), phases of flight for different airports in Poland etc. Aircraft with an maximum take-off mass (MTOM) <5,700 kg (mainly general aviation) and for aircraft with an MTOM >5,700 kg (commercial aviation) were considered separately. It was found that the most events are those that relate to

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power plant (SCF-PP) airframes and related system (SCF-NP) failures, followed by collisions with birds (BIRD), events related to airports (ADRM) and events related to the required separation of aircraft (MAC). For lighter aircraft, the dominant categories are ARC, CTOL, GTOW and LOC-I events. The article presents a proposed method for predicting the number of events, determining the alert levels for the next years and assuming a normal distribution (Gaussian). It is one of the first attempts to use actual data contained in the database of events on airports in Poland. The results of this analysis may support the decisions of supervisory authorities in the areas where security threats are most important.

Keywords: air transport, security management, aircraft accident, aircraft power plant

1. INTRODUCTION

For several years, air traffic in Poland, as measured by the number of passenger operations in major airports, has remained stable, albeit with a slight upward trend (see Fig. 1). Almost half of these operations are carried out at Warszawa- Okęcie Airport. Poland, as an EU member state, is obliged to introduce a system of air traffic safety oversight, including aviation occurrence reporting for collection by ECCAIRS.

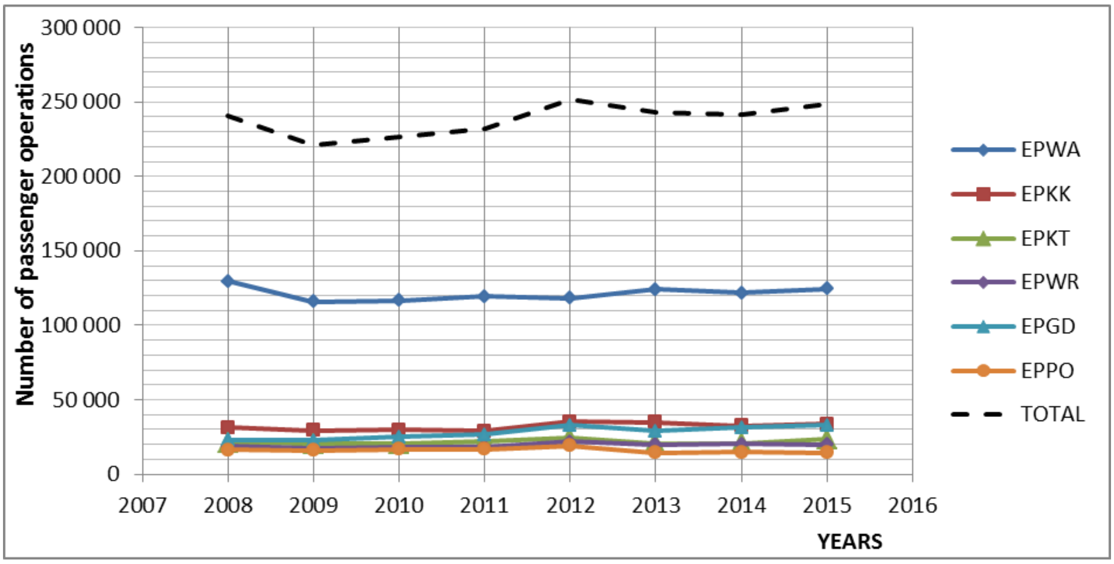


Fig. 1. Number of passenger operations at the main Polish airports [2]
(EPWA - Warszawa-Okęcie, EPKK - Kraków-Balice, EPKT - Katowice-Pyrzowice, EPWR - Wrocław-Strachowice, EPGD - Gdańsk- Rębiechowo, EPPO - Poznań-Ławica)

It should be noted that the number of reported occurrences involving large aircraft (with an MTOM >5,700 kg) increased between 2009 and 2014 by as much as 112% (see Fig. 2), while in the same period the number of passenger operations increased by just over 9%.

Reported air traffic events are eligible for each category defined by the ICAO in periodically published bulletins [1]. The most recent provides 36 aviation occurrence categories related to traffic events at the airport, during flights, weather conditions, events in the cabin, or power plant or airframe failures. Each category is coded, such as ARC (abnormal runway contact), BIRD (bird strike) and GCOL (ground collision).

