RISK ASSESSMENT OF AIRPORT OPERATION MANAGEMENT PROCESSES

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Abstract

There is a fear that a sharp increase in air transport volume will result in an unacceptable increase in the number of accidents in the future. Experience demonstrates that before an accident occurs various incidents and numerous failures reveal the existence of safety risks. In this context, the risk assessment procedure consent the determination of the probability of the causes that generate accidents, and becomes an operative instrument, particularly efficient in the prevention of hazards. Airport operators deal with risk every day. The risk is sometimes under their control, and sometimes it is not. Although this approach has been successful for many years, safety performance needs to improve. With traffic growth, the number of accidents tends to increase when the level of safety remains constant. To preserve public confidence, the aviation industry, using new technologies and approaches like Safety Management System (SMS), needs to further reduce the chances of accidents. Safety Risk Management is the key operational component of an SMS - a creative method that looks into the future. Managing risk needs to be proactive and consider the specific characteristics of each airport. This article shows a process how to evaluate the performance of the SMS operations at Slovak international airports. The first stage was to acquire the seriousness and rankings of the SMS components and elements, and the second stage was to evaluate and rank their performance. The rankings of safety management system seriousness of components from high to low are: safety risk management, safety policy and objectives, safety promotion, and safety assurance.

Keywords: Air transport, safety management system, method of risk management solution

1. INTRODUCTION

Safety is the state in which the risk of harm to persons or property damage is acceptable. The state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management [1]. Risk Analysis is the process during which a hazard is characterized for its likelihood and the severity of its effect or harm. Risk analysis can be either quantitative or qualitative; however, the inability to quantify or the lack of historical data on a particular hazard does not preclude the need for analysis [2]. Risk Assessment is the process by which the results of risk analysis are used to make decisions. The process combines the effects of risk elements discovered in risk analysis and compares them to acceptability criteria. A risk assessment can include consolidating risks into risk sets that can be jointly mitigated, combined, and then used in making decisions. According to ICAO, a hazard is a “condition or object with the potential of causing injuries to personnel, damage to equipment or structures, or reduction of ability to perform a prescribed function.” The FAA uses this definition-“a condition that could foreseeably cause or contribute to an accident”.

Some hazards are obvious, like a worn out tire. When driving, a flat tire may cause loss of directional control or braking capability, which may lead to an accident. Other hazards are more intangible. A passenger bridge operated by personnel with inadequate training may cause damage to an aircraft arriving at the gate [3]. Some hazards are common to all airports-jet blast or rotating propellers, and hazardous materials like fuel, oil and hydraulic fluid. The existence of these materials and equipment by themselves does not set up a hazard; but when humans are exposed to them, or operations are conducted contrary to normal procedures, these materials and equipment can become hazards [4].

2. HAZARD IDENTIFICATION

Each individual airport will also have unique hazards based on their configuration and procedures. Airport personnel recognizes and understands many of these unique conditions. These well-known hazards may affect many systems or situations in different ways and, therefore, are routinely identified during the SRM process. Developing a *preliminary hazard list (PHL)* is a timesaving SRM technique. The PHL can be a catalyst for proper hazard identification. Appendix E lists some common airport hazards [5].

