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Conception of "4 Goals and 3 Levels" in Risk Management in Road Transport Systems

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Abstract

"Four goals and three levels" conception of risk management in transport comes out from triple interpretation the notion of system and from process approach to transport system interpretation. The title of the lecture suggests hierarchical risk management, but it is not so obvious and that is why is better saying about risk management at three levels of transport system: 1. level of system structure elements; 2. level of processes which realize system purposes; 3. level of system "attitude". In presented conception risk is a "multidimensional" constructor and relates all negative effects of transport (NET-s). It is, among the others, about risks: life loss (safety aspect), natural environment degradation, transport congestion arising.

Keywords: transport, risk management, structural risk, functional risk

1. Introduction

The main goal of risk analysis in transport is working out sensible basis to make decisions related loss avoiding, which can happen at any level of transport management and in any place of concrete transport system, [1]. Such decisions are an element of risk management process. The first level of that process is risk analysis where risk size is estimated. Risk analysis in transport systems is a structural process of identification both possibilities and range of losses caused in system and/or its surrounding; to special losses are counted physical damages caused by system elements (people, infrastructure, means of transport) and/or surrounding

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(environment). From general formula of risk counting becomes that risk analysis provides to choose "the best" method, which allows to: 1. danger identification (undesirable events); 2. frequent estimation of undesirable events; 3. consequences estimation of undesirable events; 4. reconstruction of possible emergency scenarios.

Risk analysis depends on "dangers map" in analyzed transport system. And will be dangers? Dangers will be there where are potential losses. Those should be searched in: 1. system structure; 2. system work processes; 3. negative effects of system behavior. This is a main idea of that conception, [2]. This is a simple implication of interpretation of complex system which is each transport system.

Problems of risk analysis and wider risk management has a rich bibliography and it is difficult to relate to all its streams; representative literature related to analysis methods, valuation and risk control in technology, also in transport is in author's monograph, [3]. From extensive monograph foreign publications of risk analysis are [4], [5], [6], [7], [8]. Among reports of research institutions there is e.g. [9].

Risk management problem from years is in articles published in famous magazines of safety ad reliability. From old publications let us mention: [10], [11]. From earliest publications are [12], [13].

From 2000 year there are tries of harmonizing risk management methods in technology (EC-JRC, 2000), but up to now there is not general European standard in this subject, [14]. It relates also risk management in transport. Recommendations for further works on risk estimation in transport are among others in ETSC reports, [15], [16]. On the other hand risk estimation criteria in transport safety programs are a subject of among others of a report [17] and article [18].

Publications from risk analysis in traffic and road transport appear from long ago and as often as not [19], [20], [21], [22], but as opposed to many technology fields there is not yet uniform method of risk management. There are just created bases of risk management methodology based on standard elements: risk analysis, valuation and risk estimation and risk elimination and residual risk steering, [23]. More important problems of risk management in transport are discussed in article [24].

Risk management elements can be met as a tool supporting making decision at different levels of management, e.g. in [25], [26]:

– road infrastructure management: planning, designing and exploiting road tunnels, road infrastructure safety management, road net planning, traffic road safety audit;
– traffic management: road net, traffic management automating;
– people and goods transport management realized by means of road transport; dangerous material transport, professional risk in transport companies, risk in collective transport;
– driving process realized by individual traffic road participant: driving models, risk calculators, risk maps.

More often researchers which work on transport risk use generalizations which find out in load chain risk management, [27]. Research perspectives in that range are described in one of the newest publications [28].

2. Taxonomies of Road Transport Safety Problems

Road transport safety – is a multidimensional problem, hence all science researches have to take into consideration its basic taxonomies; we announce them after monograph [22].

Road transport safety taxonomy according to Haddon:
– human (transport user);
– mean of transport, environment (transport infrastructure);
– “around-accident” process phases: pre-crash, crash, post-crash.

