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JUDGEMENT OF LEVEL OF INTEGRAL SAFETY THAT ENSURED THE RISK MANAGEMENT PLAN FOR METRO STATION OPERATION

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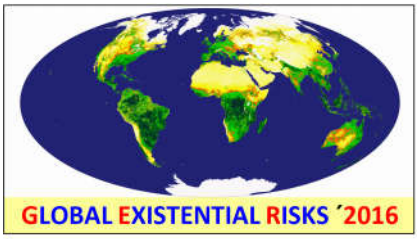
POSOUZENÍ ÚROVNĚ INTEGRÁLNÍ BEZPEČNOSTI, KTEROU ZAJIŠŤUJE PLÁN PRO ŘÍZENÍ RIZIK PRO PROVOZ STANICE METRA



ABSTRACT
TO ENSURE THE SAFE METRO STATION IT IS NECESSARY TO APPLY A MODEL FOR SAFETY MANAGEMENT THAT HAS MORE THAN ONE LAYER. THE FURTHER IMPORTANT TOOL IS THE RISK MANAGEMENT PLAN FOR SIGNIFICANT RISKS ACCORDING TO THE TQM PROJECT MANAGEMENT TYPE DEMANDS. THEREFORE, THE ARTICLE INCLUDES THE RISK MANAGEMENT PLAN FOR PRIORITY RISKS AND JUDGEMENT OF LEVEL OF SAFETY THAT IT ENSURES, NAMELY BY HELP OF THE CHECKLIST ESPECIALLY DERIVED FOR COMPLEX TECHNOLOGICAL FACILITIES SAFETY JUDGEMENT.

KEY WORDS: *metro station; integral safety; station security; safety management; risks; TQM; risk management plan*

ABSTRAKT
PRO ZAJIŠTĚNÍ BEZPEČNÉ STANICE METRA JE TŘEBA APLIKOVAT MODEL ŘÍZENÍ BEZPEČNOSTI, KTERÝ MÁ NĚKOLIK ÚROVNÍ. DLAŠÍM DŮLEŽITÝM NÁSTROJEM JE PLÁN PRO ŘÍZENÍ RIZIK SESTAVENÝ PRO VÝZNAMNÁ RIZIKA SESTAVENÝ PODLE POŽADAVKŮ PROJEKTOVÉHO ŘÍZENÍ TYPU TQM. PROTO ČLÁNEK OBSAHUJE PLÁN PRO ŘÍZNÍ PRIORITNÍCH OČEKÁVANÝCH RIZIK A POSOUZENÍ ÚROVNĚ BEZPEČNOSTI, KTEROU ZAJIŠŤUJE, A TO POMOCÍ KONTROLNÍHO SEZNAMU SPECIÁLNĚ SESTAVENÉHO PRO POSUZOVÁNÍ BEZPEČNOSTI SLOŽITÝCH TECHNOLOGICKÝCH ZAŘÍZENÍ.

KLÍČOVÁ SLOVA: *stanice metra; integrální bezpečnost; zabezpečení stanice; řízení bezpečnosti; rizika; TQM; plán pro řízení rizik*

1. Introduction

The humans need for their lives not only the enough food but also the high quality green and grey infrastructures (it means environment and technological systems), i.e., safe conditions for their development according to the Maslow's pyramid of needs [1]. The technological systems ensure the higher quality of human lives, and they are entirely needed for human survival at critical conditions [2].
The transportation system has significant importance in the human community because it provides basic services in the territory. Present work deals with the metro that is the important transportation system in big towns. It shows principles and demands which can ensure the safe metro station that are based on the concept of integral safety. Then, it determines the priority risks for the metro station by method of comparison between the normative (the demanded model for safe metro station based on integral safety concept) and the real situation in Praha metro stations. The differences are considered as sources of risks, and therefore, for priority risks the risk management plan is performed. The quality of plan under account is judged according to the special checklist.

2. Development of management directed to cope with risks

Development on management of entity is in detail described in [3-6]. Significant milestones in management are: the scientific study of F.W. Taylor (1856 - 1915); the studies of bureaucracy processed by Max Weber (1864 - 1920); the administrative management theoretically supported by Henri Fayol (1941 - 1925); and the school of interpersonal relations, the main representative of which was Elton Mayo (1880 - 1949). Max Weber defines 6 principles of bureaucracy which are: division of labour is the base of organisation; in an organisation it is necessary correctly to define rights and duties of each worker; in an organisation it is set of rules needs to exist; the leader leads impersonal and fairly; work is a service in which the rules are respected; the leader is obligated to make conditions for order and stability of organization and to ensure efficiency. At that time, the bureaucracy was the most efficient management system.
At the beginning of the 20th century, the methods of scientific management were introduced. After The Second World War, the start-up of development of impoverished countries was need, which meant to ensure the fast recovery of businesses and areas. For this purpose, it was needed an initiative of wide inhabitant mass and more dynamic way of management. Therefore, the special management was introduced (this type has been still used for solving the critical states). This management type presents the targeted management (programmes are split into projects which are further divided into processes; each process manifests itself under the project coordination – new types: project management; and process management). The characteristic feature of this management type is the orientation on:

- priorities and the use of planning,
- methods of setting the goals,
- initiative of managers / leaders.