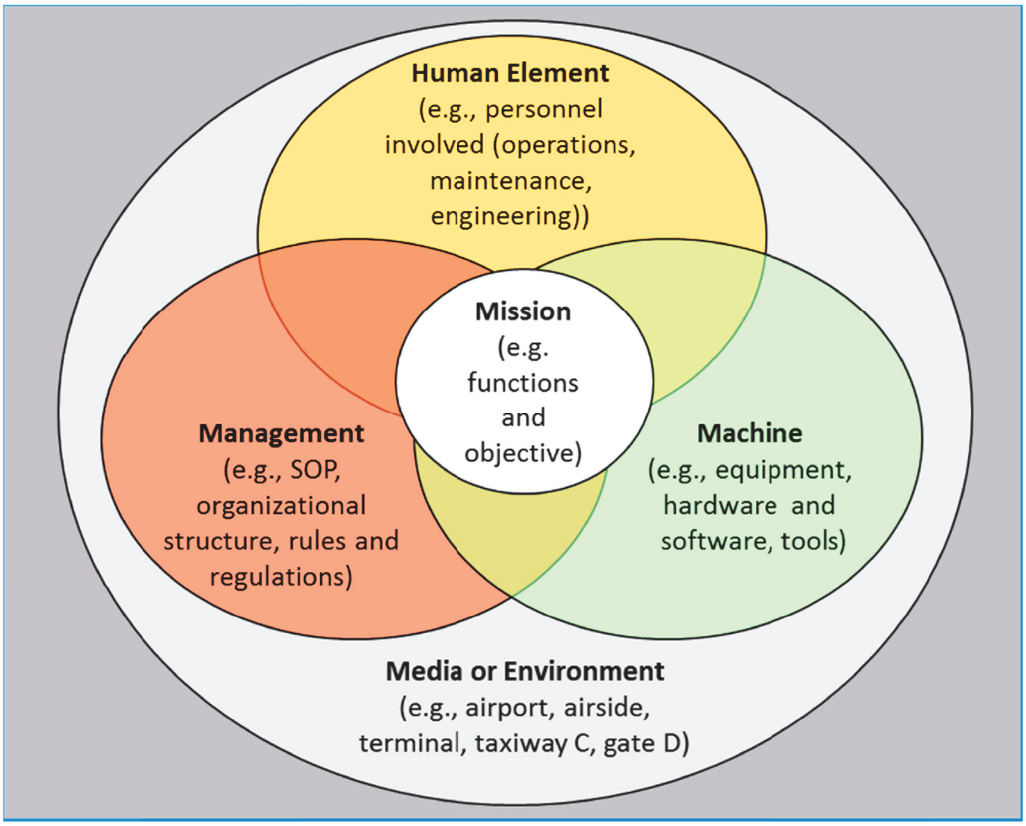

Figure 1 Relationships of the 5M Model [5]

Ways to identify hazards at an airport follow:

- Checklists prepared for self-inspections may include the presence of FOD, pavement deterioration,
- Observation and experience - operations inspector is continuously searching for anything that may pose a safety risk to airport operations, even when not listed in the self-inspection checklists.
- Brainstorming - this is the most common method used during SRAs. A group of stakeholders meet to identify hazards and analyze risks.
- Accident/incident investigations - when studying the causes of accidents and incidents, the hazards and contributing factors to the event are identified.
- Job hazard analyses - this is a technique that uses job tasks to identify hazards. A job hazard analysis explores how the worker, the specific task, the required tools, and the work environment relate.
- Preliminary hazard lists (PHLs): based on the safety issue or activity, preliminary lists of hazards can be prepared using a PHA [6, 7].

Table 1 Definitions for risk severity to airport [5]

Minimal	Minor	Major	Hazardous	Catastrophic
No damage to aircraft but minimal injury or discomfort risk to passenger(s) or workers	Minimal damage to aircraft, or Minor injury to passengers, or Minimal unplanned airport operations limitations (i.e. taxiway closure), or Minor incident involving the use of airport emergency procedures	Major damage to aircraft and/or minor injury to passenger(s) /worker(s), or Major unplanned disruption to airport operations, or Serious incident, or Deduction on the airport's ability to deal with adverse conditions	Severe damage to aircraft and/or serious injury to passenger(s) /worker(s); or Complete unplanned airport closure, or Major unplanned operations limitations (i.e.. runway closure), or Major airport damage to equipment and facilities	Complete loss of aircraft and/or facilities or fatal injury in passenger(s) /worker(s); or Complete unplanned airport closure and destruction of critical facilities; or Airport facilities and equipment destroyed

3. RISK MANAGEMENT PROCESS

System safety is a specialty within system engineering that supports program risk management. It is the application of engineering and management principles, criteria and techniques to optimize safety. The goal of System Safety is to optimize safety by the identification of safety related risks, eliminating or controlling them by design and/or procedures, based on acceptable system safety precedence. The causes of an accident are factors, events, acts, or unsafe conditions which singly, or in combination with other causes, result in the damage or injury that occurred and, if corrected, would have likely prevented or reduced the damage or injury. A hazard is any condition, event, or circumstance, which could induce (cause) an accident. Risk is defined as the probability that an event will occur. A risk is “the combination of the probability, or frequency, of occurrence of a defined hazard and the severity of the consequences of the occurrence”. A risk is thus an attribute of a hazard [8].

Risk assessment and risk management are important tools for understanding risks, defining acceptable levels of risks, and reducing risks. Risk management (RM) is based on the philosophy that it is irresponsible and wasteful to wait for an accident to happen, then figuring out how to prevent it from happening again. We manage risk whenever we modify the way we do something to make our chances of success as great as possible, while making our chances of failure, injury or loss as small as possible.