Road transport safety taxonomy according to “vision zero” conception:
– inadequate transport system construction and human tendency to faults [inadequate human factor, ergonomics];
– dangerous behaviors of transport user [risk psychology, cognitive engineering]; problems of wrong post-crash medical care (inadequate trauma care).

“Measurements” taxonomy (of aspects) road transport safety problems:
– magnitude – indicate by population size covered by transport risk;
– externality – indicated by level of “forcing” risk phenomenon by one to another users of transport;
– complexity of transport system;
– spatial distribution of dangerous transport events;
– dynamics;
– “perceived urgency” of transport events;
– “responsibility” of approach to problems solving.

Taxonomy of basic transport risk factors.

To specify notions which characterize road risk can be used risk factors criteria. The most often marked out are two risks categories and related them factors:
– primary risk;
– secondary risk.

The first relates road accident and the second accident consequences.

Basic risk is related with following factors, [29]:
– exposure;
– behavioral factors;
– road environment;
– vehicle factors.

On second risk have influence, [29]:
– vulnerability of certain modes of transport,
– vehicle factors;
– use of safety devices;

– road environment;
– post-crash medical care.

Taxonomy of essential data of road safety management:

1. data of risk exposition;
2. data of special risk factors exposition;
3. data of traffic participants behavior who respect safety requirements, e.g. crossing, speed, alcohol, etc.
4. data of severity of traffic participant damages;
5. data of potentially effective safety measures.

3. Four Goals of Risk Management in Transport

The main purpose of management in transport is safety, efficient and economics justified realization transport processes with existing technology, organization and economics conditions, [30]. Transport safety is just one transport system feature. It means that transport safety management is a quasi-optimization task. If taking as a goal safety level maximization then rest of vector component “transport quality” – efficiency and cost of transport are essential limit. In turn the essential issue in safety management is estimation all possible risks in analyzed transport system.

Safety management is a kind of system management, that is managing by goals. Taking rule of “depth defense” can be defined four main goals and relating them four groups of risk management methods in transport:

1. minimizing risk of transport accidents by safety methods; it is about minimizing the possibility of transport dangers and/or minimizing the potential losses in system;
2. minimizing the number of undesirable transport events (incidents, conflicts, collisions, accidents); there are used active methods of safety improvement;
3. minimizing the transport accidents effects; there are used passive methods of safety improvement;
4. minimizing effects of transport crashes; there are used methods of crisis management.

Mentioned above four main goals of safety management in transport are realized in different layers of management and for different areas of influence. For road transport offers of layers and areas of safety management are mentioned in the lecture [2, p.281]. Each level of safety management in transport relates horizon of safety management, which can be defined as: expected time (period) essential for assuring safety realization of work processes in transport system. It is anticipated “time of advance” needed for adaptation transport system to settled goals and parameters of activity. For each object and goal of safety management there is in concrete conditions optimal horizon of safety management.

Above goals fulfill phases of safety management in transport. At each phase of management there should be worked out methods, procedures and technologies of minimizing risk of transport accidents. All together have to create chain of multiple safety barriers. According to “depth defense” rule any system of transport safety management should have a structure of multilevel chain of protection which supervise main transport processes.

Realization above goals requires using procedures and technologies which create multilevel protection system of traffic processes, load processes and processes of traffic steering. It is approach according to “depth defense” strategy. It can assure effective safety management, that is where “risk level” is relatively steady and possibility of accident is inversely proportional to “consequences”; it relates also transport.

4. Three “Levels” of Risk Management in Transport

“Three levels” conception of transport risks (3L-TR) are signalized in non published work [2]. This conception comes out from three different definitions of general system [31], [32]:

1. structural definitions – which relate to internal system construction;
2. functional definitions – which relate to system functioning by processes identification as a changes carrier of system (features change follows by process);
3. model-simulation definitions – which allow for observation and prediction system behavior in determined conditions of activity.

