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VOICE ON QUANTITATIVE METHODS IN RISK MANAGEMENT BY AN AIR OPERATOR

Summary. This article is devoted to the diagnosis of problems arising from risk management obligations under the safety management system implemented in civil organisations of certified air operators (carriers). Focus was on the use of quantitative methods in safety risk analysis. The idea of an approach to determine the probability of accidents and serious incidents based on the intensity of symptoms with lower consequences and risk factors as a function of time or number of performed air operations was proposed, based on Markov discrete processes [6,10-12,16]. The essence of this approach is explained by the mathematical model of Runway Excursion probability during landing operations. The concept of improvement of operators' cooperation in the exchange of information about safety indicators by profiling the organisation was presented. The last proposal concerns the construction of a comprehensive risk assessment indicator using a safety risk matrix.

Keywords: discrete processes, quantitative methods, risk management, safety risk

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1. INTRODUCTION

For organisations providing civil air transport services, the risk associated with ensuring the safety of air operations is a priority component of operational risk, as well as affecting market risk (for example, given reputational risk). The importance of proper safety management, including these risks, has led to cooperation (among competitors) in this regard and the association of air carriers within international organisations. The entry into force of the provisions of Commission Regulation (EU) No. 965/2012 in 2014, laying down technical requirements and administrative procedures related to air operations conducted by holders of an Air Operator Certificate (AOC)[2] - hereafter referred to as air operators (AOs), is part of the European Union Aviation Safety Agency system (EASA System[3]), which regulates, inter alia, the functioning of the Safety Management System (SMS) in the management structure of civil AOs. It is designed to manage safety within aviation organisations. More so, its implementation required the fulfilment of organisational requirements for the performance of tasks related to it: establishing safety policy and its objectives, safety risk management, safety assurance and safety promotion.

Among the many difficulties accompanying the process of SMS implementation in AOs management organisations, the problems related to the development of effective quantitative methods of safety risk assessment[4] that meet the individual needs of these entities deserve attention. This problem was left for AOs to solve. In other words, some forms of risk assessment were proposed; however, the task of working out their content was entrusted to the contractors. While it is not so difficult to assess the hazards and safety status, given the usually extensive experience of safety personnel, predicting the anticipated safety status in quantitative terms (risk assessment) is a problem. The random nature of incidents and air crashes with an extremely low probability of occurrence creates a situation where the assessment of the testability of individual safety forecasts of a particular carrier is very limited in practice. Thus, this does not allow for empirical verification of the author's safety risk analysis and evaluation concepts and may hamper the creativity of performers. Therefore, the assessment of any new proposals in this area should be based on scientific achievements or a rational, careful benchmarking of solutions from other areas of risk management.

This article aimed to propose opportunities to improve AOs safety risk assessment, based on quantitative risk analysis methods and subject them to the judgement of those concerned, within the framework of this publication.

2. LITERARY SOURCES REVIEW IN TERMS OF PROBLEMATIC SITUATION

The problematic situation is created by the formal need to meet the recommendations of the civil aviation authority to individually develop dedicated forms of safety risk assessment by AOs. In the last edition of the Safety Management Manual [1], serving as advisory documents of the International Civil Aviation Organization (ICAO) dedicated to SMS implementations, it is difficult to find, apart from general guidelines, the methodology of risk assessment, and

[2] AOC is the official, formal and internationally recognised confirmation that the relevant Operator State Authorities has permitted it to carry out the commercial air transport operations specified on this certificate.
[3] The European Union Aviation Safety Agency associates 32 States. The Agency develops know-how in all areas of civil aviation safety.
[4] The name officially used in EASA documents. A risk usually inherits its name from the effect or risk factors. Safety is none of these concepts.

especially the proposal regarding methods of risk analysis and evaluation in quantitative terms. Furthermore, it needs to be stressed that such a methodology should be adapted to the specificity of AOs; hence, they should be responsible for its creation. Important problems include choosing the methods of safety risk analysis and ensuring measurability of data necessary for its use [9].