From the 70s of last century: it comes in useful the employee participation in the management, profit and ownership; and demands on a qualification at all professions have been increasing. At beginning the 90s is characterised by: the wide usage of automate and office technics; the flexible manufacturing system; telecommunication and informatics.
Reforms in the public governance, i.e., marking by the transition from the bureaucracy management to the targeted management, i.e. the project management, were the response to big problems in the EU regional policy, and they were being started-up by the Maastricht treaty in 1989 [3].
At present, the goal of project management of entities from profit and non-profit (public) sector is ensuring the safe entities with sufficient development potential, and therefore, it is strategic, proactive and systemic [3]. However, it is necessary to consider that it is not possible to use the same criteria for the management of public and private sectors, because e.g. the human protection, the education and research need the investment without consideration of profit. The main differences between public and private sectors are:

- A difference in goals. In the public sector that is represented by municipalities and regions, the profit or another gain for any legal or physical person is not the main goal, but the main goal is the public interest and its procuration.
- Legislation. The public sector has a greater connection to justice, which leads to significant constraints in domain of decision making. It is caused by the need to respect and satisfy the duties and the principles of governance, to respect the elected bodies, the adjust and the position of state organizational units, rights and duties of their employees, requirements on financial and property management, etc.
- A profit absence at public sector has consequences that some benchmarks and indicators, which are used in private sector for support of more quality management, are not possible to use.

For both mentioned sectors, however, it holds that it goes on the process management, on which all stakeholders are participated. The process management leans on the partnership, it is based on negotiation with risks and at the decision making it goes from the variant assessment on the basis of qualified criterion [3].
Currently, the three types of the project management are used [1], i.e.:

- New Public Management.
- Total Quality Management (TQM).
- Common Assessment Framework.

In our conditions the Total Quality Management (TQM) is used [3]. For its success the ISO standards 9000, 14000 etc. had been set up. The TQM approach consists in the requirement that all employees, from the plain

employee up to the top management employee, are participated in the process of quality improvement. The process of quality improvement (i.e., in its top level it goes on de facto on integral safety increase) comes from the impulses which come from customer/citizen needs.
The TQM comes from the assumption, that the stable quality of products and services cannot be ensured by commands, supervision, partial programmes, organizational or economic measures, but it can be reached by seeking, measuring and evaluating of causes, why the productivity and quality do not improve [3]. De facto it goes on certain safety culture (in the other words it is a way of application of measures and human activities). Attention is focused on processes ongoing in the entity. At the TQM implementation they are taken into account the entity specifics, because all measures shall reflect the structure of entity from the reason of efficiency [3], it means they shall be site specific.
The modern management, that leans on the project and process management, uses the general process (Problem Solving Process) that is the part of best-practice (i.e., the best experiences) and it is worldwide used [6,7]. It goes on the process that is universal and it exceeds the problems of projects and the project management; it involves ten points: problem identification; problem definition; analysis of present conditions; looking for causes; definition of target; proposal of solutions; solution selection; solution validation; realization; and evaluation.
In real practice we distinguish three common management levels, which are needed to harmonize. The strategic level determines the basic development directions, from which it follows: which processes are necessary to modify or create; which organizational changes are necessary to perform; and where to obtain know-how, financial sources, etc. The tactical level helps to sort activities, which are necessary for realization of long-term intentions. It looks for answers on questions: how to set up the processes; in which condition to maintain processes; and how the processes need to cooperate mutually. The operational management decides about the real allocation of sources in the process (human, technological, financial) and also about the execution of appropriate activities in the range of adjusted processes (how to perform the real operation). An effort is to ensure the knowledge transfer and skill transfer among workers.
The organisation can reach a competitive merit when it harmonises all three management levels. The aim is to achieve the state when the processes are defined and managed on the basis of strategy and the operational management does not mean only response to emergency conditions or other types of faults. The processes are improved on the basis of knowledge coming from operational management. New findings coming from the management processes are then quickly reflected into the strategy and they invoke next important change connected with the business development or another entity development.
The process management is based on the principle of integration of activities into the integral processes. It means that the partial operations are necessary to integrate. The processes are controlled by process teams. Each process team controls the processes on its level and it distributes the tasks which lead to aim achievement to subordinate groups. At the same time all process teams shall be motivated to achievement of optimal outcomes, and all management levels shall follow the final goal at achieving the particular aims. Within the process management, two management systems exist, namely, the functional one and the process one, which create the more complex management.

