Airports SMS Penetration with Occupational Health Protection

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Abstract — **Safety of operation is one of the most important tasks at the airport. The aim is to develop, implement and improve strategies and processes, to lead to an increase in quality of aviation activities, maintaining the highest level of operational safety and must be based on national and international standards. The health of workers at work is guaranteed by Art. 36 of the Constitution of the Slovak Republic and it establishes a system of regulations for ensuring safety and health at work. Occupational safety and health is a state of eliminating the impact of hazardous, working conditions and environment or harmful factors in the work process to employees. The security policy should set out how the airport deals with health and safety at work. This policy should include measures to protect workers assess any risks to health and safety, consultation with the various processes with employees, provide sufficient facilities for their maintenance, training and ensure staff training and minimalization of accidents and incidents at the airport.**

Key words: air traffic safety, occupational health, risk management, numerical computational methods

I. INTRODUCTION

The term safety management systems and occupational health are used to denote all procedures used to the improvement and unification of safety in society. This can include anything - from the ambition of continuous improvement of safety towards utopian goals without the direct health risks at work, corporate sensors for control of personnel and penalties of groups which have rather poor results of OSH. The need to specify a safety management system (SMS) often occurs within the organization. Top managers may have very different perceptions of the system, which they seek to uphold, from that of OSH specialists and safety representatives. The Safety Management System of OSH and all the other cooperating "systems" (such as ISO 9000) are not really scientific systems (von Bertalanffy, 1968). Scientific Systems is an entity of interacting units and functions that are struggling to survive more or less independently of their surroundings. The purpose of the safety management system is, on the contrary, to integrate functions (eg. Better OSH or other quality) in the overall conduct of the company. If the aim is to improve health and safety, safety management must be an integral aspect of self-management of each company - the operation of the airport included.

II. THE HAZARDS AND RISKS

In general, any risks to which passenger in transport may be exposed - infectious diseases, slips and falls - airport workers may be exposed to in the first place. The most effective first step in preventing threats to passengers, visitors and airport employees is the elimination of hazardous conditions as much as possible. International and national occupational health and safety legislation obliges employers to ensure a healthy and safe workplace for all workers. However, the primary and fundamental part of the contracting process is the transfer of responsibility. It may be difficult to establish responsibility for staff, airport visitors and the traveling public - for their safety at airports and their health.

For each section and the element of air transport there must be established "supervisory authority" - through the airport terminal to the aircraft. Airport and Airlines Company still carry responsibility for ensuring cleanliness and disinfection of the individual components of the air transport of infectious contaminants, including air conditioners. Entities that use outsourcing services are required to ensure suppliers at a maximum rate of utilization of technical expertise and safety at work practices.

Subcontracting could have serious consequences for health and safety, because these companies operate simultaneously in one place, with a different organization of work and time pressure. It is very important to coordinate the various subcontractors and "airport managing body" must ensure that these operations are coordinated through joint airport information and management system (Collaborative Decision Making - CDM) and other governing documents.

Technical handling of aircraft requires a complex series of processes, from the moment when aircraft lands and is directed to a parking place to the moment of its departure. Workers can be divided into “ground staff airside" and "ground staff landside". The public part includes terminals, storage areas, parking and land access. Airside includes "clean" zone of terminals and all areas accessible to aircraft, including the movement areas [1, 2].

Eurofound research shows that compared with other sectors, workers in aviation:

- ✓ are working more often on weekends,
- ✓ have a greater change in the number of working days per week,
- ✓ have a greater change in the start and end of working hours,
- ✓ are working in alternating / rotating shifts.

In the course of business and technical handling of the aircraft, personnel in the air transport sector often works on tight deadlines and under great pressure. The main health problems are: stress, overall fatigue, back pain and hearing problems [2].

Figure 2. Defined by the European agency for safety and health

Airports and aircrafts create a very dangerous environment and workers in aviation are exposed to a wide range of hazards and risks.