Risk management is the systematic application of management and engineering principles, criteria and tools to optimize all aspects of safety within the constraints of operational effectiveness, time, and cost throughout all mission phases. To apply the systematic risk management process, the composite of hardware, procedures, and people that accomplish the mission or produce mishaps, must be viewed as a system.

An airport has a lot of interfaces with the outside world, air traffic control has radio and telephones; there are navigational aids that communicate with aircraft, such as the distance measuring beacons and instrument landing systems; there are road links; there may be rail links; etc. We will consider an airside interface, the runway. It is “A defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft“ (ICAO 1995). It is the interface between the air navigation system and the ground handling area [9].

3.1. Data requirement for risk assessment

The current methodology requires some data to be available about airport movements and aircraft types followed, and for each accident/incident, about ground path (runway, taxiway, apron), phase of flight and aircraft type. Data about accidents/incidents occurring at Slovak airports are collected by Aviation and Maritime Investigation Authority, the Slovak agency for flight safety, and stored in their database.

The phase of hazard identification is carried out according to other study, basing on historical accidents/incidents data obtained from aviation safety network database.

In order to characterize the airside risk level, we take into account the hazards that follow, aggregated by flight phase.

Take-off and landing: overrun, veer-off, collision with obstacle, collision with another aircraft, ending short. We identify the causes which may produce the hazards listed above, and group them in four categories: aircraft performance characteristics, surface conditions, environmental conditions, human factors [10].

4. RISK ASSESSMENT

In the present risk assessment methodology we use quantitative measures to determine the probability, and qualitative measures to determine the severity associated with single hazard.
The risk assessment is based on the following formula:

$$R = P \cdot S \tag{1}$$

Where:
R = the risk of the event (overrun, veer-off, collision or landing short)
P = probability that the hazard will occur
S = severity of the hazard

The probability is proportional to the cumulative probability of the causes identified for the hazard, so we used the total probability theorem in order to calculate the probability:

if the events C_1, C_2, …., C_n are pairwise mutually exclusive, have positive probabilities and together form the whole space the following holds for every event A.

that is:

Hypothesis n° 1: $C_1, C_2, \ldots, C_n \in A$

where:
$C_1, C_2, \ldots, C_n$ = n causes;
A = space of the total probability.
Hypothesis n° 2: $C_i \cap C_j = \emptyset \;\; \forall \; i \neq j$; i,j = 1,….,n

Hypothesis n° 3: $P(C_i) > 0 \; \forall \; i = 1, \ldots, n$

Thesis:
$$P(E) = \sum_{j=1}^{n} P(E/C_j) . P(C_j) \tag{2}$$

where:
$P(E|C_i)$ = probability that, in presence of the cause *i* (e. g. heavy rain), the hazard (e. g. landing overrun) will occur (*Conditional probability*).
$P(C_i)$ = probability that the cause *i* (e.g. heavy rain) will occur.
$P(E|C_i) \cdot P(C_i)$ = probability that the cause *i* will produce the hazard.
We assume the frequency as the value of probability.

$$P(E/C_i) = \frac{N_E}{N_{MC}} \tag{3}$$

where:
N_E = number of events occurred during take-off (landing), in a stated period, generated by the cause *i*.
N_{MC} = number of take-offs (landings), in a stated period, occurred in presence of the cause *i*.
The probability $P(C_i)$ of the cause *i* is assumed equal to the frequency, at which the cause occurred in the airport studied.

$$P(C_i) = \frac{N_{MC(A)}}{N_{M(A)}} \tag{4}$$

where:
N_{MC} = number of flight take-offs (landings), in a stated period, in the airport studied occurred in presence of the cause *i* (e.g. number of landings occurred in presence of snow).
N_M = total number of take-offs (landings), in a stated period, occurred in the airport studied.

The total number of take-offs and landings occurred in the airport and the number of flight movements occurred in presence of the causes belonging to environmental and surface conditions categories are provided by the airport management company. The probability of the causes belonging to the aircraft performance characteristics category is not dependent on the airport where they occur, so data about failures, for each type of aircraft, should be provided by airlines companies. The formula for $P(C_i)$ assessment belomes the following:

$$P(C_i) = \frac{\sum_{j=1}^{n} N_{Fj} . N_{MC(A)j}}{\sum_{j=1}^{n} N_{M(A)j}} \tag{5}$$

where:
N_{Fj} = number of failures associated with the cause *i* suffered by the aircrafts of the type *j*, in a stated period, to refer to total number of take-offs (landings), which an aircraft makes in the same period (e.g. if aircraft of type *j* had one engine failure).
N_{Mj} = total number of take-offs (landings), which an aircraft of type *j* makes, in a stated period, in the airport studied.