Processes for safety support, which need to be followed in the organisation, in public administration and their institutions, are in detail described in works [6, 8, 9]. For illustration, the processes and sub-processes in industrial company are given. It goes on six main processes:

- The process of concept and management that is divided into sub-processes for: the overall concept creation; partial safety targets establishment; safety leader-ship and management; safety management system; staff management (which is divided into following sections: human resource management, training and education, internal communication / awareness, working environment); and revision and evaluation of safety target fulfilment.
- The process for administrative procedures execution that is divided into sub-processes for: hazards identification from possible disasters and risk assessment; documentation; administration procedures (including the work permit systems); change management; safety connected with contractors; and super-vising the product safety.
- The process for technical matters that is divided into sub-processes for: research and development; engineering and installation; application of more inherent safety processes; industrial standards; storage of hazardous substances; and maintenance of integrity and maintenance of equipment and facilities.
- The process for external cooperation that is divided into sub- processes for: cooperation with governance; cooperation with public and other stakeholders (including academic institutions); and partnership with next concerns.

- The process for emergency preparedness and response that is divided into sub-processes for: on-site preparedness planning, help for off-site planning (in responsibility of governance); and for coordination of activities of resorts organisations at ensuring the emergency preparedness and at response.
- The process for message proceeding and executing of investigation of disasters, which affected the factory that is divided into sub-processes for: reports about disasters, accidents, near-misses, and other learned experiences; reports from the investigation of damages, losses and harm and their causes; and reports on response and consequent activities after disasters (including application of lessons learned and sharing information).

Modern management types, which are the project and process managements, are only successful, when they can properly deal with risks, which are inherent to human system and also to each its sub-system. If risks are not properly managed, so it will not be possible to reach successfully targets, and therefore, the project feasibility is assessed in advance. The importance of risk role is caused by the matter that on the risk mastering it is dependent not only the project price, but overall successfulness of total project. Thus, it is needed, so that each project may own specific structure, risk separation and way of financing that corresponds to its character. Risk management deals with the risks in projects, that shall be a part of each project and that shall run from the very beginning, because only by this way it can respond to occurred risks.
From the logic thinking it follows that the risks have various sources [6,9] and they depend on: disasters; local vulnerabilities; methods of management and coping with risks; and they occur on the side of all stakeholders. For achievement of understanding the stakeholders and following the risk´s reductions, it is necessary properly to work with risks, it means to choice the right concept for the risk management (five concepts exist in the risk context [10]); risk identification, risk analysis and evaluation [9-11], to correctly decide about risks and to perform the right risk allocation including the risk´s coping and the risk´s negotiation to stakeholders; to get over the risks; and to introduce the permanent monitoring, in which if necessary to apply the in advance prepared corrective measures [12].

The correct outputs for needs of proper management according to the TQM, given in work [9] are following:

- The risk assessment document – it contains information about appropriate risks.
- The list of top risks – it contains the list of selected risks, the solution of which demand big claims on resources and time.
- The list of retired risks – it serves as the historic link for decision making in future.

The technique of only risk management from the reason of economic handling with forces, resources and funds formally before work with risks reviews the management and coping the risks in the context of benefits and costs on the outputs.

3. Data and methods for risk management plan elaboration

The risk is understood as probable size of objectionable impacts (losses, damages and harms) on protected assets when the disaster occurs, i.e. the phenomenon that damages or can damage the protected assets under certain conditions. For needs of strategic management that is aimed to safe locality and also safe surrounding of locality, it is used the planning that considers the size of objectionable impacts of all disasters with size denoted as "design disaster" (normative determined hazard from disaster) that is normalized on a time unit and a unit of territory. In the special cases (facilities having high potential to cause damages and losses in the area and its surrounding) there are also determined the severe impacts of beyond design disasters from the safety reasons [9, 12].
Data for compilation of risk management plan follows from an areas of interest; basis followed areas in the EU are given in the work [9]. Method for plan´s elaboration uses the procedure that is needed for strategic planning [6].
From the knowledge it follows that risks have different sources, i.e., it means that they depend on: disasters, vulnerabilities, methods of their management and bringing under control, and they occur on the side of all stakeholders. Therefore, for achievement of understanding and consecutive decreasing the risk, it is necessary to perform the activity: risk identification; risk evaluation; risk allocation, including the bringing the risks under control and the assigning them to real stakeholders; the risks´ treatments; and introducing the continual monitoring. Detailed procedure in appropriate place is following:

- TO DETERMINE DISASTERS, THAT CAN AFFECT THE ENTITY and at the same time to respect ALL HAZARD APPROACH.
- TO DIVIDE POSIBLE DISASTERS into categories: RELEVANT, SPECIFIC AND CRITICAL.
- TO APPLY THE PROCESS MODEL FOR WORK WITH RISKS and to determine, for which risks it is necessary to perform: prevention; only mitigation and measures and activities of response and recover; and which risks can stay without special activity.
- TO PERFORM THE MEASURES REALIZATION AND TO ESTABLISH MONITORING.