The source literature dedicated to the subject matter in question consists of official publications of civil aviation authorities and information and advisory materials. National publications on SMS issues omit aspects of safety risk quantitative assessment methods; at most, they confirm the existence of the problem [5]. Rich literature devoted to risk analysis methods allows knowledge of the essence of many of them, unfortunately without assessing their usefulness for AOs [6,7,10-12,16]. However, this does not apply to quantitative-qualitative methods, as such [14]. For example, in the writings of Jacek Skorupski [14], we find descriptions of several methods based on fuzzy logic, combined with techniques of discrete (Petri net). These are simulation models and can be used, for example, to study the effects of exceeding safety standards or their identification (for example, time and space separations). The ability of AOs to apply this acquis in solving risk assessment problems is further hampered by the fact that they require expert data (which is a certain way to overcome the difficulty of accessing "hard" data). (Name of author needed) of an innovative method combining elements of statistics and expert assessments allowing for risk evaluation of a specific flight plan and landing airports considering the hierarchy of risk factors (the method is under development and evaluation). Failure Mode Effect Analysis (FMEA), whose adaptation to the needs of aviation has been announced for years is an example of such a method that has already gained classic status. Sometimes, referring to expert evaluations is the only way to achieve the goal, but it entails the need to identify the model with reality, which is usually a long process and consequently forces it to return to statistics. The shortage of incident data needed for statistical inference and forecasting has long been reported by AOs. "*The use of incomplete numerical data, with omission of some unknown part of the occurred incident data, introduces a latent and unrecognisable error into each calculation, which will result in incorrect calculations of indices of particular risks...*". [13, p.11]. These needs were offset by several years of SMS operation and EASA's efforts to ensure the cooperation of AOs for safety, which resulted in the definition of events reported in the Mandatory Occurrence Reporting System (MORS) in civil aviation and their corresponding indicators describing the state of safety, transmitted to national databases and recorded in the European Central Repository (ECR). These incidents are classified under the European Risk Classification Scheme (ECRS). They include Aircraft Upset, Runway Excursion[5], Runway Collision, Airborne Collision (list of 11 items), belonging to an identified Key Risk Area [3]. Polish AOs are required to complete a quarterly spreadsheet, which is available on the website of the Civil Aviation Authority (ULC), stating the number of operations and the number of events according to the defined list. This allows calculating the value of safety performance indicators (SPIs), being the number of these events per number of operations or flight hours multiplied by 1E4. SPIs used by AOs may belong to high-level SPIs and their precursors may be described by low-level SPIs [5]. Moreover, it is worth noting that events to which low-level SPIs are dedicated are in fact symptoms allowing identifying safety risk through its component, related to the occurrence hazard of an incident featured on the list of high-level SPIs.

Whereas AOs can check in publications, for example, EASA or ULC, how their safety status is compared to the aggregated results of other organisations representing a similar type of service in terms of defined high-level SPIs events, and the four priority factors of these events.

[5] Loss of control of an aircraft after a touchdown on the runway.

These factors, combined with statistical dependencies and consequences (high-level SPIs) could be theoretically known as key risk indicators (KRI), however, there are no publications on the subject. One of many statistics contained in the EASA publication [3], is presented in Fig. 1, which plots the accidents and serious incidents related to CAT Airlines, Air Taxi and non-commercial business, by the key risk area, which the occurrence would potentially lead to safety issue.

