COMPARISON OF ACCIDENT PREVENTION PROCEDURES AND SAFETY MANAGEMENT SYSTEMS AT COMMERCIAL AIR TRANSPORT OPERATOR AND ATO

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Abstract. This article focuses on the prevention of aviation accidents and incidents. It starts by defining the basic concepts and the regulatory basis, the current methods of prevention at the state and air operator level. The main part of the paper contains a detailed analysis of the Safety Management System (SMS) of the air transport company and the ATO/DTO training organisation. The analysis is supplemented by guided interviews with safety personnel and a comparison of the two safety management systems. The information gathered is used to suggest possible improvements in operational safety, which is explained in the final part of the paper.

Keywords: safety management system; airline; approved training organisation

1. INTRODUCTION

The importance of safety in aviation is a recurring theme in the literature. Emphasis is placed on the significance of a robust safety management system in minimizing risks and maintaining a high level of safety [5, 9]. Iordache underscores the role of safety culture in identifying and managing hazards [7], while Hutsaliuk highlights the impact of various hazards on aviation and the need for a structured approach to safety management [6]. These studies collectively underscore the critical role of safety in aviation and the need for comprehensive systems and cultures to ensure it.

A Safety Management System (SMS) is a comprehensive tool used to manage safety in various industries, including transportation, aviation, construction, and others [10, 11]. It encompasses policies, objectives, plans, procedures, organization, responsibilities, and other measures [10]. The system is designed to reduce workplace risks and improve safety performance [4]. Its effectiveness has been demonstrated in various studies, with positive outcomes in safety performance and productivity [10]. However, there is a need for further research to define SMS, understand its failures, and improve its application [4].

2. THE MOST COMMON CAUSES OF ACCIDENTS IN AVIATION

A range of studies have explored the occurrence categories of aviation incidents, as defined by the International Civil Aviation Organization (ICAO)The analysis of these categories has been conducted with Głowacki focusing on events in Poland [3] and Choi on those in Korea [1]. Both studies found that the most common occurrences were related to loss of control, controlled flight into terrain, and runway excursion. These categories are further expanded identifying human factors, technical errors, environmental causes, and procedural issues as key threats [8]. Finally, Filip and Kandráč specifically examined airframe icing accidents, highlighting the importance of understanding the factors that contribute to these occurrences [2].

Based on the latest available ICAO Safety Report, the total number of accidents and the accident rate increase to 2.05 accidents per million departures in 2022, which is 6.3% higher than in 2021 [12]. The main causes of fatal accidents are:

- Turbulence (TURB): the most common category of accident occurrence.
- Runway Excursion (RE): the second most common category, involves running off the runway.
- Runway Incursion (RI): Involves the improper presence of an aircraft, vehicle, or person on a protected area of surface intended for aircraft landing and takeoff..
- Controlled Flight Into Terrain (CFIT) and Loss of Control In-Flight (LOC-I): These are global high-risk categories that should be addressed to reduce the risk of fatal accidents.
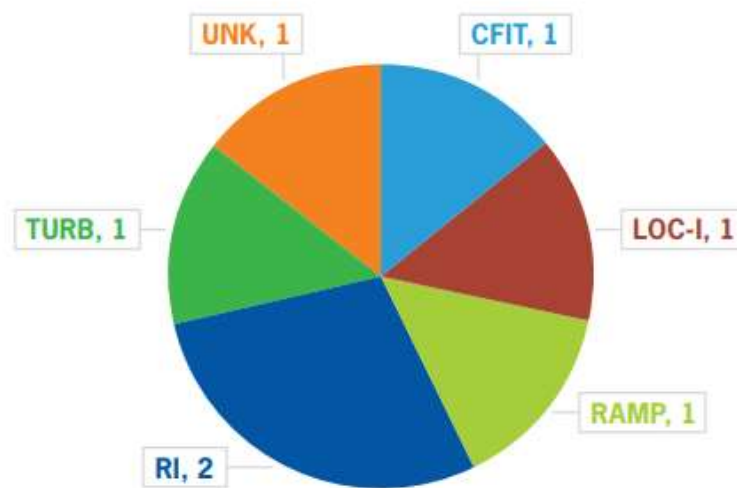-

Figure 1 Total fatal accidents by occurrence category in 2022 [12]

As can be seen in Figure 1, there were seven accidents with at least one fatality in commercial aviation in 2022. However, the causes of the accidents are so diverse that it is not possible to point to a common denominator. Therefore, safety improvement cannot be focused in one direction alone, but must be approached systematically and measures must be applied on the basis of a Safety Management System that must be continuously improved across the different categories of aviation and air transport enterprises.

