Civil Aviation Occurrences

Subjects: Engineering, Aerospace
Contributor: Anna Grincova

The nature of a civil aviation occurrence may be defined in three different categories while considering its severity. General categories include civil aviation accidents, serious incidents and incidents.

Keywords: civil aviation ; occurrence ; incidents ; regression models

1. Introduction

Civil aviation is currently the safest, fastest and most comfortable mode of transport. This is a result of strict safety regulations governing the piloting, air traffic and aviation technology maintenance. According to the recommendations of the International Air Transport Association, the demand for civil aviation services is expected to double over the following two decades. This would, however, bring more problems to the field of aviation safety as a result of increased air transport congestion and more load put on the civil aviation system.

Aviation safety is significantly affected by the constant development of novel technologies [1]. However, despite the well thought-out technical and safety precautions, civil aviation occurrences still happen. According to [2][3], a civil aviation occurrence (CAO) is defined as an occurrence associated with the operation of an aircraft that affects or could affect the air traffic safety, and which is due to its consequences assessed as an aviation accident, serious incident, incident or ground incident. The Annual Safety Review [4] stated that the accident rate has been constantly decreasing since 2014, whereas the rate of serious incidents stabilised on the peak value reached in 2016. In 2018, there was an increase in the number of serious incidents compared to the mean value observed in the previous decade.

According to [5], with more intensive air traffic, the number of reported civil aviation occurrences increases, too. The authors of this publication processed the data obtained from the European Coordination Centre for Aviation Incident Reporting Systems (ECCAIRS), which analyses the reliability and safety of large aircrafts in terms of aviation occurrences by individual categories, as defined by the International Civil Aviation Organisation (ICAO).

2. The Causes of Civil Aviation Occurrences

Civil aviation occurrences are rarely a result of a single cause. Janic [6] summarised the causes of civil aviation occurrences as follows: pilot human error, mechanical failures, air traffic control errors, ground support failures, and dangerous weather conditions. According to [7], such occurrences are usually caused by various combinations of multiple circumstances. Kharoufah et al. stated that human errors contributed to almost 75% of the aviation accidents and other occurrences [8]. The authors observed that the most important human factor that contributes to aviation accidents and incidents is the situational awareness followed by non-adherence to procedures). According to [9], as much as 79% of the fatal accidents which occurred in the USA in 2006 were attributed to a pilot error. According to Caldwell [10], the tiredness of pilots also negatively affects the crew's capabilities, which may significantly contribute to civil aviation occurrences. The impact of managerial and organisational effects (e.g., pilot errors, ATC errors, maintenance staff errors, and technology failures) on the air traffic failures were examined by Lin et al. [11]. According to [12], maintaining operational safety and the status of airport runway (especially in bad weather) is very important for the overall aviation safety. Li et al. [13] analysed 41 civil aviation accidents which happened to the aircraft registered in the Republic of China in the years 1999–2006. They observed that incorrect decisions at higher control levels may indirectly impair the performance of pilots, and this consequently leads to accidents.

Incidents represent an important subgroup of civil aviation occurrences. According to [14], although incidents are not paid as much attention as is paid to accidents, it is still important to investigate incidents to identify dangerous conditions that might lead to serious occurrences. The most frequent aviation incident, i.e., a collision of an aircraft with a bird, and a correlation between the type of incidents and changes in the temperature cycle are discussed in the paper [15]. The authors proposed a simulation model for predicting the probability of an aviation incident caused by a collision of an

aircraft with a bird. According to [14][16], the absence of the aircraft maintenance causes a more intensive wear and ageing of most system components, and this leads to their complete wear or failure and subsequently disrupts the safety of the system. Marais and Robichaud observed, based on the data from the years 1999–2008, that the accidents associated with maintenance are approximately 6.5 times more likely to be fatal than accidents in general [14]. Insley and Turkoglu [16] examined and analysed aviation accidents and serious incidents associated with the aircraft maintenance that occurred in the years 2003–2017. They observed that the most frequent causes of civil aviation occurrences were runway excursions and air turnbacks, while the second-level categories were associated with failures of engine and landing gear systems.

Roelen et al. [17] pointed out a need for the models representing potential scenarios of a succession of causal occurrences, including the technical, human and organisational factors. The authors [18] created a hierarchically structured model containing various accident scenarios in different flight stages. They created the model by applying the methodology combining the event sequence diagrams, fault trees, and Bayesian belief networks. A causal model of air traffic safety, based on a study of accidents and incidents over the last two decades, was described in the paper [19]. The authors created the model by applying the event sequence diagrams, fault trees, and a Bayesian belief network. The paper [20] presents an accident model based on the elementary concepts of the systems theory. According to Leveson, the use of such a model provides the theoretical basis for implementing unique novel types of accident analyses, hazard analyses and accident prevention strategies, including novel approaches to safety designing. Blom and Bloem [21] applied the Bayesian estimation of the function of a combined conditional rate of accidents and statistical data on accidents and flights. A structured process for the creation of a qualitative model of evaluation that might be used by airline companies to identify human errors and select an intervention strategy with the highest potential for success was described in the paper [22].