The process of events qualification is quite complicated, because it sometimes requires the extraction of vital meaning from the occurrence description submitted by the crew or ground service. Mistakes made at this stage of the database creation can result in the falsification of outcomes and conclusions reached. It seems that efforts should be made to "objectify" the process. Reservations cover a range of events according to the categories introduced by the ICAO. Some of them are very detailed or even duplicated, for example, F-NI (fire/smoke non-impact) and F-POST (fire/smoke post-impact).

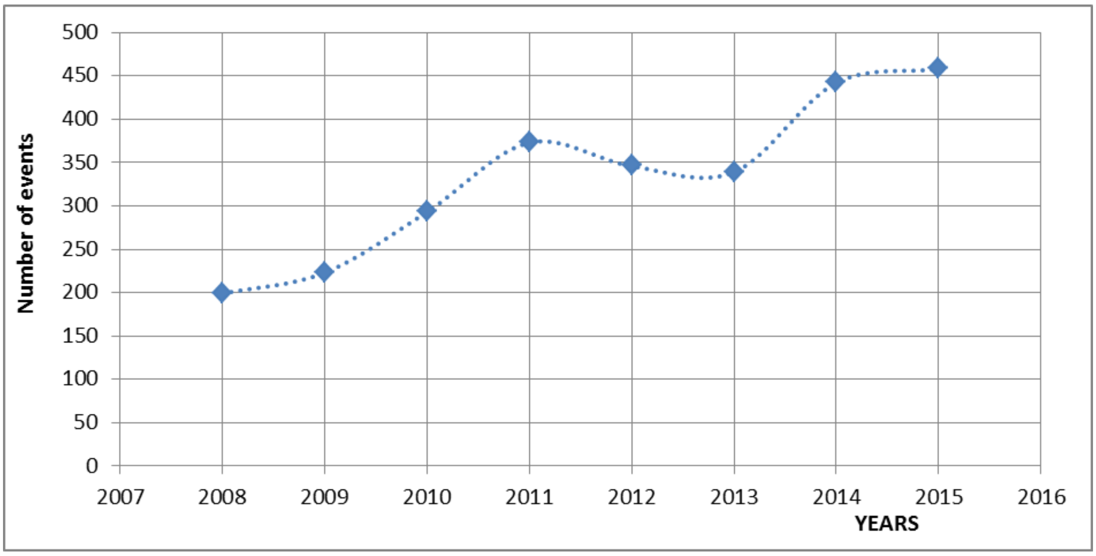


Fig. 2. Number of reported occurrences in the main Polish airports for aircraft with an MTOM >5,700 kg (from ECCAIRS database)

The authors introduced, for the purpose of analysis, the additional category of LASER in order to define cases of the blinding of aircraft crews by laser lights from the ground on the approach to landing.

2. RESEARCH METHOD

ECCAIRS comprises reports submitted by different aviation organizations. It is very extensive, containing more than 6,000 records (events) for air traffic reported from 2008 to 2015. During this period of time, the number of aircraft involved in air traffic changed, as well as the number of passenger operations at airports. In order to objectify the analysis of the data, coefficients, relating the number of events to the number of registered aircraft (per 100 aircraft) or the number of passenger operations at a given airport during the period considered (per 1,000 passenger operations), were introduced.

$$ZS_{GA} = \frac{100 * LZ_{GA}}{LSP_{GA}} \tag{1}$$

$$ZS_{K} = \frac{100 * LZ_{K}}{LSP_{K}} \tag{2}$$

where LZ_{GA}, LZ_{K} represent the number of events for aircraft with an MTOM <5,700 kg and an MTOM >5,700 kg, respectively, while LSP_{GA}, LSP_{K} represent the number of registered aircraft with an MTOM <5,700 kg and an MTOM >5,700 kg, respectively.

$$W_{1000} = \frac{LZ * 1000}{LO_{airport}} \tag{3}$$

where LZ represents the number of events, while $LO_{airport}$, is the number of passenger operations at a certain airport.

The current method for analysing the data contained in ECCAIRS is based on comparing the number of events in the current year with a corresponding number of events in the previous year. The decrease in the number of events is considered as an indicator of safety improvement.