Experiences show that if the risks in the entity are not properly settled up, the achievement of safety is not possible successfully to reach, i.e. in the followed case it means to secure the metro station in way that public interest and filling the main state functions will not be endangered [2,6].
The priority risks in the followed case are determined on the basis of comparison of: normative requirements that respect the principles of All-Hazard-Approach and Defence-In-Depth that have been created for complex technological systems [11], with the real state in the Praha metro that corresponds with legislative requirements; the obtained outcomes are presented in the work [13].
Each neglecting the risk leads to the losses. For figuration of economic impacts of losses and costs for loss prevention, it is possible to use adjusted tradition interpretation of the Cease's Theorem [14]. Economic optimum for system operation is shown in Figure 1.

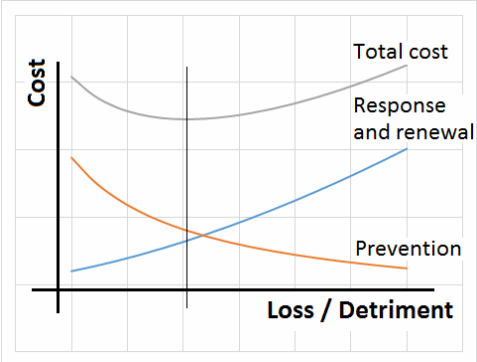


Fig. 1 - Economic optimum of costs on prevention, response and recovery.

The issue to find the optimal costs is the reality that losses at followed entity, and possible in its surrounding, is not possible easily to quantify and standardize. Costs on prevention, response and recovery are the costs of more subjects, and therefore, it is necessary to negotiate with several subjects and appropriately to assign duties and responsibilities among them.
Mentioned facts above demonstrate that number of risks continuously increases with increasing complexity of entity, and therefore, for ensuring the safe entity total costs are increasing on all mentioned items. Because a lot of risks can be reduced if we avert the organization accidents [7, 11], it is necessary to improve safety culture, which means the education and culture of behaviour of staff, which just leads to decreasing the total costs on ensuring the safe entity; decreasing the costs on prevention always leads to increasing the costs on response and recovery, which mostly means also increasing total costs.
It appears that the evaluation of successful copping with risks shall have rules and methodical procedures. Therefore, for assessment of success copping with risk, the special check list has been elaborated (Table 1) by the analogy procedure for the check list for the assessing the sustainability [15] that ensures the law of grow expressed by exponential curve. In practice it is suitable to apply the scale for criticality determination that is used in the ČSN standards, FEMA standards and other ones, Table 2:
0 point – the fulfilment of criterion has the negligible deficiencies in the followed area (less than 5%), it means that it has negligible criticality,
1 point – the fulfilment of criterion has low deficiencies in the followed area (5-25%), it means that it has low criticality,
2 points – the fulfilment of the criterion has middle deficiencies in the followed area (25-45%), it means that it has middle criticality,
3 points – the fulfilment of the criterion has high deficiencies in the followed area (45-70%), it means that it has high criticality,
4 points – the fulfilment of the criterion has very high deficiencies in the followed area (70-95%), it means that it has very high criticality,
5 points - the fulfilment of the criterion has extremely high deficiencies in the followed area (more than 95%).

Table 1 - Check list for assessment of quality of risk management plan.

Question	**Assessment**
Is the plan for risk management led by clear concept and with followed aims?	
Is the integrity principle applied in the risk management plan (it means the consideration of social, ecological and economic subsystem; an expression of costs and benefits; impacts and benefits of economic activity by using monetary and non-monetary values)?	
Are essential elements considered in the risk management plan (e.g.: a fair division of using resources between current generation and future generation; excessive consumption and poverty; human rights; environmental circumstances that are prerequisite for life; welfare that is allowed by economics development and by off-markets activities)?	
Has the plan for mastering the risks adequate scope (e.g. appropriate scale of time and space)?	
Is the plan for mastering the risks practically oriented (e.g. explicitly defined categories, which connects established idea with indicators and criteria; limited number of key targets; limited number of indicators; standardized way of measurement and comparison; reference values of indicators, threshold values, development trends)?	
Is the plan mastering the risks opened (e.g. generally accepted methods and database; explicit credibility; elimination of uncertainties)?	
Is in the plan for mastering the risks an effective communication in the interest society?	
Is in the plan for mastering the risks wide public participated?	
Does the plan for mastering the risks calculate with next evaluation (e.g. refinement of successive aims due to system development)?	
Are in the plan for mastering the risks included the capacities of instructions (e.g. determination of responsibilities for compliance of targets in process of decision making, gathering the data, data storage, documentation)?	
SUMMARY	

Table 2 - Value scale for criticality rate of the Risk Management Plan.