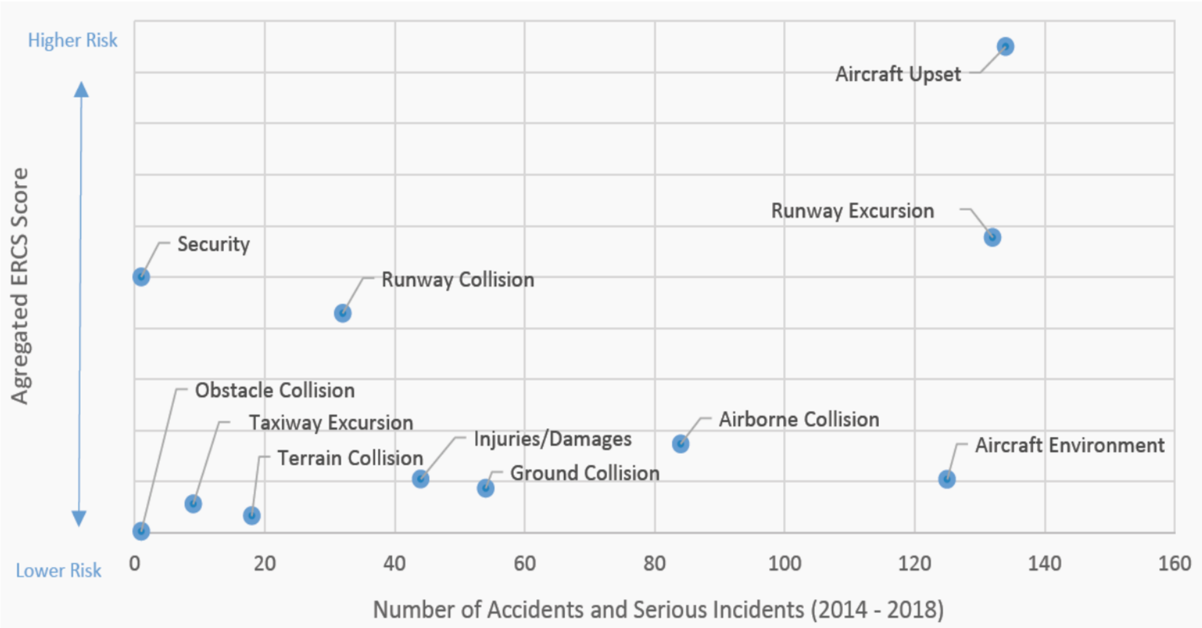

Fig. 1. Distribution of higher risk occurrences by number of events and aggregated risk score ECRS
Source: [3, p. 46]

The risk margin (aggregated ECRS score) (Fig. 1.) is questionable, as there are no explanations of what it is in the main text of the source material. As a side note, it should be stated that the ECRS tools: "*... is still in the working tests and evaluation phase*." [15, p. 7]. According to the definition of the safety risk, its measure should be the estimated average severity of the consequences, which each AO assesses according to a subjective scale of assessment. This shows difficulties in developing methods of safety risk assessment, similarly at the EASA level.

Risk assessments are ex ante assessments, while these safety assessments are ex post assessments. They are undoubtedly useful for AOs; however, they do not solve the problems of safety risk assessment in their organisations, because aggregate statistics may not reflect the significant determinants of the organisation's specificity concerning specific Key Risk Areas.

The experience gained concerning the functioning of SMS resulted in the following conclusion: "*For example, aggregated safety data may be valid to define SPIs related to airspace management. De-aggregation may be necessary to address specific operational issues at particular facilities (that is, ACAS/TCAS alerts), or related to different service providers (that is, airline or ATS provider)*" [1, p. 74].

In turn, it is useful to refer briefly to the current form of risk assessment proposed in the latest edition of the manual [1]. The definition of risk itself is questionable: safety risk is defined as "*The predicted probability and severity of the consequences or outcomes of a hazard*" [1].

In this context, the risk is a specific indicator (a measure of hazard). What should then be thought of other risk indicators? Thus, the following problem arises: is a risk, as an ontic object, a feature of a situation that is a fragment of reality, or is it a designator of the world of symbols as seen by Popper[6]? The consequence of this definition is the adoption, as a form of assessment, of the risk matrix, here, with a three-stage scale of assessments: risk intolerable for an index of risk:{5A, 5B, 5C, 4A, 4B}; risk tolerable for an index of risk: {5D, 5E, 4C, 4D, 4E, 3B, 3C, 3D, 2A, 2B, 2C, 1A}; risk acceptable - for other indexes of risk (Fig. 2).