3. RESEARCH QUESTIONS AND METHODS

This section defines research questions related to the prevention of aviation accidents and incidents. At the same time, the second chapter includes the specification of the methodology of the paper, which aims to suggest ways to improve the prevention of accidents and incidents in aviation.

3.1. Defining the research questions

In line with the main objective of the research and in relation to the expected outcomes, four research questions were set by the authors:

RQ1: How are accidents and incidents prevented in ATO/DTOs?

Training organisations - flight schools and aeroclubs provide various forms of flight training, both for complete beginners and pilot licence holders. This research question aims to analyse the internal principles that are applied to ensure safe operations, risk elimination and compliance with legislative requirements.

RQ2: How are accidents and incidents prevented at commercial air transport companies - air carriers?

Commercial air transport and airlines themselves are constrained by a large number of legislative rules that impose obligations on the operators in the terms of safety. This research question analyses the internal principles to meet these requirements, ensure safe commercial aviation operations and eliminate the risk of accidents.

RQ3: What are the differences between the risk management systems of ATO/DTOs and commercial air transport operators?

In the context of this question, the authors try to identify differences in approaches to operational safety and risk management in training organizations, which typically do not have the same financial resources and staffing levels as commercial airlines. At the same time, both operate manned aircraft, fly in the "same air" and are subject to the same physical rules.

RQ4: What are the most serious operational and safety threats at the present times?

Each type of air traffic has its own threats and level of risk. In this question, the targeted response is to define the most risky threats to the given type of operation.

3.2. Methods applied

In the framework of our own research, it is planned to compare the prevention methods of a commercial air transport operator and a training organisation. This comparison requires an analysis of safety procedures and documentation for operational safety. In particular, the comparison can provide information about any differences in security data acquisition, analysis, threat prioritisation, and actions taken. The identification of these differences can be an important guide for mutual inspiration in SMS improvement.

When conducting a literature search, it is important to work with credible and relevant information. The origin of this information can be taken from the specialised literature, the legislative framework, as well as from internet sources.

In addition to literature and internet reviews, moderated interviews were conducted with safety personnel. Interviews have an advantage in this case as they allow to obtain personal experience and insights from a real operation, without high demands on the initiative of the respondent. And it is exactly personal experience that is a significant factor in risk management. To better follow the previously mentioned methods, safety managers of an airline and an ATO/DTO training organisation were selected.

4. ANALYSIS OF ACCIDENT PREVENTION PROCEDURES

For the purposes of this article, both companies are anonymised. Thus, neither their brand names nor the names of the companies are mentioned.

4.1 Analysis of a selected commercial airline

After performing a basic analysis of internal procedures and documentation, the principles and methods used by this company to ensure the required level of operational safety are outlined below:
- Corporate safety policy – The company emphasizes continuous evaluation and updating of safety rules. The main objective is to identify threats, reduce risks and maintain the required level of safety while keeping ticket prices affordable. Employees should be made aware of

the risk reporting system and that the aim is to eliminate risks, not to punish them. Good training and sufficient numbers of experienced safety staff are key to the implementation of the safety policy.

- Just culture principles – The airline supports the principles of Just Culture, which is designed to encourage open communication between employees and the safety department without fear of punishment. The goal is to motivate the reporting of unsafe situations, even self-reporting, except in cases of negligence, serious violations of rules or intentional acts. The protection from sanctions applies only to non-intentional errors. Each report is considered on an individual basis, taking into account the views of the relevant departments. The Safety Department should be able to contact the reporting person.
- Company (safety) staff structure – Key roles are defined to ensure the functioning of the SMS: Accountable manager: responsible for the operation "in a professional way", Safety manager: oversees SMS, flight analysis, incidents and communicates with management., Deputy safety manager: deputises for the safety manager and investigates incidents, Safety Officer: Analyzes risks, updates threat list and evaluates countermeasures, Operational Gatekeeper: collects FDA data, identifies hazardous situations and informs the safety manager.