Criticality rate	Values in %e	Number of points for all criteria
Extremely high – 5	More than 95 %	More than 47.5
Very high – 4	70 - 95 %	35 – 47.5
High– 3	45 - 70 %	22.5 – 35
Middle – 2	25 – 45 %	12.5 – 22.5
Low – 1	5 – 25 %	2.5 – 12.5
Negligible – 0	Less than 5 %	Less than 2.5

Final criticality rate can reach values from 0 to 50 if all criteria have the same weight; the threshold values for the criticality rate of risk management plan corresponding to this scale are given in Table 2.

Information about level, on which the normative requirements are fulfilled, i.e. the level of safety of followed entity and also on level of copping with priority risks in entity, is reached by assessment of risk management plan using the criteria of check list.

The risks in the model metro station have been identified by method of judgement of harmony between normative and real state in the metro station. As it was said above the normative has been established for the model metro station on the basis of integral safety of systems of systems [9, 11].

4. Priority risks of model metro station

A metro station together with its technologies and other stations create the transportation infrastructure of urban guided transport in Praha. It goes on a complex system that is a part of a superordinate system that is generally called the system of systems [11]; i.e. the station is subordinated to the central control centre of transport system (central dispatching) and it is interconnected with surrounding systems along to whole line of metro. The central dispatching and individual metro stations are operated by the operator, i.e. in Praha capital by the Praha Public Transport Company.

Safety management system of followed system corresponds to the quality management system, in which there are integrated the requirements of international standards ISO 9001 and EN 13816 on determination of service quality, targets and measuring the public transport of humans. Its main aims are according to [16]:

- reliability,
- awareness,
- accessibility,
- security,
- comfort at traveling.

Each metro station connects various types of systems which have different nature, i.e. technological, cybernetic, economic and social. Stations are constructed on basis of legislative requirements that are in force in the Czech Republic (e.g.: just only some disasters are respected; individual systems are designed and operated separately, i.e. without considering the others; beyond design disasters are not considered [10-12]).

Therefore, in the phase of building and operation, there is not consistently considered interconnection of individual systems, and therefore, the protection against cross sectional risks is not introduced [9-11], which leads to disharmony between the ideal and reality, it means between the normative, which respects demands of Defence-In-Depth and All-Hazard-Approach [11], and reality.

Following assets have been taken into account within determination of risks for model metro station [13]:

- protected assets in metro station surrounding (citizens, parking places, bus stations, crossways, oil pumps, housing estate),
- protected assets of the model metro station (humans and property):
- humans (human lives and health of passengers and staff) and environment,
- objects (e.g. public places - vestibules, platforms, train sets; assembly areas, technology rooms, place of station supervisor),
- energetic devices (substations and distribution transformers),
- communication equipment (communication cables, UHF connection with trains, automatic passenger checking in, equipment of CCTV, telephones, radio equipment, time equipment, electrical fire signalisation, electronic security alarm),
- machinery equipment (escalators in stations, pump stations in the stations and between them, elevators in stations, maintenance workshops and stores in stations),
- air conditioning (main ventilation, air conditioning in stations),
- mobile machines and devices (rolling stock, devices and equipment for the purification of waste including the washing and sweeping trucks, dumpsters and the system of ladders and scaffolding for cleaning the illuminative technology, means of fire protection placed in stations, which allow fast response to fire in underground areas),
- next important equipment (security and alarm buttons, equipment for the fire alarm, traction equipment and lighting, wayside equipment, main water catch, escalators, platforms, signalling panel of machinery, closing devices - electric shutters)
- station devices of control system (station node of “ASDR-D” – automatic dispatcher system of transportation steering, station devices of automatic route setting, station nodes with connection to energetic and technological dispatching, station nodes of central lighting system, station nodes with connection to dispatching of communication, security dispatching and firefighters dispatching),
- security and protection devices and systems (station, wayside and trains),
- flows (energetic, informational, and material).

Outcomes of comparison of normative demands and real station state, in detail described in [13], are given in Table 3. For each asset, there are given three lines corresponding to levels 1 up to 3 levels that are given in the normative that is compiled on the integral safety principle. The numbers determine the level of ensuring the security: 1 – ensured, 2 – partially ensured, 3- non ensured, - it does not have direct impact

Table 3 – Level of coping with selected disasters in appropriate levels of safety management system.