Zhang and Mahadevan [23] analysed the accidents of passenger airline companies that happened in the years 1982–2006. They identified the correlations between the causes of accidents by applying the Bayesian network. The paper [24] described the identification of common causes of serious and major incidents in the air traffic by applying the Heinrich's triangle. According to this theory, the causes identified at high severity levels are always located at low levels. In the analysis, the authors of the paper used the data on serious and major incidents for four consecutive years. Boyd and Howell [25] applied the method of statistical analysis (Poisson distribution, contingency tables, hypothesis testing) in order to analyse the rates of aviation accidents. Mannering and Bhat [26] discussed the methods used in the field of accident analyses (e.g., Poisson regression model, generalised estimating equation models, Poisson and negative binomial regression models, etc.). The effects of the financial factors which influence the maintenance policy, procurement and training in airline companies on air traffic safety are described in the paper [27]. The study monitored 110 airline companies operating in 26 countries, and the analyses and evaluations were carried out while applying, for example, testing methods, Poisson regression, etc. Similarly, the paper [28] described the investigation of the effects of particular business decisions of airline companies on the tendency for aircraft accidents. The author studied the probability of an aviation accident using the Poisson and negative binomial regression models. Li et al. applied the geographically weighted Poisson regression to create crash prediction models at the district level [29]. A spatial regression model was used in the analysis of road traffic accidents, as described in the paper [30]. Salvagioni et al. [31] investigated a potential correlation between teachers' burnout and car accidents that happened to teachers. The research was carried out with 509 teachers, and one of the accident occurrence evaluation methods was the Poisson regression model. The investigation, identification and evaluation of the factors affecting car accidents were carried out while applying the negative binomial distribution and the Poisson regression methods [32]. Gildea et al. [33] applied the Poisson regression to analyse the use of antihistamines, which may deteriorate the pilot's performance and hence contribute to an aircraft accident.

3. Conclusions

Understanding civil aviation occurrences and their causes leads to a higher safety of air traffic. The experiences show that there are many different minor occurrences that may indicate the existence of a hazard and the development of a risk that might result in an accident. It is important to know such minor occurrences; that is why the relevant data should be collected and assessed to take adequate preventive measures. Each CAO is unique, and finding the causes of the event is not always easy. The proven method of preventing CAOs is the implementation of an integrated Safety Management System that allows a real change in the organisation's ability to increase safety.

References

1. Latorella, K.A.; Prabhu, P.V. A review of human error in aviation maintenance and inspection. Int. J. Ind. Ergonom. 2000, 26, 133–161.