Risk probability		**Risk severity**				
		Catastrophic A	Hazardous B	Major C	Minor D	Negligible E
Frequent	5	**5A**	**5B**	**5C**	**5D**	**5E**
Occasional	4	**4A**	**4B**	**4C**	**4D**	**4E**
Remote	3	**3A**	**3B**	**3C**	**3D**	**3E**
Improbable	2	**2A**	**2B**	**2C**	**2D**	**2E**
Extremely improbable	1	**1A**	**1B**	**1C**	**1D**	**1E**

Fig. 2. Example of a safety risk matrix
Source: [1, chapter 2, p. 16]

The matrix dimension, which is a probability, was divided into 5 class ranges (similarly to risk severity), whose indices were described by frequency adjectives. No limits of these ranges were defined in terms of frequency units or probability values. More so, the assessment horizon was not defined. In the EU civil aviation, it was assumed that the probability of an aircraft crash is assessed as improbable for event frequencies 1E-8 per hour flight [4, p. 8]. However, the content of the handbook does not state who owns the safety risk. Does its assessment concern a specific air operation or all operations carried out by AOs? It is easy to see that for a risk with a given probability index, expressed as a measure of frequency, the actual severity (and its index) will increase with the duration of AO's operations, as the actual and average number of effects of the materialisation of risk will potentially increase.

The matrix makes it difficult to assess hazards with a different distribution of severity than the dichotomous one, and in the case of many hazards, it requires solving the problem of a comprehensive assessment. In the proposed method of comprehensive assessment based on FMEA, we are dealing with adding point representations of risk indices of various hazards and factors to assess the total risk, which contradicts the laws of mathematics for conducting probability calculations.

To monitor the state of security and formulate objectives in this respect, AOs are recommended to draw up monthly lists of security indicators in the form of charts[7] [2]. For forecasting SPIs, it is recommended to use the method of, for example, time series with moving average.

[6] Karl Raymond Popper divided the Universe into the following worlds: material, mental phenomena and symbols used for encoding information.
[7] According to the idea of Walter A. Shewhart, creator of Statistical Process Control – SPC.

Conclusively, it can be stated that one of the most important problems of safety risk analysis within SMS is currently the determination of probability value in the existing, available AOs, information environment and the lack of dedicated, quantitative methods of its determination for safety risk assessment.

3. METHODOLOGY AND THEORETICAL BASIS

Formulating the diagnostic evaluations presented above, the source literature was researched, the most important items of which were listed in and the results of pilot studies carried out using the diagnostic survey method with the use of expert interview technique. Selected employees of airlines, including Safety Manager Small Planet Airlines (Poland) Sp. z o.o. and Ground Operations Quality & Compliance Manager at Luxair Airline[8], gave interviews on problems of risk assessment in civil aviation organisations.

The theoretical assumptions of the proposed method (later described in this article), limited to the example of calculating the probability of occurrence category from the high-level SPIs list based on the intensity of events from the low-level SPIs list, were taken from Markov's process theory, described to a sufficient extent in the literary references: [6,10-12,17] especially in the aspect of the application of Kolmogorov stochastic differential equations for homogeneous Markov processes, for which all intensities are finite and stationary. The use of Laplace transformation to solve the proposed types of differential equation systems with stationary coefficients was described in the reference [8,11].

The identification of an exemplary mathematical model, for obvious reasons, cannot be experimental, as its validity results directly from accepting the results of assumptions identification, the most important of which concerns the condition that the probability of transition to the next state does not depend on history. Replacement of a continuous variable (customary time) by a discrete variable (number of air operations) is a known procedure (for example, from analogous applications of normal distribution); however, it causes inaccuracies in conclusions with small numbers of operations. The accuracy of the model depends mainly on the reliability and accuracy of the input data.

The remaining proposals for improving AOs risk management process, presented below, were the result of the heuristic process and do not require further explanation.

4. RESULTS AND DISCUSSION ABOUT PROPOSED SOLUTIONS

4.1. Proposed approach to determine the probability of accidents and serious incidents - example of a probability estimation model of Runway Excursion

The use of stochastic process theory or more precisely discrete processes to determine the value of probabilities of aviation events with high consequences (according to the ECRS classification belonging to the Key Risk Area), is an idea resulting from the fact that in civil aviation organisations, safety indicators of intensity (SPIs) are used.