TABLE I.
AVIATION OPERATORS / EMPLOYEES, THEIR OCCUPATIONAL RISKS AND HAZARDS

		aircraft crews	*Workers of control*	*Ground staff - ground handling of aircraft*
Risks and hazards	Labour Organisation	extreme, responsible and demanding tasks	aggression from clients, stress, fatigue	stress, shift work, night work, time impact work
	Factors of hysical work	noise, vibration, exposure to the sun, rapidly changing climate conditions	X-rays (check security devices)	noise, unfavorable weather conditions, lightning, vibration, mostly working in the open area
	Hazardous substances	infection, exotic diseases, exposure to engine exhausts, pesticides / biocides		exposure to de-icing chemicals, aviation fuel, substances used for the maintenance, cleaning chemicals, maintenance technology, biological agents
	Ergonomic factors	confined spaces, prolonged standing, uncomfortable work environment	prolonged periods of standing or sitting, working in inappropriat e positions	working in awkward body positions, working with heavy loads, work in enclosed spaces (hold of the aircraft, etc.).
	Accidents	falling objects, slips, falls from height	heavy lifting, falling objects	fall from heights, slips, falls, electric shock, accidents, hits from falling or moving objects, fires and explosions,

A. *Organisational Factors*

Quality and above all the speed of the aircraft handling process (technical handling) are crucial to airlines' profits. This causes time pressure on workers, which leads to negative consequences, such as: lack of concentration, inadequate decisions, errors, incomplete fulfilment of tasks and stress. Stress is mainly due to shifting work, high workload, change of workplace (performance of tasks in different parts of the airport), early or late arrivals, changes in the management and malfunctions of equipment. Stress affects the performance of employees and can cause fatigue. According to Michie, stress situations are unpredictable and uncontrollable, uncertain, unclear or unknown, or if there is a conflict, loss or expectation of organizational elements intervention.

Violence from aggressive passengers is a serious problem for workers of clearance. Politics of re-booking of some airlines leads to an increase in verbal and physical assaults by passengers. A study carried out by Rosskam and a team at three Canadian airports showed that one in twenty check-in staff were physically attacked at work, more than 80 % have been exposed to a verbal attack by passengers and more than 20 % have been threatened by passengers [3].

B. *Physical work*

Noise and vibrations are the main natural hazard affecting ground staff. The main source of noise and vibration at the aerodrome are take-off and landing, followed by maintenance, ground operations and equipment. According to measured noise levels from aircraft engines, auxiliary power units (APU), ground vehicles and equipment, noise may exceed 85 decibels, which can cause permanent hearing loss during prolonged exposure. Another factor is vibration caused by vehicles (including forklifts) and ground operating equipment. Exposure to high frequency whole-body vibration over the years can cause a loss of balance, impaired vision, upset stomach, decreased fine motor skills or backache. Hand-arm vibration can lead to circulatory disorders of fingers, degenerative changes in the bones of the hands, wrists and finger joints and elbow and shoulder area. The threat of lightning threatens the maintenance staff of airport facilities and equipment, maintenance of aircraft on the area and so on. Considering the potential for serious injury or death by lightning it is important to early warn airport staff against lightning. Workers of aircraft fuelling and fuel economy are at risk of fire and explosion [3, 4].

C. *Dangerous substances*

Hazardous substances affect transport workers in different ways. The concentration of the engine exhaust gases (oxides of nitrogen, carbon dioxide, carbon monoxide, volatile organic compounds, including polycyclic aromatic hydrocarbons, carbon dioxide and fine particles of fine dust and aerosols). Also means to clean toilets and very toilet systems can be life-threatening. Furthermore, it is de-icing - de-icing fluid - glycol, dethylene glycol or propylene glycol. Fillers may come into contact with Jet A-1 and AVGAS - risks of contact with the skin for a long time include skin damage, dryness, cracking, and possibly dermatitis. Prolonged inhalation of vapours may cause a chronic inflammatory response of the lungs [3, 4].

D. *Accidents*

Airport aprons are the unique and potentially hazardous working environment. They are noisy and busy workplaces, full of vehicles and equipment, where workers face many potential hazards. The number of injured workers on the apron is increasing compared to other sectors every year. According to the IATA (International Air Transport Association), the leading cause of accidents on the ramp is a human error (human factor) – 92 % of cases fall under the infringement of proceedings, the lack of adequate training and air traffic congestion. Based on data collected by IATA, Flight Safety Foundation estimated that worldwide each year occur over 27500 accidents and incidents on the apron and about 245000 people are wounded. This corresponds to one accident for

almost 1000 departures and nine injuries for over 1000 departures [5].