The overall concept of SMS is based on four fundamental pillars: 1) Safety, Quality and Reporting Policy and objectives 2) risk management 3) Safety assurance 4) Safety promotion. These pillars must always be considered as a whole, as none of them can function well on their own.

In the framework of the risk management system itself, the airline's procedures are based on the typical three phases: threat identification, risk assessment and risk mitigation.

Processes related to identification of threats include analyses focused on human factors and human performance, as well as potential threats caused by organisational structure. Of course, the threat identification process includes information from all reported occurrences, flight analysis data, audit report results, analysis of hazard trending, training reports, LOSA, etc.

Predictive threat identification mainly uses data and analyses from which certain trends can be traced, such as analysed data from completed flights. The predictive identification method includes Hazard Identification & Risk Analysis (HIRA).

Proactive threat identification methods include assessing the impact of conducting flights to new destinations and airports unfamiliar to crews. Similarly, the implementation of a new aircraft type or variant may pose a threat.

In addition, flight data analysis is used and external findings from various studies and analyses by international institutions, aviation authorities, education and training organisations are also used. Reactive methods, as the name implies, are a response to safety investigations and findings from surveillance audits. As in the previous cases, the analysis of flight data is used.

Reporting Safety Database (RSD) / IQSMS

To ensure effective and procedurally correct Safety management, the use of the IQSMS (Intuitive Quality & Safety Management) electronic system was implemented.

Processes managed within the IQSMS interface:
- Reports: voluntary and mandatory (all including confidential, third parties' reports and anonymous)
- Fatigue reports
- Ramp inspections
- Final Reports
- Audit findings
- Management of Change
- Flight data analysis based events
- Safety Performance Indicators

4.2 Analysis of a selected ATO

As in the case of the airline mentioned above, the method chosen in the introduction was an analysis of the internal procedures and internal documentation of the training organisation. The findings can be summarised in the same key points:

- Corporate safety policy –The ATO has a Safety Management System (SMS) in order to prevent incidents according to the rules set out in the SMM manual. The company emphasizes compliance with regulations and safety policies that define three pillars: 1) Compliance for all employees, 2) Resourcing and enforcement of safety as a priority, and 3) A non-repressive approach to incident reporting in the Just Culture spirit.
- Just culture principles – Corporate culture that motivates a positive and responsible approach is the key to promoting safety. Management plays a key role and motivates to comply with standards. In particular, regular instructor meetings (organised by the head of training) and company circulars with information on changes and safety (issued by the accountable manager and safety manager) are used as support tools.
- Company (safety) staff structure –The ATO defines three key positions to ensure operational safety: Accountable manager: responsible for overall safety and compliance. Manages safety activities and obtains information for SMS. Safety manager: Supports and coordinates the SMS. Has operational experience and knowledge of the risk management system. Compliance monitoring manager: Oversees compliance with regulations and procedure requirements (including safety and SMS).Safety review board (SRB) serves as a support body for safety processes. The SRB monitors safety performance, sets goals and assigns tasks. It also oversees the availability of resources to achieve safety objectives

The analysed ATO has identified activities in its Safety Management Manual that are implemented to ensure the safe operation of the organization. In addition to risk identification and management, these are processes to monitor compliance with SMS regulations. The accuracy of the content of documentation is monitored, especially manuals and logs of training undertaken.

The compliance manager carries out audit activities according to defined checklists. In the presence of non-compliance, he is obliged to inform the accountable manager and make an appropriate report. The operations of an organization may undergo various changes over time and for this reason Management of Change (MOC) is established. In this area, changes of an organisational nature such as personnel changes, reorganisations, changes in the economic situation of the company, outsourcing of e.g. maintenance, new aircraft type are mainly considered.