The authors propose forecasting based on observing trends over several years and setting alert levels, while assuming a normal distribution. These forecasts should be verified annually by comparing them with actual numbers of events.

To determine the alert levels, we propose the method of Shewhart control charts, which allow for the observation of process variability, as well as identifying the reasons that cause this increase in volatility [3]. Shewhart divided causes of process variation between random and special. Random causes are many and the effect of each is relatively small compared with the result of the occurrence of special causes, although the cumulative effect of random causes is usually quite significant. The main purpose of this kind of process monitoring is, thus, to signal deviations from a statistically stable condition caused by special reasons. They are associated with human activities (operator, pilot etc.) or characteristics of machine changes (e.g., aircraft engine) and, when found, should be removed or corrective action taken.

The Shewhart control chart limits (see Fig. 3) are located 3σ on each side of the centre line (average values m), where σ is the standard deviation in each subset of the population estimated by the variability of the samples. The interval from -3σ to +3σ comprises 99.73% of the total area of the characteristic dispersion. The boundaries established at 3σ show that about 99.73% of the subset will be in the area defined by control lines, assuming that the process is statistically regulated. The control chart also contains 2σ limits on both sides of the line of mean values m as alert levels. In this area should be 95.4% of the variation of the studied phenomenon.

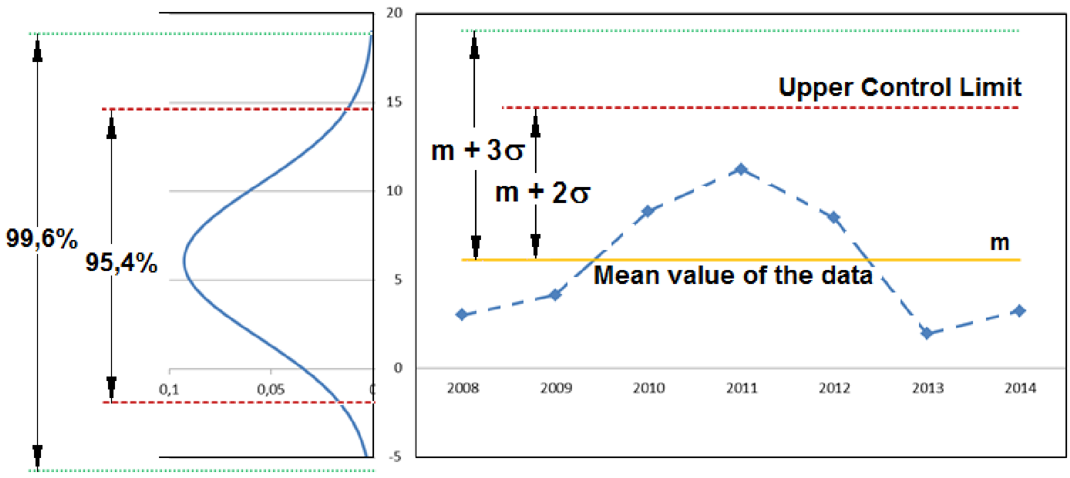


Fig. 3. Dependence between the confidence level and confidence interval: m - mean; Ϭ - standard deviation

Samples that appear outside 2σ may indicate the possibility of going beyond the defined control limits. Methodology for determining the forecast for the next year and determining alert levels for specific types of events involving the 2σ criterion has been developed.

To date, the data from ECCAIRS have been processed by dividing the events according to the following criteria:

- aircraft with an MTOM <5,700 kg and an MTOM >5,700 kg
- ICAO aviation occurrence category (36)
- site of the event
- flight phase

Between 2008 and 2015, around 2,100-2,200 aircraft with an MTOM <5,700 kg and 110-140 aircraft with an MTOM >5,700 kg and with Polish registration were operated (the number of helicopters in both categories was 10 times less). Every year, about 140-300 events involving aircraft with an MTOM <5,700 kg and 300-700 aircraft with an MTOM >5,700 kg are reported. It is highly noteworthy that, in relation to the number of aircraft, the number of reported events is almost 40 times less for aircraft with an MTOM <5,700 kg.