Disasters / **Assets**	Flood	Earthquake	liquefaction of ground	Gas release	Epidemic	Pandemic	Welfare disruption Welfare disruption	Crime	Intent disruption	Terroristic attack	Attack with CBRNE	Armed conflict	War	Industrial accident	Leakage of hazardous Dangerous substance	Traffic accident	Blackout	Disruption of economy
Human lives and health	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Objects	1	1	1	2	-	-	-	2	3	3	3	3	3	1	3	2	2	-
	1	1	1	2	-	-	-	2	3	3	3	3	3	2	3	3	2	-
	2	1	1	2	-	-	-	2	3	3	3	3	3	2	3	3	3	-
Energetic devices	1	1	1	2	-	-	-	2	3	3	3	3	3	1	3	2	2	-
	1	1	1	2	-	-	-	2	3	3	3	3	3	2	3	3	2	-
	2	1	1	2	-	-	-	2	3	3	3	3	3	2	3	3	2	-
Communication Equipment	2	2	2	2	-	-	-	2	3	3	3	3	3	1	3	2	3	-
	2	2	2	2	-	-	-	2	3	3	3	3	3	2	3	3	2	-
	2	2	2	2	-	-	-	2	3	3	3	3	3	2	3	3	2	-
Machinery equipment	1	1	1	2	-	-	-	2	3	3	3	3	3	1	3	2	2	-
	2	2	2	2	-	-	-	2	3	3	3	3	3	2	3	3	2	-
	3	3	3	3	-	-	-	3	3	3	3	3	3	3	3	3	2	-
Air conditioning equipment	1	1	1	2	-	-	-	2	3	3	3	3	3	2	3	2	2	-
	2	2	2	2	-	-	-	2	3	3	3	3	3	2	3	3	2	-
	3	3	3	3	-	-	-	3	3	3	3	3	3	3	3	3	3	-
Mobile machines and devices	1	1	1	1	-	-	-	3	3	3	3	3	3	3	3	3	3	-
	1	1	1	2	-	-	-	2	3	3	3	3	3	2	3	3	2	-
	2	1	1	3	-	-	-	3	3	3	3	3	3	3	3	3	-	-
Next important Equipment	1	1	1	1	-	-	-	3	3	3	3	3	3	3	3	3	3	-
	1	1	1	2	-	-	-	2	3	3	3	3	3	2	3	3	2	-
	2	1	1	3	-	-	-	3	3	3	3	3	3	3	3	3	-	-
Station nodes of control systems of metro System	1	1	1	-	-	-	1	1	1	1	1	1	1	1	3	1	1	-
	1	1	1	-	-	-	2	1	1	2	1	1	2	1	3	1	1	-
	3	2	2	-	-	-	3	2	2	3	3	2	2	2	3	2	2	-
Security and protection systems	1	1	1	-	-	-	1	1	1	1	1	1	1	1	3	1	1	-
	1	1	1	-	-	-	2	1	1	2	1	1	2	2	3	1	1	-
	3	2	2	-	-	-	3	2	2	3	3	2	3	3	3	2	2	-
Linkages and flows	1	1	1	-	-	-	1	1	1	3	3	3	3	3	3	3	3	3
	1	1	1	-	-	-	2	1	1	3	3	3	3	3	3	3	3	3
	3	2	2	-	-	-	3	2	2	3	3	3	3	3	3	3	3	3

From Table 3 it follows that the humans are secured very little; the higher security they have control, energetic and information flows, air conditioning, machinery, communication and next equipment; and more secured are the mobile machines and devices, next important equipment, construction (property) and places. The table also shows that in the transport protection system there are missing the measures for response to: accident with dangerous substances; terrorist attacks; war; attacks with CBRNE; armed conflicts; traffic accidents; industrial accident; and in many cases for response to blackout or crime (often also in the entity concept, e.g. at first security level).

5. Risk management plan for model metro station

The real risk management plan for selected metro station for risks connected with technical and organizational systems is shown in Table 4, which introduces the relevant risk areas, the risk description, their occurrence probability, their impacts and proposal of possible measures for the risk mitigation. Measures related to human safety are not given, because the risks connected with humans, except thin area of OHS, are not followed in the concept of metro station safety. Requirements of standards ISO 9001 [17], IRIS [18] and SIL (safety integrity level) approach for all E/E/PE [19] are considered at the application of measures.

Table 4 - Risk management plan for priority risks of model metro station; SMS – safety management system.