Structural system interpretation relate to classic definition of L. von Bertalanffy, where the system is “a collection of elements which stay in relations”, [33]. Structural definitions describe the system by: a. elements collection; b. relation collection between elements; c. goal – that is system-creating relation. Functional interpretation of system relate to short definition of M. Mesarović, [34]: “system is a collection of relations between its features”.

Relations between features describe system functioning. Researched those relations we can state if system functioning is normal. Systems functioning in cybernetics represents as transformation of entries to surroundings. Each system has some features and change one value or few features is an event. Series of events determine system functioning. The process goal is achieving by system preferred (in determined time period) effects (products, results) which determine new system phases. In that sense system phase is a collection of its essential features, [35]. Functional definitions put an accent on processes identification which are in system. In transport system there are four interesting process groups: 1. traffic processes; 2. steering processes; 3. loading processes (initial-final); 4. disturbing processes.

Model-simulation interpretations put the accent on observation and prediction of system behavior in determined conditions of activity. Simulations give possibility of prediction the hypothesis consequences of system activity and verification and choose of analyzed variants of system activity.

So according to 3P-TR conception risk analysis should be provided on each three levels:

1. level of transport system structure;
2. level of work processes in transport system;
3. level of transport system "behaviors" that is de facto – level of "negative effects of transport" (NETs).

It is all about: 1. structural risks – generated by elements and relations which create system structure; 2. functional risks – generated by working system processes; 3. system risks – generated by system in long term and related with danger of falling system into undesirable situations, that is such, which generate losses; for example transport accidents, Fig. 1. Here:

I: structural risks (SR); losses risk management in system structure;

II: functional risks (FR); losses risk management in working system processes;

III: risks of negative effects of system activity (NET-s risks); management of system losses risk.

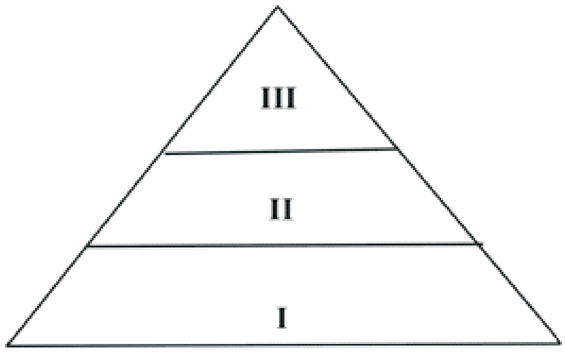

Fig. 1. "Iceberg" model for illustration the conception of "3 levels" (self study)

4.1. Structural risk (SR) – level I

If the structural definition would be used in "transport system" then at level of "elements" and "relations", that is at level "structure of system" can be analyzed different risks; they can be called as "structural risks". Structural risks should be relate to undesirable changes of transport system structure. Precisely "structural risks" come out from dangers "which are effect of such changes of number and elements features and changes of system structure that in system and in surrounding can be generated losses", [3, p.68].

Structural risks are dependent on effects of all undesirable interactions between elements of transport system structure, it means such which generate losses in that system. Here can be defined undesirable reliable states of transport infrastructure elements and means of transport: 1. inefficient state; 2. defects; 3. damages; 4. break-downs.

There is arising the need of logic classification the structural dangers. Helpful is here classification proposed in non published lecture [35]. After some modification it is presented below (table 1); here: RF– risk factor; HF – human factor in transport; MT – means of transport; TI – transport infrastructure; N – norms, rules, procedures; TA – transport accident; → – implication operator; □ – conjunction operator.

Table 1

Classification structural risk factors of accident with propositions of analysis that risk

Risk	RF→ TA	Structural risk factor
SR1	HF → TA	Human factor
SR2	MT → TA	Damage means of transport
SR3	TI → TA	Defect/damage of transport infrastructure
SR4	N → TA	Wrong norms, bad rules
SR5	HF □ MT → TA	“wrong fit of means of transport to human-operator”
SR6	HF □ TI → TA	“wrong reading a transport infrastructure elements”
SR7	HF □ N → TA	“norm breaking and road regulations”
SR8	MT □ TI → TA	Effects at: means of transport – transport infrastructure
SR9	MT □ N → TA	“norms for means of transport”
SR10	TI □ N → TA	“norms of designing and IT exploitation”

Beside ten risk factors described in Table 1, there can be specified nine others – risk factors which are implications of other transport system structure elements:

11.HF □ MT □ TI → TA.