3. CALCULATION OF RESULTS

The analysis shows that, in the observed period of 2008-2015, the most commonly reported events were related to the malfunction of an airframe (SCF-NP), representing more than 25% of all events regardless of the aircraft category (see Fig. 4).

Other events having a significant impact on the level of safety were identified as follows:

- MTOM >5,700 kg: BIRD, ADRM, SCF-PP, MAC, LASER, MED, RAMP
- MTOM <5,700 kg: SCF-PP, ARC, CTOL, MAC, GTOW, LOC-I, BIRD

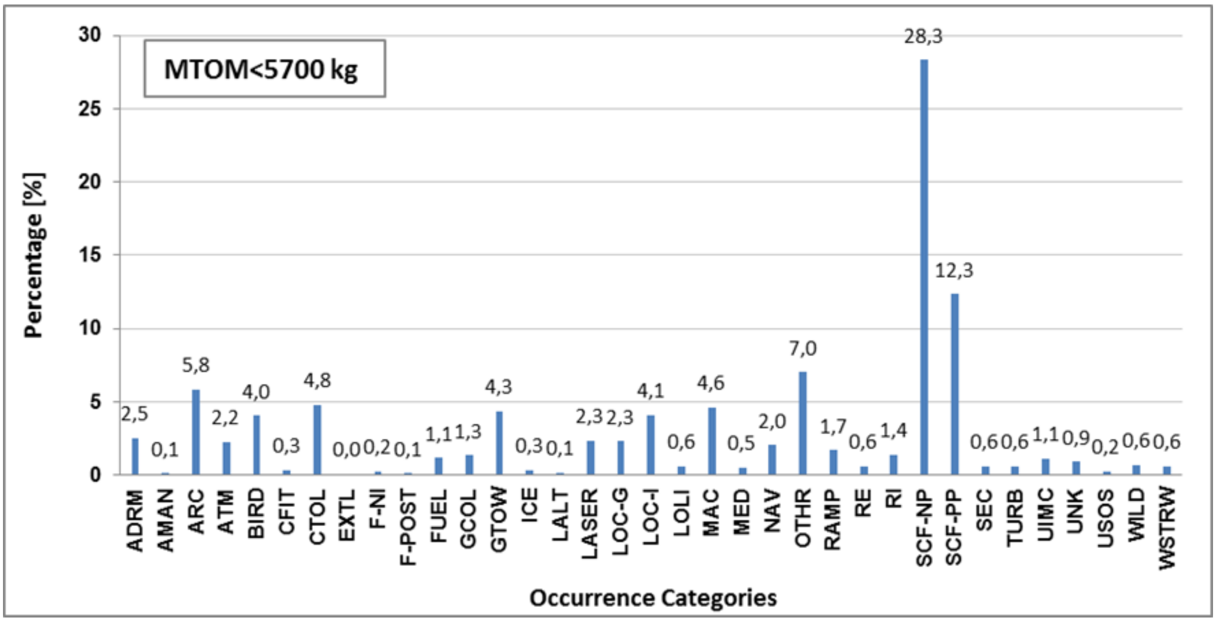
Figure 5 shows that the events reported in many phases of a flight do not depend on the aircraft category and are similar for take-off, standing, taxi and en-route. In the MTOM <5,700 kg category, events during landing twice as often than for the MTOM >5,700 kg category. On the other hand, in the MTOM >5,700 kg category, the majority of events were reported during the approach.

Analysis of the total number of events with reference to the number of passenger operations (i.e., the coefficient W1000) indicates an increasing trend. In 2008, its value was 0.83, while, in 2015, it increased to 1.84 (see Fig. 6).

The above-described method can be used to predict the number of events in the future and set alert levels. Figure 7 shows the results of these calculations for all occurrences in Poland concerning MTOM <5,700 kg category aircraft. The expected average values and alert levels for 2016 and 2017 were calculated using the known values of the ZSGA coefficients for previous years.

The LASER category was analysed in a similar manner. Figure 8 shows the growth of this phenomenon in the past seven years and the forecast for the next two years.

Figures 7-8 present examples of possible transformations; while others exist, they were not shown due to space limitations.