Domain of risk	**Risk description**	**Occurrence probability and severity of impacts of risk**	**Measures for mitigation or mastering the risk**
SMS Layers	Weaknesses in provisions against external harmful phenomena	***Probability:*** middle ***Severity:*** weak to high	To perform measures of nature technical or organizational given in the security plan based on the concept of system of systems safety and to apply the principles of All-Hazard-Approach and Defence-in-Depth. ***Responsibility:*** Director General.
	Occurrence of internal random failures of system	***Probability:*** low according to SIL ***Severity:*** high	To perform measures of quality management system ISO 9001 [17], IRIS [18], and introducing at least SIL 0 for all E/E/PE [19]. ***Responsibility:*** Head of metro operation unit with support of head of metro rolling-stock management unit, head of metro transport route unit, director of security, train dispatcher, and station supervisor**.**
	Occurrence of systemic internal failures in the system	***Probability:*** low according to SIL ***Severity:*** high	To perform measures of quality management system ISO 9001 [17], IRIS [18], and introducing at least SIL 0 for all E/E/PE [19]. ***Responsibility***: Head of facilities' technical management and metro operation support with cooperation of head metro operation unit management section, train dispatcher and station supervisor.
	Failures in processes, human error	***Probability:*** very high ***Severity:*** high	To perform measures of quality management system ISO 9001 [17], IRIS [18], training, examination, exercise, acknowledgement functions of E/E/PE [19], introducing feedback. ***Responsibility***: Head of education and staff section with cooperation of director of security check department and head metro operation unit management section.
	Limited resources	***Probability:*** low ***Severity:*** middle	To perform measures of quality management system ISO 9001 [17], IRIS [18], maintaining reserves for carrying out critical activities. ***Responsibility***: Director general of the transport company and all top management.
	Mutual influences of requirements on safety and security	***Probability:*** high ***Severity:*** middle	To perform measures for search of trade-offs designed in SESAMO project [20]. ***Responsibility***: Director of security in cooperation with Head of metro operation unit, head of metro transport route unit, head of metro rolling-stock management unit, head of facilities' technical management and operation support.
	Faulty or insufficient identification of influencing factors	***Probability:*** middle ***Severity:*** high	To perform measures of standard EN 50126 [21], it means to introduce independent assessment of failures, monitoring and to find an appropriate solution. ***Responsibility***: Director of security in cooperation with Head of metro operation unit, head of metro transport route unit, head of metro rolling-stock management unit, head of facilities' technical management and operation support.
	Faulty work with risks, choice of methods, scales, and risk assessment.	***Probability:*** low ***Severity:*** high	To perform measures of standard EN 50126 [21], it means to introduce independent assessment of failures, monitoring and to find an appropriate solution, verification, and assessment methodology. ***Responsibility***: Director of Security in cooperation with head of metro operation unit, head of metro transport route unit, head of metro rolling-stock management unit, head of facilities' technical management and operation support.
	Responsibilities, competencies, independences and confidentiality of the research body.	***Probability:*** low ***Severity:*** high	To carry out independent assessment of failures and to apply measures of EN 50126 [21] and quality management system ISO 9001 [17]. ***Responsibility***: Director of Security, in cooperation with Human Resources Director

Mutual links and flows between secondary and superordinate systems.	Transmission of erroneous and confusing information, it means system input and output errors.	***Probability:*** middle ***Severity:*** very high	To carry out independent assessment of failures and to apply measures in monitoring and interdisciplinary communication, to introduce common terminology. ***Responsibility***: Head of metro operation unit, train dispatcher, and station supervisor.
	Disruption of information and material flows.	***Probability:*** low ***Severity:*** high	To continuously ensure creating reserves and system redundancy. ***Responsibility***: Head of facilities' technical management and operation support in cooperation with of head metro operation unit management section, train dispatchers and station supervisor.
	Execution of mutually influencing functions	***Probability:*** high ***Severity:*** high	To ensure monitoring and rules for interdisciplinary communication. ***Responsibility***: Director of Security in cooperation with head of facilities' technical management and operation support.
	Failures of surrounding systems; triggering relevant disasters.	***Probability:*** middle ***Severity:*** very high	To ensure monitoring and rules for interdisciplinary communication. ***Responsibility***: Director of Security in cooperation with head of facilities' technical management and operation support.
Dependences among SMS layers	Flawed methodology for hazard identification and risk analysis within the higher levels of SMS	***Probability:*** high ***Severity:*** very high	To ensure monitoring and rules for interdisciplinary communication. ***Responsibility***: Director of Security in cooperation with head of facilities' technical management and operation support, and head of metro operation unit.
	Misunderstanding of requirements and information from other level of SMS.	***Probability:*** high ***Severity:*** high	To ensure monitoring and rules for interdisciplinary communication, education and reallocate competencies. ***Responsibility***: Director of Security in cooperation with head of facilities' technical management and operation support, and head of metro operation unit.
	Transmission of fault conditions from one layer to another if they occur.	***Probability:*** middle ***Severity:*** Middle	To ensure adequate independence of layers, physical separation of layers and diversity data collection. ***Responsibility***: Director of Security in cooperation with head of facilities' technical management and operation support, and head of metro operation unit.
	Missing input information.	***Probability:*** high ***Severity:*** very high	To improve top management of safety, education and research. ***Responsibility***: Director of Security in cooperation with head of facilities' technical management and operation support Human Resources director.
Other unpredictable events and human factors	External factors.	***Probability:*** high ***Severity:*** middle	To ensure improving quality management system according to ISO 9001 [17], IRIS [18], training, examination, exercise, competency, information security management system ISA/IEC 27000 [22], cyber security according to ISA 99 [23] and common criteria [24], monitoring. ***Responsibility***: Director of Security with cooperation of all top management and heads of units.
	Internal factors.	***Probability:*** middle ***Severity:*** high	To ensure improving quality management system according to ISO 9001 [17], IRIS [18], training, examination, exercise, competency, information security management system ISA/IEC 27000 [22], cyber security according to ISA 99 [23] and common criteria [24], monitoring. ***Responsibility***: Director of Security with cooperation of all top management and heads of units.
	Malicious damages.	***Probability:*** low ***Severity:*** very high	To ensure improving quality management system according to ISO 9001 [17], IRIS [18], training, examination, exercise, competency, information security management system ISA/IEC 27000 [22], cyber security according to ISA 99 [23] and common criteria [24], monitoring. ***Responsibility***: Director of Security with cooperation of all top management and heads of units.