III. LEGISLATIVE ASPECTS

Directive 89/391 - Framework Directive for OSH is the main EU legislation governing health and safety at work. The directive was adopted by a number of general principles of EU law in the field of OSH. Many of them are important for air travel because of the diverse nature of activities (work) in a given sector.

The working hours of technical handling staff (aircraft handling) are governed by the EC Directive 2003 of 1988, which lays down minimum safety and health requirements for the organization of working time. It lays down minimum rest requirements for employees (daily, weekly, annual leave, breaks) and maximum weekly working time. Other important directives concerning safety are Directive 94/56 / EC, which aims to facilitate the investigation of civil aviation accidents and improve the safety of air navigation and Directive 2006/23 / EC of the EU Air Traffic Controller License.

TABLE II.
DIRECTIVES CONCERNING THE SAFE OPERATION OF THE AIR TRANSPORT SECTOR:

The safe operation	Directives
Use of work equipment	89/655 / EEC
Personal protective equipment	89/686 / EEC
Fuels	90/396 / EEC
Requirements for the workplace	89/654 / EEC
Directive on new machines	2006/42 / EC
Manual handling of loads	90/269 / EEC
Noise	2003/10 / EC
Vibration	2002/44 / EC
Ionizing radiation	96/29/ Euratom
Electromagnetic fields	2013/35 / EU
Biological agents at work	2000/54 / EC
Working time of mobile workers in civil aviation	2000/79 / EC

Then there is EC Regulation No 216 from 2008 on common rules in the field of civil aviation and establishing the EASA (European Aviation Safety Agency) as amended by EC No 1108 from 2009.

IV. PREVENTION AND CONTROL MEASURES

When selecting actions, a certain hierarchy must be followed to ensure the most effective measures. It is appropriate to involve workers in the risk assessment process because they have a good understanding of the conditions and risks in their workplaces. Training and guidance should be provided as part of education for all employees, all types of measures and new methods and procedures. Effective risk control can include a single control measure or a combination of two or more different controls [6, 7].

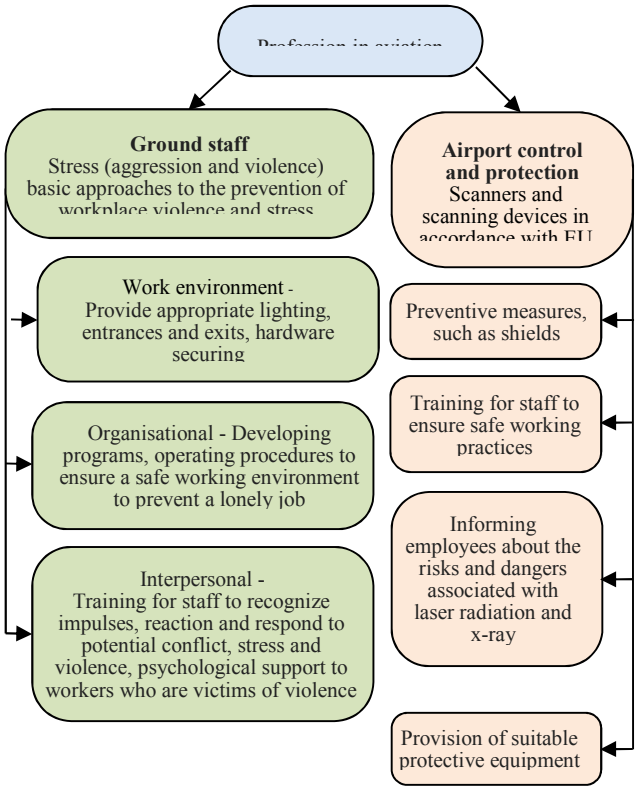

Figure 3. Examples of preventive measures for selected operations and risk

The employer is obliged:

- ✓ to create a safe working environment and working conditions by an appropriate organization for health and safety at work and take measures to prevent risks,
- ✓ to constantly seek dangerous agents and processes of the working environment and working conditions, secure the causes and sources, and based on this search, assess and eliminate the risks,
- ✓ where risks cannot be eliminated, the employer must evaluate and take measures to limit their exposure,
- ✓ to organize at least once a year a review of health and safety at work in all workplaces,
- ✓ to document search and evaluation of risks and the measures taken to reduce/remove them.