Let us consider an example of an incident from the Key Risk Area list. Risk factors, particularly safety issues for this incident are also defined in ECRS, in aggregated groups, only some of which fall under the responsibility of AO (Tab. 1). Based on the flight's register records

[8] Being the students of extramural studies in the field of aviation.

analysis, AO is can measure the number of premature/late touchdowns, which usually have no adverse consequences (but can turn into Runway Excursion). They indicate a reduced quality of procedure execution (low-level SPI incident). Furthermore, it can be observed that the gross causes of both events are identical. The differences concern technical problems or braking after touchdown (Table 1, rows 5 and 7). AO can determine, within an assumed assessment horizon, the intensity of these events, measured by the number of occurrences to the number of landing operations of a given aircraft type at aerodromes equipped with a given category of instrumental landing system.

Tab. 1.

List of safety issues with an assessment of their impact for Runway Excursion

Safety issues for Runway Excursion* Bands of aggregated ECRS Risk Score	AO responsibility**	Safety issues for Premature/late touchdown**
1	*2*	*3*
1. Monitoring of flight parameters and automation modes	x	x
2. Convective weather	x	x
3. Ice in flight	x	x
4. State of well-being and fight for duties	x	x
5. Handing of technical failure	x	-
6. Crew Resource Management	x	x
7. Aircraft braking and steering	x	-
8. Flight planning and preparation	x	x
9. Inappropriate flight control inputs	x	x
10. Runway surface condition	-	-
11. Experience, training and competence of Flight Crew	x	x
12. Entry of aircraft performance data	x	x
13. Alignment with wrong runway	x	x
14. Bird/wildlife strikes	-	-
15. Ice on ground	-	-
16. Aircraft maintenance	x	x
17. Windshear	-	x
18. Transport and carriage of lithium batteries	x	x
19. Baggage and cargo loading	x	x
20. Fatigue	x	x
21. False or disrupted ILS signal capture	x/-	x
22. Handling and execution of go-around	x/-	x

* Column 1 quotes terms from [3, Table 7. Large aeroplane safety risk portfolio, p. 48, 49]
** the characters: "x” - means yes, "-" -I mean no.
Source: Author’s study based on [3]

Let us consider the graph of selected states when landing a given type of aircraft (fig. 3).

State "**1**" vertex shall be the agreed state of deciding on landing, "**2**" vertex is a premature or late touchdown incident state, "**3**" vertex is the state of the Runway Excursion event, "**4**" vertex is the good touchdown incident. The criteria of Markov's discrete processes concern processes for which the probabilities of transition to particular states from t1 to t2 moment are dependent on the difference (t_2 - t_1) and do not depend on history. In the model under consideration, it is assumed that the time variable will be "mimicked" by the number of operations – *n* because we are interested in the results solely for discrete values. Each number of air operations will correspond to a specific probability of events for the vertices of the graph: "**1**", "**2**", "**3**", "**4**" regardless of what happened before.

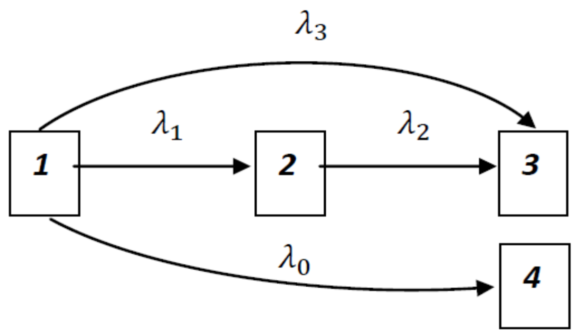

Fig. 3. The graph of selected aircraft states during landing
Source: Author's study

Number of good touchdowns – events of k_0 type: "**1**"→"**4**", is the information available and, when referred to the total number of operations - N, it allows determining the intensity λ_0 of these events.

Number of events of k_1 type: "**1**"→"**2**" per N determines λ_1 intensity of these events and can be determined as a result of analysis of flight parameter recorders (it aggregates information about their causes – marked with "x" in column 3 of Tab. 1).

Number of events of k_3 type: "**1**"→"**3**" per N determines λ_3 intensity of these events. Their causes are under the responsibility of the aerodrome administrators or the causes of technical failures after the touchdown (this aggregates information about their causes marked with "-" symbol in column 2 of Tab. 1, except the items from row 17[9]), which are the direct cause of the Runway Excursion incident.