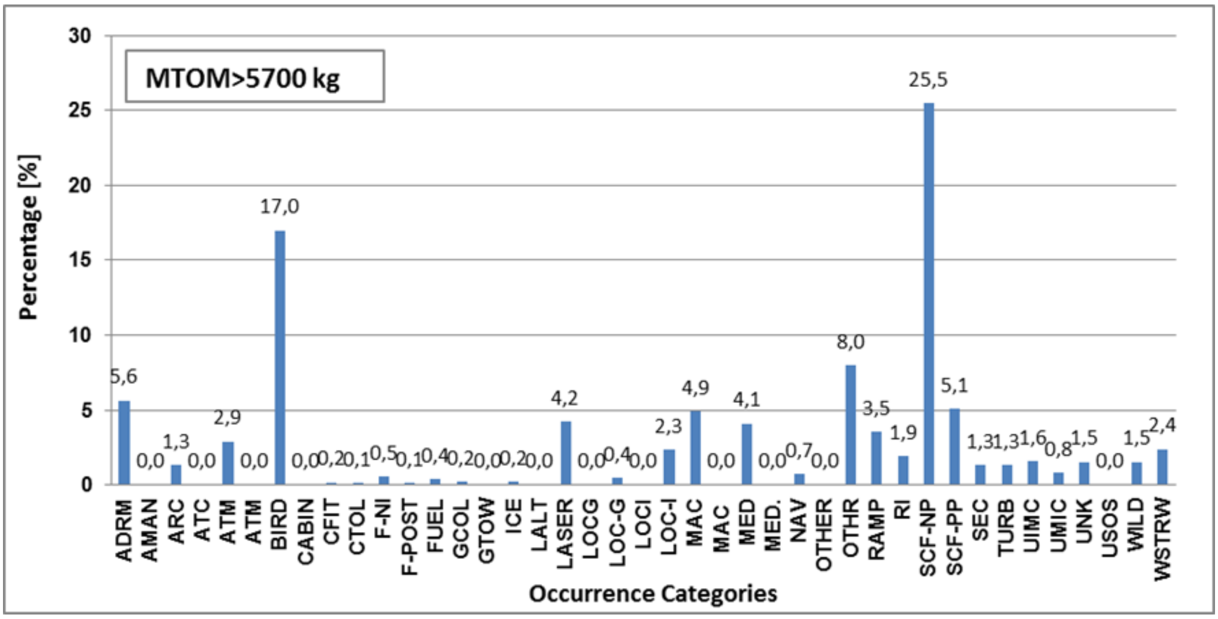
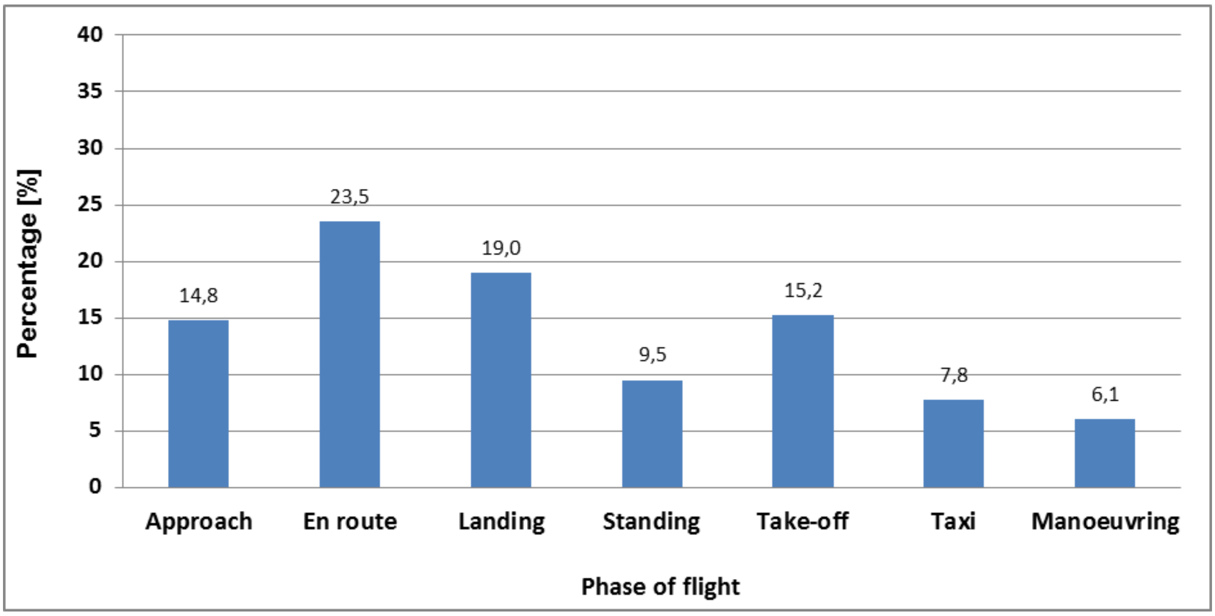