2. Regulation L 13 Investigation of Accidents and Incidents, Ministry of Transport of the Slovak Republic; Air traffic services of the Slovak Republic: Bratislava, Slovakia, 2007.
3. Annex 13 To the Convention on International Civil Aviation Aircraft Accident and Incident Investigation. Available online: (accessed on 13 April 2021).
4. Annual Safety Review 2019. Available online: (accessed on 13 April 2021).
5. Balicki, W.; Głowacki, P.; Loroch, L. Large aircraft reliability study as important aspect of the aircraft systems' design changes and improvements. Proc. Inst. Mech. Eng. Part G J. Aerosp. Eng. 2020.
6. Janic, M. An assessment of risk and safety in civil aviation. J. Air Transp. Manag. 2000, 6, 43–50.
7. Saleh, J.H.; Marais, K.B.; Bakolas, E.; Cowlagi, R.V. Highlights from the literature on accident causation and system safety: Review of major ideas, recent contributions, and challenges. Reliab. Eng. Syst. Safe 2010, 95, 1105–1116.
8. Kharoufah, H.; Murray, J.; Baxter, G.; Wild, G. A review of human factors causations in commercial air transport accidents and incidents: From to 2000–2016. Prog. Aerosp. Sci. 2018, 99, 1–13.
9. The Nall Report 2007: Accidents Trends and Factors for 2006. Available online: (accessed on 13 April 2021).
10. Caldwell, J. Crew schedules, sleep deprivation, and aviation performance. SAGE J. 2012, 21, 85–89.
11. Lin, P.H.; Hale, A.R.; Van Gulijk, C.; Ale, B.J.M.; Roelen, A.L.C.; Bellamy, L.J. Testing a safety management system in aviation. In Proceedings of the 9th International Conference on Probabilistic Safety Assessment and Management 2008, Hong Kong, China, 18–23 May 2008. Code 96615.
12. Koščák, P.; Berežný, S.; Vajdová, I.; Koblen, I.; Ojciec, M.; Matisková, D.; Puškáš, T. Reducing the negative environmental impact of winter airport maintenance through its model design and simulation. Int. J. Environ. Res. Pub. Health 2020, 17, 1296.
13. Li, W.C.; Harris, D. Routes to failure: Analysis of 41 civil aviation accidents from the Republic of China using the human factors analysis and classification system. Accid. Anal. Prev. 2008, 40, 426–434.
14. Marais, K.B.; Robichaud, M.R. Analysis of trends in aviation maintenance risk: An empirical approach. Reliab. Eng. Syst. Saf. 2012, 106, 104–118.
15. Burmistrova, V.G.; Butov, A.A.; Volkov, M.A.; Yavtushenko, M.S.; Kostishko, B.M.; Moskvicheva, M.G.; Pchelkina, Y.Z. The change in the probability of aviation accidents "collision of an aircraft with a bird" in accordance with of a change in the temperature cycle. Journal of Physics: Conference Series, Volume 1745. In Proceedings of the VI International Conference on Information Technology and Nanotechnology (ITNT-2020), Samara, Russia, 26–29 May 2020. Code 167456.
16. Insley, J.; Turkoglu, C.A. Contemporary Analysis of Aircraft Maintenance-Related Accidents and Serious Incidents. Aerospace 2020, 7, 81.
17. Roelen, A.L.C.; Lin, P.H.; Hale, A.R. Accident models and organisational factors in air transport: The need for multi-method models. Saf. Sci. 2011, 49, 5–10.
18. Roelen, A.; Wever, R.; Mosleh, A.; Groth, K. Development and validation of a comprehensive hybrid causal model for safety assessment and management of aviation systems. In Proceedings of the 9th International Conference on Probabilistic Safety Assessment and Management 2008, Hong Kong, China, 18–23 May 2008. Code 96615.
19. Ale, B.J.M.; Bellamy, L.J.; Van Der Boom, R.; Cooper, J.; Cooke, R.M.; Goossens, L.H.J.; Hale, A.R.; Kurowicka, D.; Morales, O.; Roelen, A.L.C.; et al. Further development of a Causal model for Air Transport Safety (CATS): Building the mathematical heart. Reliab. Eng. Syst. Safe 2009, 94, 1433–1441.
20. Leveson, N. A new accident model for engineering safer systems. Saf. Sci. 2004, 42, 237–270.
21. Blom, H.A.P.; Bloem, E.A. Modeling and estimation of accident rate and trend in air transport. In Proceedings of the 13th Conference on Information Fusion, Fusion 2010, Edinburgh, UK, 26–29 July 2010. Article number 5711871.
22. Chen, J.C.; Lin, S.C.; Yu, W.F. Structuring an effective human error intervention strategy selection model for commercial aviation. J. Air Transp. Manag. 2017, 60, 65–75.
23. Zhang, X.; Mahadevan, S. Bayesian network modeling of accident investigation reports for aviation safety assessment. Reliab. Eng. Syst. Safe 2021, 209.
24. Cheng, S.Z.Y.L.; Valdés, R.M.A.; Comendador, V.F.G.; Nieto, F.J.S. Detection of common causes between air traffic serious and major incidents in applying the convolution operator to Heinrich pyramid theory. Entropy 2019, 21, 1166.
25. Boyd, D.D.; Howell, C. Accident rates, causes, and occupant injury involving high-performance general aviation aircraft. Aerosp Med. Hum. Perf. 2020, 91, 387–393.

26. Mannering, F.L.; Bhat, C.H.R. Analytic methods in accident research: Methodological frontier and future directions. Anal. Methods Accid. Res. 2014, 1, 1–22.
27. Fardnia, P.; Kaspereit, T.; Walker, T.; Xu, S. Financial performance and safety in the aviation industry. Int. J. Manag. Financ. 2020, 17, 138–165.
28. Brown, A.S. The effects of airline behavior on aircraft accidents. Gettysbg. Econ. Rev. 2017, 10, 70–105.
29. Li, Z.; Wang, W.; Liu, P.; Bigham, J.M.; Ragland, D.R. Using geographically weighted Poisson regression for county-level crash modeling in California. Saf. Sci. 2013, 58, 89–97.
30. Al-Hasani, G.; Asaduzzaman, M.; Soliman, A.H. Comparison of Spatial Regression Models with Road Traffic Accidents Data. In Proceedings of the International Conference on Statistic: Theory and Applications, Lisbon, Portugal, 13–14 August 2019. Paper No. 31.
31. Salvagioni, D.A.J.; Mesas, A.E.; Melanda, F.N.; dos Santos, H.G.; González, A.D.; Girotto, E.; de Andrade, S.M. Prospective association between burnout and road traffic accidents in teachers. Stress Health 2020, 36, 629–638.
32. Sajed, Y.; Shafabakhsh, G.; Bagheri, M. Hotspot location identification using accident data, traffic and geometric characteristics. Eng. J. Can. 2019, 23, 191–207.
33. Gildea, K.M.; Hileman, C.R.; Rogers, P.; Salazar, G.J.; Paskoff, L.N. The use of a poisson regression to evaluate antihistamines and fatal aircraft mishaps in instrument meteorological conditions. Aerosp. Med. Hum. Perf. 2018, 89, 389–395.