The basic requirements for SMS include the ability to identify threats in a timely manner. The developed methodology defines the basic steps for identification, which include possible tools for threat detection and defines the scope of staff responsibilities. The first two steps of the process are accountable to all crew personnel. These are the responsibility for identifying the threat and informing the safety manager. In principle, information provided via the prescribed reporting form (Flight Occurrence Report) is preferred, but findings can also be communicated verbally. At this stage, the main responsibility passes to the safety manager, who must carry out a risk analysis, assess the probabilities, severity and establish a risk tolerance matrix. If the result of the matrix is such that a solution is required, mitigation measures are determined. The following are the steps in which the staff and accountable manager are informed. At the very end of the process, an internal audit is conducted.

4.3 Analysis of interviews with ATO and airline representatives

In order to become more familiar with the issue of risk management at the air carrier and ATO/DTO organisation, two interviews were conducted with safety managers. In both cases, these were employees of the companies analysed in the previous subchapters. The reason for this decision was to follow up on the previous research of risk management systems in these two companies. The scope of the questions was oriented towards the practical knowledge and experience of these professionals. The structure and wording of the questions corresponds to the nature of the operation and therefore the questions in both interviews are not the same. The answers of the respondents are presented in a revised form and at the same time they have been shortened in order to preserve the content of the communication.

4.1.1 Interview with an airline safety manager

The interview touched on the topics of safety information sharing, risk assessment, Just Culture, specific threats and the impact of the Covid-19 pandemic. Key takeaways include:
- The list of threats is categorised and assessed according to likelihood and impact. Among the most serious are flights into war zones.
- The probability of an occurrence is determined subjectively based on the experience of experts. For a comprehensive analysis, the RMS methodology including ERC and SIRA assessments is used.
- Just Culture protects employees who report incidents in good faith. Even under Just Culture, a thorough assessment is made of whether the pilot could have prevented the event. Repeated pilot misconduct is analysed in depth by a panel of experts.
- Longer breaks in pilots flying during the Covid-19 pandemic led to a temporary increase in non-stabilized approaches. Stricter stabilisation parameters were introduced to minimise risk.
- Pilots report all safety incidents, including landings outside the cleared area. Repeated events within a given timeframe are analysed and lead to preventive measures.
- The Safety Department does not deal directly with information from training programs and simulator lessons. Tracking of failed simulator tests is the responsibility of the Training Manager. In the future, it is envisaged to digitize simulator recheck data for easier analysis and use.
- Flight data is downloaded automatically or manually from memory cards, depending on the type of aircraft. Once uploaded to the server, the data is analyzed in the AirFASE system using preset filters to automatically evaluate flights for parameters and warnings. Manual analysis is performed for flights with more than 10 recorded events or with an event classified in the highest category.

4.1.1 Interview with an ATO safety manager

- The flight school also promotes the principle of Just Culture, which encourages incident reporting without fear of being penalized. This environment allows for open communication and knowledge sharing between staff and clients, thereby enhancing accident prevention.
- A proactive approach to identifying and reporting potential hazards is key to preventing incidents. The ATO encourages its staff and clients to share knowledge and to report any risks early.
- Managing risk in a flight school environment brings with it specific challenges as it involves working with inexperienced pilots. The school therefore emphasises thorough preparation and instruction, takes into account the effects of weather and aircraft performance, and categorises pilots according to their experience.

- Variability in pilot experience levels, underestimation of weather impacts and aircraft performance are key risk factors. The flight school implements preventive measures such as flight limits and restrictions for inexperienced pilots after engine overhaul.
- The ATO emphasises the active gathering of safety data from a variety of sources, including employee and client reports, flight data analysis and information from ATC and AFIS/radio services.
- Anonymous reports are not widely used, pilots rather prefer the regular form of reporting.
- The flight school analyses complete flight data from aircraft equipped with a modern glass cockpit. Data analysis is limited for aircraft with analogue equipment.
- The implementation of a possible mandatory flight data analysis for all ATO aircraft is perceived positively, but with regard to the financial costs of acquiring and maintaining modern equipment.

4.4 Conclusions comparing prevention in airline and ATO

Both commercial air transport and flight training organisations (ATO/DTOs) use the Safety Management System (SMS) and controlled documentation to prevent accidents and incidents. The basic document in both cases is the SMM, which contains the SMS pillars: safety policy, risk management, safety assurance and safety promotion. Safety culture and the Just Culture principle are very important as well.