Fig. 4. Percentage share of the number of reported occurrence categories in each aircraft category: MTOM <5,700 kg (top), MTOM >5,700 kg (bottom)



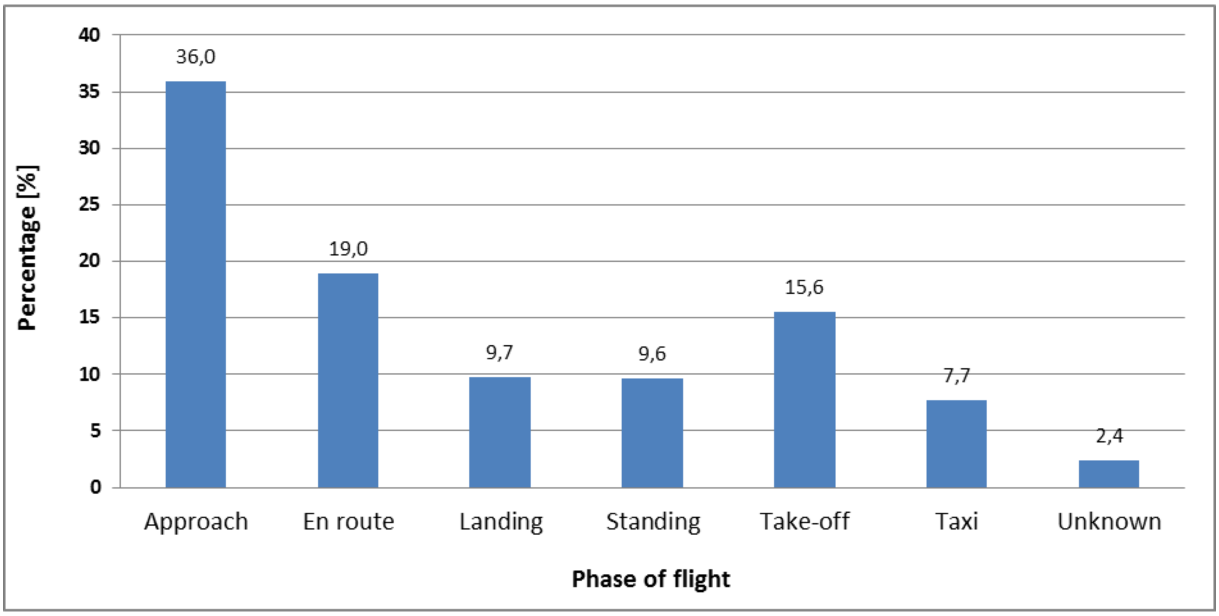


Fig. 5. Percentage share of the number of reported events during certain phases of an aircraft flight in each aircraft category: MTOM <5,700 kg (top), MTOM >5,700 kg (bottom)