Incident of k_2 type: "**2**"→"**3**" refers to a situation where a premature or late touchdown is transformed into a Runway Excursion incident. The number of k_2 events per N determines the λ_2 intensity of these events. It can be determined from statistics relevant to the conditions of landing operations considered in a given model, excluding events caused by reasons of k_3 type events.

Since the model is to be of a forecast nature, the mentioned intensities should be predicted as stationary means in a given time horizon, for example, by time series method, in general not only by AO data. Additionally, it should be stressed that the levels of SPIs in civil aviation are relatively constant, with slight downward trends [3].

[9] Refers to failures of aerodrome wind measurement systems.

For a graph in Fig. 3, the following arrangement of Kolmogorov's differential equations can be arranged in light of the aforementioned assumptions:

$$\begin{cases} P_1'(n) = -(\lambda_0+\lambda_1+\lambda_3)P_1(n) \\ P_2'(t) = \lambda_1 P_1(n) - \lambda_2 P_2(n) \\ P_3'(n) = \lambda_3 P_1(n) + \lambda_2 P_2(n) \\ P_4'(t) = \lambda_0 P_1(n) \end{cases} ; \tag{1}$$

where: $P_1(n)$ – probability of state "**1**" 1 continuing; $P_2(n)$ – probability of transitioning from state „**1**" to state "**2**" $P_3(n)$ – probability of state "**3**"; $P_4(n)$ – probability of state „**4**".

From the physical side of the issue, it follows that:

$$(\lambda_0+\lambda_1+\lambda_3) = 1\,. \tag{2}$$

Considering the dependency (2) results in the loss of the possibility of tracking the logic of physical units in the transformations, but does not affect the final result, as from now on all variables will be treated **as dimensionless**.

For the model under consideration, the following initial conditions can be assumed for $n=0$: $P_1(0)=1$ and $P_2(0)=P_3(0)=P_4(0)=0$. By transforming Laplace's differential equations system (1) and taking into account the initial conditions and equation (2), the following algebraic system of equations was obtained:

$$\begin{cases} P_1(s) - 1 = -P_1(s) \\ P_2(s) = \lambda_1 P_1(s) - \lambda_2 P_2(s) \\ P_3(s) = \lambda_3 P_1(s) + \lambda_2 P_2(s) \\ P_4(s) = \lambda_0 P_1(s) \end{cases} ; \tag{3}$$

where: s – Laplace's operator.

For example, Laplace's transformation was obtained concerning the said probability of Runway Excursion:

$$P_3(s) = \frac{\lambda_3}{s} - \frac{\lambda_3}{s+1} + \frac{\lambda_1}{s} - \frac{\lambda_1}{(1-\lambda_2)(s+\lambda_2)} + \frac{\lambda_1\lambda_2}{(1-\lambda_2)(s+1)}\,. \tag{4}$$

By performing a reverse transformation of Laplace's dependency (4), the original was obtained:

$$P_3(n) = \lambda_3(1-e^{-n}) + \lambda_1 - \frac{\lambda_1}{1-\lambda_2}e^{-\lambda_2 n} + \frac{\lambda_1\lambda_2}{(1-\lambda_2)}\,e^{-n}\,. \tag{5}$$

Dependency (5) allows assessing the risk of Runway Excursion (for dimensionless input) for a single aircraft to n operations or for n operations of the aircraft type used by the AO at any time within the assessment horizon. Due to the nature of the variable n, the lower limit of the model utility range was estimated[10] for n=20, which is sufficient in practice, considering the volume of air operations of an average AO. This allows simplifying the relation (5) to the form:

[10] By examining the course of the function: $P_1(n)=e^{-n}$, which for $n>20$ should equal zero. $P_1(20)\approx 2E\text{-}9\approx 0$.

$$P_3(n) \approx \lambda_3 + \lambda_1 \left(1 - \frac{1}{1-\lambda_2} e^{-\lambda_2 n}\right). \tag{6}$$

The assessment horizon of $P_3(n)$ depends on the input forecast horizon and the condition: $n<20/\lambda_2$ should be met, which in practice usually means over 1E4 operations. In practice, the relationships occur: $\lambda_1 >> \lambda_2$ and λ_3. Fig. 4. shows an example of the $P_3(n)$ function.