From Table 4 it follows that in the metro there are necessary:

- To introduce quality / safe and monitored processes of maintenance and operation, which are introduced in the station operation rules.
- To apply the security, plan at the design, construction and management of changes, which is targeted to elimination of system failures and to have a plan for the cope with system failures in the operation.
- To introduce periodic training, examination and exercises of staff; the confirmation function of E/E/PE from [19] and feedbacks.
- To ensure the safety by the high quality of the installed systems according to the requirements of [17, 18,21].
- To carry out regular audits, evaluation of competences and to ensure the independence of solved teams, etc.

The Table 4 depicts several basic groups of risks; with which it is necessary to work within the SMS metro station as the object of critical infrastructure need work.

6. Assessing the quality of risk management plan

The quality or criticality of risk management plan is evaluated in Table 5; the score is estimated on the experience from inspections in the metro operation [25], and logical considerations on the stability of the security plan for the metro from the view of dynamic evolution of our planet, technologies and human society (based on existing data and experience the measures against disasters have validity as follows: natural ones - hundreds of years, technology ones - tens of years, social ones – years).

Table 5 – Assessment of risk management plan criticality.

Question	**Assessment**
Is the plan for risk management led by clear concept and with followed aims?	0
Is the integrity principle applied in the risk management plan (it means the consideration of social, ecological and economic subsystem; an expression of costs and benefits; impacts and benefits of economic activity by using monetary and non-monetary values)?	2
Are essential elements considered in the risk management plan (e.g.: a fair division of using resources between current generation and future generation; excessive consumption and poverty; human rights; environmental circumstances that are prerequisite for life; welfare that is allowed by economics development and by off-markets activities)?	3
Has the plan for mastering the risks adequate scope (e.g. appropriate scale of time and space)?	1
Is the plan for mastering the risks practically oriented (e.g. explicitly defined categories, which connects established idea with indicators and criteria; limited number of key targets; limited number of indicators; standardized way of measurement and comparison; reference values of indicators, threshold values, development trends)?	1
Is the plan mastering the risks opened (e.g. generally accepted methods and database; explicit credibility; elimination of uncertainties)?	1
Is in the plan for mastering the risks an effective communication in the interest society?	2
Is in the plan for mastering the risks wide public participated?	4
Does the plan for mastering the risks calculate with next evaluation (e.g. refinement of successive aims due to system development)?	1
Are in the plan for mastering the risks included the capacities of instructions (e.g. determination of responsibilities for compliance of targets in process of decision making, gathering the data, data storage, documentation)?	1
SUMMARY	**16**

From comparison Table 5 with Table 2 it follows that the risk management plan has middle criticality, which means that in some sections there are risks that are treated just only from partial view, in other words only known risks are solved. Mentioned fact is in accordance with the outcomes of expert inquiry [26] according to which the management and copping with risks which are based on integral safety for systems of systems model

have certain criticality, because we don't know all possible interdependences among the assets, their possible changes caused by dynamical world development. At considering the relationship between safety rate ***b*** and criticality rate ***k*** in the expression ***b = 1 – k,*** we obtain the middle safety rate, which corresponds to reality, because knowledge and available possibilities of humans are limited.

7. Conclusion

Risk management is an integral part of internal control and surveillance system of each entity and each activity, i.e. also the metro station. Manufacturing technologies are more complex, as well as more detailed information is needed to safety ensuring. H. H. Fawcett in work [27] gives: "To know means to survive; to ignore means to ask for destroy". Ignoring or disparagement of risk management is cause of most problems, failures, catastrophes, and therefore, it is important to have in advance prepared tool giving the instructions how to tame expected risks; the risk management plan is such tool. The similar tool for unexpected risks is the contingency plan.
Real metro stations are the parts of critical transport infrastructure, thus they have to serve to human survival [2, 10, 16]. The main lack is the fact that the safety management systems of real metro stations do not deal with the human security in the metro station and in its surrounding at critical conditions in the stations. Due to that nothing is absolutely safe, it is necessary to admin to possibility of critical conditions origin, and to prepare the plan for management of realized risks with considering the passengers, staff of metro station and inhabitants in metro station surrounding.
On the basis of legislation in force (Act No 240/2000 Coll. and related legislation) the metro operator (DP hl. m. Praha) has the obligation to handle the emergency preparedness plan, inter alia, to chemical attack. According to the Praha security system the metro objects provide in addition to the transport services also the protection of city population in case of an enemy attack. So-called The Protection System of Metro is intended to this purpose. Thus, it is very important to introduce the compiled risk management plan into the practice and to expand it into other parts of metro system.

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