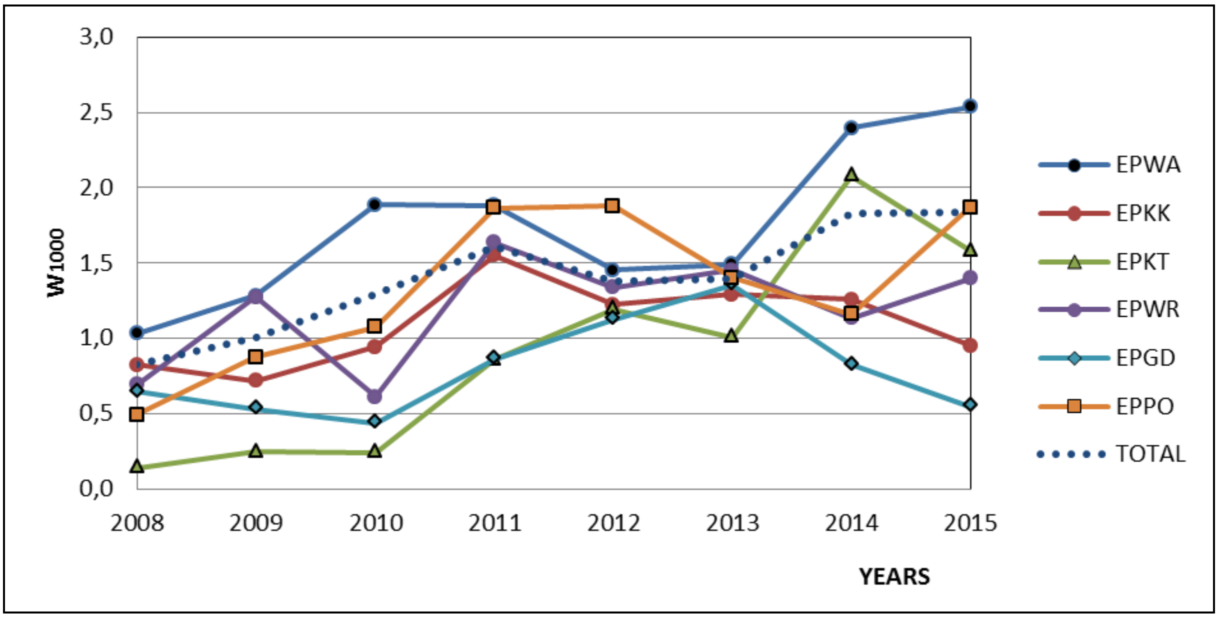


Fig. 6. Changes in the value of W_{1000} coefficients at a particular airport (airport symbols are the same as in Fig. 1)

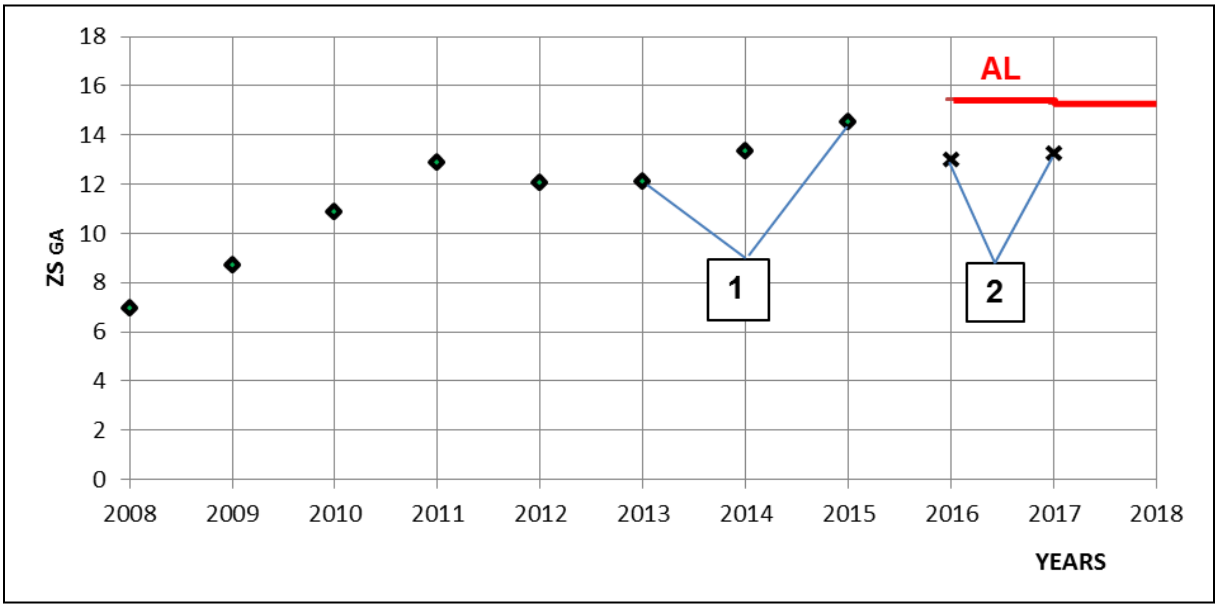


Fig. 7. Changes of ZS_{GA} coefficients (per 100 registered aircraft):
1 - calculated real values, 2 - forecasted means, AL - forecasted alert levels