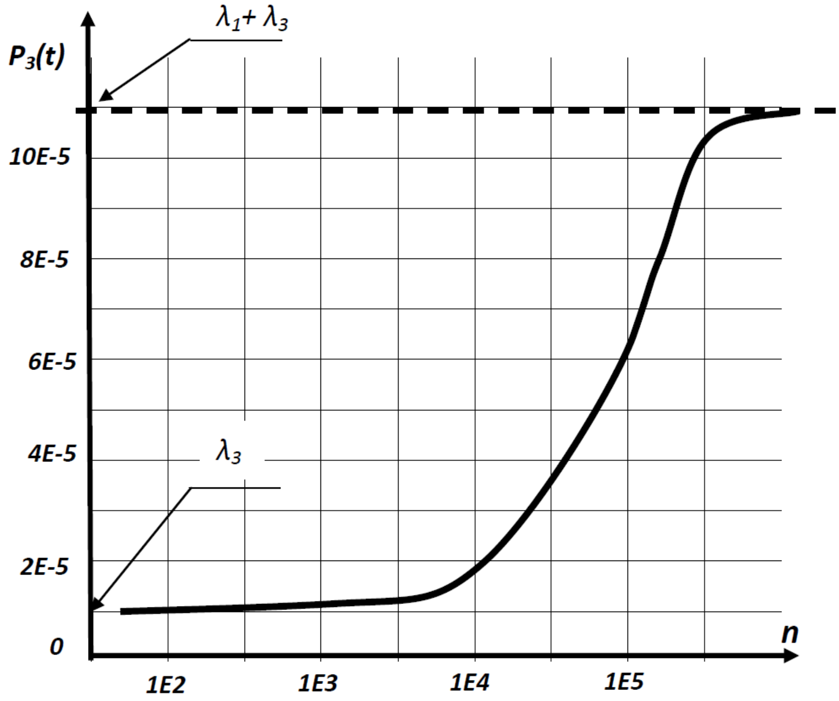

Fig. 4. Example of a graph for $P_3(n)$ dla: λ_1=1E-4; λ_2= $\lambda 3$=1E-5
Source: Author's study

The use of flight recorders for λ_1 identification by AOs allows to aggregate autogenous risk factors. Thus, the model reflects the reality of a given AO better than if the averaged data of other AOs were used. In contrast, for λ_2 and λ_3 identification, it seems necessary to use the data resources of other AOs. Hence, in this case, there is a need for data exchange between AOs, users of a given type of aircraft with technical failures, bird/wildlife strikes and runway surface condition safety issues from users of the same aerodromes as a specific AO. Empirical data can be supplemented with the results of training on flight simulators.

4.2. Postulates regarding the data repository

Each of the ECRS classified events belonging to the Key Risk Area requires separate profiling of the data sources for its model for probability calculation. In the proposed modelling approach, the relevant profiling criteria for these sources will be the selected intensities of risk symptom (or SPIs), and possibly of risk factors. A complete list of criteria can be identified after developing the final form of the remaining models.

The proposed intensities (as criterions) have the advantage that the differences in the size of the AO organisation are no longer relevant.

Thus, it is proposed that the search for AOs with similar risk profiles should be carried out in a variable, standardised[11] criterion space for the required intensities, adequate to the current needs of the model. For example, using Euclidean or urban metrics.

It seems obvious that the civil aviation authority of AO's country or EASA should administer the data repository of this data. This would facilitate the continuing operational oversight of AOs by the Aviation Authority and ensuring data confidentiality.