All employers have a duty to train their employees in accordance with the requirements set out by the safety and health at work and related regulations.

Principles and objectives - organization's security policy determine the security measures and the training of the staff.

The safety assessment - regular safety checks identify areas where care must be taken to increase safety due to an unforeseeable risk, changes in legislation and practices, or revelation of deficiencies that must be eliminated by the acquisition of new equipment or inspections.

Identification of training needs - data collected during security screening will be analyzed and the analysis will have to be made by qualified safety experts. After the identification of training needs, objectives can be set for the development of security procedures for the organization and the individual.

Design and performance training – it is essential to ensure sufficient teaching materials and an appropriate

level of training. A copy of each training must be maintained for future use and must be available for consultation.

Efficiency Evaluation - safety training should take place at least annually to ensure that the objectives of the training are implemented and that training is effective in achieving the desired changes and safety awareness.

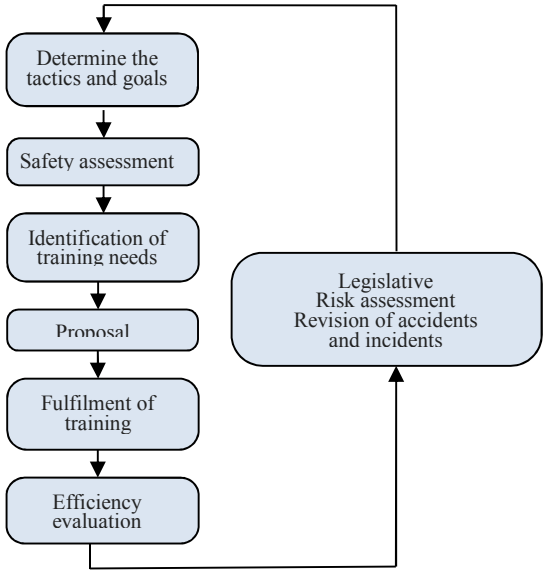

Figure 4. Model safety training

V. APPLYING OF MODEL DESIGN IN SMS FIELD

An essential task in controlling threats is to analyze potential risks in security management, which ideally involves simulation and risk modeling. There can be different reasons for introducing risk management, ranging from upgrading existing ones to introducing new operating procedures. Creating a risk model is a potential method of describing the underlying structure and calculating all possible risks in airport operations. If the model is properly selected, it can serve to identify risks, and then analyze them, identify the causes of their emergence, and, last but not least, the ability of companies to eliminate these risks. Risk modeling refers to the models and methods used in the risk assessment of airport operations. Most organizations typically have a simple, functional model that describes the various inputs that affect key performance indicators. Most structured financial models are deterministic models. These models can be converted to stochastic. Airport companies can use a wide range of risk modeling methods for their own analysis [23].

A. Deterministic models of risk

Operational methods of analysis based on deterministic models play an important role in reducing risk. In these models all variables, constants and functions are chance quantity or functions. Using methods for operational analysis the risk can be reduced before or after the risk model is calculated. These models are mainly used to manage decision-making risk reduction, which is addressed repeatedly. The aim of the decision is to find the optimal solution to the decision-making process. Minimizing costs and maximizing profit is also an optimal solution. The success or failure of an airport company depends on the decision-making process of the company's management. Safety Manager plays an important role in addressing operational issues that are immediately reflected in airport operations. Deterministic models are used to solve operational decision-making processes that occur mostly at the level of operational management and for which the relationships between input and output variables of the model are clearly defined. Linear programming models, network analysis methods, and queuing models are most commonly used [24]. Research on the behavior of physical systems is the study of a set of moving objects. The equation expresses the universal relationship of Newton's second law of motion:

$$\mathrm{F} = m\frac{\partial v}{\partial t} \tag{1}$$

Describing the behaviour of any moving object with mass m. acceleration

$$\frac{\partial v}{\partial t} \tag{2}$$

Expressed change in speed at time ***t*** if no force ***F*** is used. The analytical solution to the problem can be achieved by calculating the integral:

$$\int_{v_1}^{v_2} dv = \int_{t_1}^{t_2} dt\,\frac{F(t,S,v)}{m} \tag{3}$$

If we know the exact initial conditions (t_1) of any physical object (m, s, v) and all other factors that affect it (force F), it is possible to predict its future (from t_1 to t_2) accurately. Thus, the model allows us to predict the occurrence of any physical system at any time with any precision. The deterministic risk model is based on the assumption that each effect has its cause. If it is possible to analyze the causes accurately, we can better identify their consequences. If everything is known about the causes that happened in the past, then we know all the consequences that will arise in the future and which may negatively affect us.

B. Statistical models

These are models based on historical data analysis. Because models depend on the amount of input data, they are particularly useful in cases of sufficient data. In the operational risk management process, events recur so that they can be subject to careful and controlled studies. However, at a strategic level, data acquisition is very complex and it is very difficult to perform experiments. For this reason, it is a considerable disadvantage that the possible outcome of the decision and its impact can occur in several years.

C. Monte Carlo Simulation

One of the large scales of numerical computational methods based on the use of probabilistic theories and random variables are Monte Carlo methods. This is a simulation of systems using stochastic methods that use a pseudo-random number. This method has an extensive range of applications ranging from simulation experiments to solid integral calculations to differential equation solutions. Mostly, Monte Carlo is used to finding approximate solutions to such tasks where an analytical solution would be too complex. The knowledge of the method is based on the distribution functions of the inputs. With them we generate individual random inputs (numbers

and vectors) and record outputs. After a sufficient number of repetitions, it is possible to estimate the parameter of interest by statistical analysis of the outputs. Monte Carlo methods distinguish two variants: analogue and non-analogue [25].

- Non-analog model - in this case, the real behavior model is not taken into account. For example, it can be a calculation of a fixed integral or a region of a bounded unit.
- Analog model - for this type of software, the entire situation needs to be modeled. This requires knowledge of all probability distributions and physical laws that govern a particular case, event, risk. Using this simulation we get a random variable ξ. If the simulation is run n times, we get a set of results x_1 ... x_n. Then an estimate of the average value ξ is determined:

$$\xi = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{4}$$

and standard deviation σ is then determined:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}\left(\bar{y}-y_i\right)^2}{n}} \tag{5}$$

With increasing simulation repetitions *n* is modeling using Monte Carlo simulation is more reliable [26].

VI. Conclusion

Air transport is a big industry, where millions of passengers a year use the services of airlines. In proportion to the increase in the volume of traffic is increasing the number of jobs created. Many workers are exposed to different risks and hazards in the workplace (eg. time pressure, fatigue, long distance flights, aggression on the part of clients, hazardous substances and cosmic rays). Hazardous working conditions in airport operations and ground security are ubiquitous. These dangerous conditions usually are known and can be avoided and prevented. At the airport, such working conditions should be created so that it is possible to eliminate the risk of injury, damage to health or death, not only for employees but also for the travelling public. In many cases, favourable working conditions are not created and thus violate the requirements of health and safety. Airports, airlines and service providers often do not provide sufficient measures to eliminate or reduce these risks to the health and safety of workers and passengers. This article provides methods and tools for risk analysis, which are also suitable for corporations involved in civil aviation. Modelling risk in aviation is used to visualize the consequences that may arise, and all their causes. Modelling enables better focus on threats and can be used in own risk management. Therefore the risk modelling is an important part of the risk analysis. The application of risk management in aviation should not be considered as a negative activity. A positive attitude to the risk management application in aviation is a contribution and not a waste of time. The sooner we manage to identify and eliminate risks, the less impact the threat will have. Not all the risks are subject to elimination, because not all of them pose a serious threat to aviation. Calculation of the cost of protection against risks and costs incurred in maintaining a risk, help in deciding whether to reduce the risk or not.

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