12. HF □ MT □ N → TA.

13. N □ MT □ TI → TA.

14. HF □ N □ TI → TA.

15. HF □ MT □ N □ TI → TA.

16. HF □ HF → TA.

17. MT □ MT → TA.

18. TI □ TI → TA.

19. N □ N → TA.

Except classification there are relations: TA → TAE, (TAE – transport accident effect).

4.2. Process Risks (functional risks) – level II

Structural dangers can change into dangers of second level, more difficult – as I think – to identify and estimation. Dangers of 2^{nd} plane are effects of such changes of system properties, that in system and surrounding can be generated losses. And risks related with properties changes are “functional risks” – that is risks (non controlled) of undesirable changes for safety of work processes in system (e.g. traffic is a such process in road transport system). Theoretically for general

system can be mentioned five changes then five types of functional system dangers, [3]:
1. shaking dynamic balance of system;
2. disturbing information processes in system;
3. disturbing steering processes;
4. disturbing self-regulation of system;
5. shaking integration of system.

With each danger is associated risk of not fulfilling by system desirable functions 1 – 5. It would be for sure difficult to interpreted dangers 1 – 5 for transport system. Less general level of reflections is need. That is why the interpretation of "process approach to transport system" was used, [32]. According to it for transport activity consist three basic processes:
1. process of shaping transport infrastructure: a. infrastructure planning; b. infrastructure realization; c. infrastructure exploitation.
2. process of transport realization, which can be defined as follows: transport process include group of organization activities, administrative realized by experts in exact order by using means of transport for moving concrete loadings in exactly determined relations, [36].

Only moving that is traffic is a component of such defined process, and its importance for transport safety follows from that during this process more losses are generated.

Process risks in other words functional risks are connected with three process groups existing in any transport system:
– risks of losses in traffic processes – it is about losses risks related with decreasing traffic efficiency or transports efficiency;
– risks of losses in initial-final processes: it relates generally losses risks important for load chain realization, that is "logistics losses"; they can be described by logistics indicators;
– risks of losses in transport steering processes: the example is here losses caused by wrong determined signalization cycles in traffic, or losses which come out of steering the landing and taking-off cycles of passenger planes, steering subway trains, etc.

3. process of transport Policy creating; this is a process of manage character which assure integration and coordination of all transport system elements, [32]. This process relies on conscious reaction to cause concrete behaviors of institutions, companies or transport users, driven for goal realization, [37, p.9].

Cooperation of those three processes is composed on transport system functioning. Functional risks in transport system are associated risks with three above processes; they can be defined as:
RF1. risk of wrong infrastructure shaping; there are here particular risks:
RF1-1: risk of wrong infrastructure planning; possible dangers:
– RF1-1a: wrong localization;
– RF1-1b: wrong traffic prognosis;

– RF1-1c: defects of planning financial;
– RF1-1d: defects of planning ways of infrastructure;
RF1-2: risk of wrong infrastructure realization; possible dangers:
– RF1-2a: wrong choice of executors;
– RF1-2b: wrong building works;
– RF1-2c: monitoring faults;
RF1-3. risk of wrong transport infrastructure exploitation; dangers:
– RF1-3a: wrong repairs and modernizations;
– RF1-3b: wrong analysis of properties.
RF2: risk of wrong transport services; here are particular risks:
R2-1. risk of wrong transport process organization;
R2-2. executive risk in transport process;
R2-3. administrative risk in transport process;
R2-4. load risk in transport process;
R2-5. traffic risk (road, railway, sail, air);
RF3. risk of wrong transport policy; there are here particular:
RF3-1. risk of wrong macro-prognosis of transport development;
RF3-2. risk of wrong management – meant as affecting lega land public organs on transport users.