In both types of organisations, the functioning of the SMS is evaluated and steps are taken to continuously improve it. Threats are identified and analysed based on Management of Change. There are similar procedures for each level of risk. Threat lists are processed in a comparable way.

When it comes to differences, an airline has a dedicated safety department with a safety manager and other specialists, while an ATO/DTO usually has only one safety manager. The carrier has flight data reporting and analysis systems that give them a comprehensive view of what is happening in the operation. ATOs/DTOs only analyse data from certain flights and aircraft types and therefore rely more on pilot and instructor reports. Airlines have detailed processes for threat identification, including data analysis and reporting. ATO/DTOs rely more on safety manager communication with staff.Regarding risk assessment, then companies use different methodologies, but in both cases it is important to correctly determine the input parameters and possible impacts of threats.Both the airline and the ATO/DTO implement activities to promote safety, but their focus differs. Airline trains employees, ATO/DTO emphasizes an exemplary management approach.

In accordance with the defined processing methods, the research questions were defined at the beginning of the research (see chapter 3.1). Using the selected methods of analysis, these questions can be answered as follows:

RQ1: How are accidents and incidents prevented in ATO/DTOs?

The system of prevention in ATO/DTO training organisations is based on maintaining and improving their own SMS. The organisation has developed appropriate documentation, manuals and has nominated personnel responsible for safety (accountable manager) and for the SMS (safety manager). The core activities consist of identifying and analysing threats, assessing risks and establishing mitigation measures. This is based on operational information, in particular reporting and Management of Change.

RQ2: How are accidents and incidents prevented at commercial air transport companies - air carriers?

As in the case of the ATO/DTO, the SMS itself and its four basic pillars are the core. The company has documentation, manuals, and designated personnel responsible for safety (accountable manager) and for the SMS (safety manager). The organisation has established an independent safety department for safety management purposes. The core activities consist of identifying and analysing threats, assessing risks and determining mitigation measures. This is mainly based on operational information, flight data analysis, reporting system and Management of Change.

RQ3: What are the differences between the risk management systems of ATO/DTOs and commercial air transport operators?

In general principles, the two systems are very similar. The difference is mainly in the amount of input data that is handled in the risk assessment process and in the staffing of the SMS. The answer to RQ3 is discussed in more detail above at the beginning of the subchapter 4.4.

RQ4: What are the most serious operational and safety threats at the present times?

The interview with the ATO safety manager shows that he considers the most serious threat to their operations to be the different experience of pilots and possible underestimation of the effects of weather, aircraft performance, etc. Within the airline, the most serious threat cannot currently be clearly identified, but threats arising from flights into unstable and dangerous areas are considered to be high risk.

4. CONCLUSION

In this paper, the aviation safety system of both a major airline and a flight school was analysed. The comparison performed indicates that the basic concept of operational safety is very similar and some practices are mutually applicable. In the case of both a commercial airline and an ATO training organization, the basis of prevention is a well-functioning Safety Management System.

As part of the recommendations for improving the prevention of hazardous air traffic occurrences, the authors identify three key areas where attention should be focused: more effective information sharing between instructors/examiners and the airline's safety department, as well as flight data analysis within ATO/DTO organisations.

The first recommendation focuses on possible improvements in the transfer of safety information from pilot training and examination to safety personnel. It responds to the fact that, for the commercial air carrier surveyed, the simulator examination reports are not transmitted automatically to the IQSMS so that the relevant safety officer can examine possible negative safety trends (unstabilized approaches, exceeding aircraft limits, SOP errors, etc.) and identify threats to actual operations.

The second proposal is devoted to flight data analysis at ATO/DTOs. Flight data can provide valuable information not only about the progress of one particular flight, but also an overall view of compliance with specific procedures and correct flight parameters. The safety manager of a training organisation also benefits from the ability to detect flight indiscipline and the execution of prohibited manoeuvres. According to the initial research, the most appropriate use of flight data is stored via the instrument glass cockpit itself, but other alternative options have been mentioned, but their implementation requires the installation of additional equipment on board the aircraft.

The third recommendation is to increase the motivation of staff and crews to make voluntary safety reports, preferably in the form of SMS training. This recommendation responds to the significantly low number of debriefings at the training organization analysed.

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