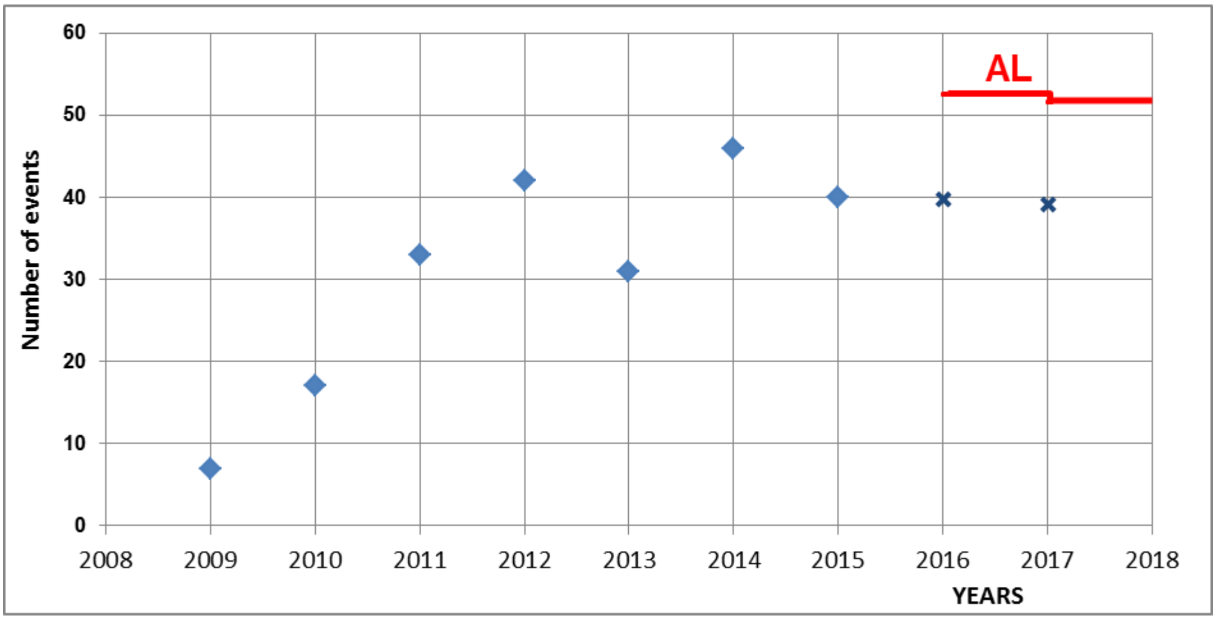


Fig. 8. Changes in number of events in the LASER category in Poland
(AL - forecasted alert levels)

4. SUMMARY

The results of our proposed method for events analysis may provide assistance to the civil aviation regulatory authorities in the implementation of state safety programmes and safety management systems in aviation organizations, as required by the EU.

It should be clarified whether the steadily increase in W1000 coefficients is due to aviation safety deterioration, as well as whether there has been any increase in employee awareness concerning the importance of events reporting.

The small number of reported events associated with MTOM <5,700 kg category aircraft is evidence of a Signiant levels restraint in such reporting. Perhaps action is needed to raise awareness of the importance of reporting events for safety improvements.

In most cases, the actual number of events does not exceed the alert levels determined by the presented method. On this basis, it can be stated that these levels were exceeded most often for events in the BIRD, MAC and RAMP categories in 2014.

It seems that events involving the LASER category are gradually disappearing, possibly because of changing “fashion” or an increased awareness that this is a serious offence.

There is a need to develop models to address the fact that, according to civil aviation authority inspection reports in the ACAM database and reported events in ECCAIRS, there is no compliance with existing rules in aviation organizations. This could inform the direction of further research in this area.

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