4.3. Comprehensive risk assessment using a risk matrix

The idea of using a risk matrix (Fig. 2) to illustrate the situation in AO's organisation consists in presenting assessments of the most significant aviation events and incidents in terms of probability and severity in the relevant cells of the matrix after assigning them with probability and severity indices. Using this matrix for the assessment of a serious accident appears to be pointless as it is not acceptable to assign this type of incident with a risk index other than {1, A}. Identified causes of such an incident shall be neutralised and AO shall suspend operations until they are removed. Moreover, the incident is accompanied by fatalities, which makes it practically impossible to compare the {A} index with other indices on a quotient scale. However, there is a need to evaluate other aviation events (for example, from the Key Risk Area list). Their number makes it difficult to comprehensively assess and compare the risk profiles of different organisations. It should be noted that these are independent incidents in terms of probability.

The condition for the usefulness of the proposals formulated below is AO's estimation of severity accumulation rights, that is, mutual relations between its indices: {B, C, D, E}. This can be done, for example, by expressing severity in the form of forecasted losses measured in the quotient scale using, for example, means of payment. This will allow defining the limits of class ranges of indices {B, C, D, E}.

To express the risk profile of AO based on this risk matrix by means of a comprehensive risk index - IR_k, with the indices of probability (IP_k) and severity (IS_k), aggregating the m of the discussed events described by IR_i indices, where i falls within the range: <1, m>, the following procedure is proposed:

1. For each IR_i and given probability index (IP_i), if the value of the mathematical probability p_i can, if it is not known, be determined as the average value of the class limits of a given IP_i;
2. The value of the probability p_k needed to determine the IP_k is proposed to be calculated from the relationship:

$$p_k = p_1 \cup p_2 \cup \dots \cup p_i \cup \dots \cup\ p_m\ . \tag{7}$$

In practice, knowing that for the probabilities of two independent events the following occurs:

$$p_1 \cup p_2 =\ p_1 + p_2 - p_1 p_2\ . \tag{8}$$

p_k can be calculated using the relation (8) in a simple recursive procedure (having the sum of the first two components we treat it as a new component of the calculated relation (7) aggregating the first two. The procedure is repeated until the result is obtained.

[11] Each criterion (for example, type of SPI) takes a linear scale <0.1> for actual values <SPImin., SPImax>.

It is easy to see that for real, very small p_i from the range (1E-7, 1E-3), for practical purposes, dependence (7) can be simplified to the following form:

$$p_k \approx \sum_{i=1}^{m} p_i \,. \tag{9}$$

3. Based on p_k we determine the IP_k;
4. For each IR_i and a given severity index (IS_i), determine the **real losses** of l_i, and if not known, determine the value of l_i as the average value of the limits of the class range of a given IS_i;
5. The value of IS_k should be formally calculated based on the average value of the distribution of real losses l_k (considering the possible accumulation of air events). Considering that for very small p_i the value of IS_k can be estimated on the basis of a simplified relationship:

$$I_k \approx \sum_{i=1}^{m} p_i \, l_i \,. \tag{10}$$

6. Based on l_k we determine IS_k ;
7. We determine IR_k based on: IP_k and IS_k , which ends the procedure (Fig. 2).

5. CONCLUSION

The use of intensity indicators in safety assessments provoked the search for solutions based on stochastic process theories. An attempt to develop an exemplary model for calculating the probability of a selected aviation incident from the ECRS Key Risk Area list, due to its relative simplicity, makes the search direction more credible. The advantage of the model is the possibility of aggregating data on many risk factors that are difficult to observe by data obtained from the analysis of flight recorders. It equally allows precise determining of the time horizon of risk assessment for the form of the recommended matrix. The model can also be used as a factoring tool to determine the directions of corrective actions. The construction of subsequent models will allow defining precise needs concerning access to statistical data by air operators, which will give shape to the outlined concepts of improving selection and access to statistical data. They should be more focused on the needs of air operators, by increasing the degree of disaggregation of the statistics provided and allow searching for "neighbours" in a variable set of criteria through profiling. These are the general demands for building the data repository needed to provide the data identified during the conceptualisation of the model described.

The postulated comprehensive assessment indicator for a form of risk matrix can be an alternative to the popular FMEA method. Hence, it seems logical, because of the separation of mathematical operations on probabilities and losses. Whereas, the postulate of subjectivisation of loss counting by the operator is the essence of risk subjectivity.

If the content of this article finds interest among the aviation community, then it will be a source of satisfaction for the author.

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