The probable cause of more than 70% of commercial aircraft hull-loss accidents has been cited as “human error”. Today, more accident/incident investigations have been focusing on the human factors in each operation during flight. This includes flight crew operations, air traffic control, ground operations, and maintenance operations. Human factors shall be systematically integrated into the planning and execution of the functions of world aviation authorities and activities associated with system acquisitions and system operations [11].

5. CONCLUSION

In the first section of this paper we dealt with risk management process, we analyzed the six steps, however, in the second section we propose a risk assessment methodology for a specific airport. The methodology consisting of the following steps:

- data collecting,
- hazard causes identification for each hazard,
- probability and severity qualitative assessment,
- risk level assessment.

The original points in this methodology are the causes identified associated with each hazard by analyzing other studies and the hazard probability assessment through to the cumulative probability of the causes identified.

Total probability theorem is the conditional probability assessment $P(E|C_i)$ and was established by analyzing the national database for causes belonging environmental and surface conditions categories and by analyzing the international database for causes belonging aircraft performance characteristics category and hazard severity assessment by analyzing of national database [12].

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REFERENCES

[1] Doc 9859 AN/474 - Safety Management Manual, Third Edition, 2013. International Civil Aviation Organization, ISBN 978-92-9249-214-4. Available on the Internet: https://www.icao.int/safety/SafetyManagement/Documents/Doc.9859.3rd%20Edition.alltext.en.pdf

[2] Safety Management Systems (SMS) for Airport Operators. Ac 150/5200-37 Federal Aviation Administration. 2007. Available on the Internet: https://www.faa.gov/airports/resources/draft_advisory_circulars/

[3] CHANG Y. H. [et al.]. Performance evaluation of airport safety management systems in Taiwan. Elsevier, Safety Science. Vol. 75 (2015), p. 72-86. Available on the Internet: www.elsevier.com/locate/ssci

[4] ROZENBERG R., SZABO S., ŠEBEŠČÁKOVÁ I. Comparison of FSC and LCC and Their Market Share in Aviation, 2014. In: International Review of Aerospace Engineering (IREASE). Vol. 7, no. 5 (2014), p. 149-154. - ISSN 1973-7459. Available on the Internet: http://www.praiseworthyprize.org/jsm/index.php?journal=irease&page=article&op=view&path%5B%5D=16503 ...

[5] Airport Cooperative Research Program - Report 131. Transportation Research Board, Washington, D.C. 2015. ISSN 1935-9802, Available on the Internet: https://www.nap.edu/read/22138/chapter/1

[6] FAA Airports (ARP) Safety Management System. FAA Order 5200.11. 2010. Available on the Internet: https://www.faa.gov/documentLibrary/media/Order/order_5200_11_arp_sms.pdf

[7] GLENDON A. I. [et al.]. Human Safety and Risk Management. Second Edition. CRC Press Taylor & Francis Group. 2006. ISBN: 0-8493-3090-4

[8] CANALE S., DISTEFANO N., LEONARDI S. A risk assessment procedure for the safety management of airport infrastructures. 2007. Department of Civil and Environmental Engineering, University of Catania, Italy

[9] PETRUF M., KORBA P., KOLESÁR J. Roles of Logistics in Air Transportation - 2015. In: Our Sea, International Journal of Maritime Science and Technology. Vol. 62, no. 3 (2015), p. 215-218. - ISSN 0469-6255. Available on the Internet: http://www.scopus.com/record/display.url?eid=2-s2.0-84943555159&origin=resultslist&sort=plf-f&src=s& ...

[10] PIĽA J. [et al.]. Safety Hazard and Risk in Slovak Aviation Regulations / - 2014. In: Our Sea, International Journal of Maritime Science and Technology. Vol. 61, no. 1-2 (2014), p. 27-30. - ISSN 1848-6320 Available on the Internet: http://hrcak.srce.hr/index.php?show=toc&id_broj=9924 ...

[11] PACHECO R. R. [et al.]. Airport airside safety index. Elsevier, Journal of Air Transport Management. 2014. Vol. 34, p. 86 e 92. Journal homepage: www.elsevier.com/locate/jairtraman

[12] PAVOLOVÁ H., TOBISOVÁ A. The model of supplier quality management in a transport company. 2013. In: Our Sea, International Journal of Maritime Science and Technology. Vol. 60, no. 5-6 (2013), p. 123-126. ISSN 0469-6255