4.3. Risks of Negative Effects of Transport (NET) – Level III

It seems that dangers of II level that is functional dangers can “release” undesirable behaviors of transport system observed in long term perspective. Those behaviors – system dangers called negative effects of transport (NET-s). They generate losses both in structure and in system surrounding. It is like 3^{rd} level of dangers and connected with them risks, which we call as “NET risks”. Theoretically for general system can be mentioned also five types of system dangers [3, p. 69]: 1. lack of adaptive; 2. loss of accommodation abilities; 3. homeostasis disturbances; 4. increase stoppage (if the increase was desirable); 5. step changes of system parameters.

With each danger is connected risk. But there are questions arise: 1. what is “lack of adaptive” of transport system?; 2. what is accommodation “ability loss ” of transport system? etc. These are difficult questions and it is necessary to find simplifications; NET are them (negative effects of transport). Here can be described at least three groups:

A. undesirable transport events – as states of working processes in transport system – which determine risk levels in transport system:

– transport incidents;
– transport conflicts;
– transport collision;
– transport accidents;
– transport crashes;

B. undesirable phases of natural environment (surrounding of transport system):

– losses in natural environment,

– lowering the quality of life;

C. undesirable phases of traffic schedule in area, that is phases of transport congestion.

The most obvious and the most researched are risks of undesirable transport event, which defined transport safety problems by analysis transport accident risk, death risk in transport accident, risk of injury in transport accident, risk of transport catastrophes and others.

Risks of appearing such events can be analyzed by:

– different transport events models; e.g. models of road accidents;

– marking out risk indicators in relation on empiric data;

– simulation methods of traffic situations.

It seems that interesting example for explaining risk management of 3^{rd} level, that is risks of negative effects of transport – there is a problem of balanced safety in road traffic (sustainable road safety, SRS). SRS conception appeared in Netherlands at the beginning of 1990 year, [38]. In that conception pointed on proactive and system activities for improvement the traffic road safety state, which would guarantee keeping that safety state in long time. In the conception of balanced road safety development were underlined latent errors in traffic system, and so called system gaps, which effect are road accidents. It was also about that in activities for road safety improvement do not become dependent on individual decisions of traffic participants, but show also those factors which are responsible for designing and functioning road traffic system. Here it was first of all about: infrastructure, means of transport, motorization education for society.

There are determined five rules of balanced safety, [39]:

“1.Functionality of roads. Mono functionality of roads as either through roads, distributor roads, or access roads, in a hierarchically structured road network.

2. Homogeneity of mass and/or speed and direction. Equality in speed, direction, and mass at and direction medium and high speeds.

3. Predictability of road course and road user behavior by a recognizable road design. Road environment and road user behavior that support road user expectations through consistency and continuity in road design.

4. Forgivingness of the environment and of road users. Injury limitation through a forgiving road environment and anticipation of road user behavior.

5. State awareness by the road user. Ability to assess one’s task capability to handle the driving task.”

To safety evaluation in different transport systems there are used many road safety indicators; here few of them, [40]:

– number of accidents per VMT, PMT, year, trip, ton-mile, and capita;

– cost of accidents;

– number of high accident locations;

– response time to accidents;

– accident risk index;
– crashes per 1,000 people.

Those and another indicators can be used for analysis risks of level 3^{rd} and A group.

Putting 4G ("four goals") conception with 3L ("three levels"; "planes"; "stages") conception of risk management can be proposed "**4G-3L"** model of transport risks management, Fig. 2, [41]. In that model the essential role have:

– structural barriers SB;
– functional barriers FB;
– behavioral barriers BB.

The goal of future researches is identification those barriers in concrete road traffic systems. According to "depth-defense" strategy the safety barriers have to exist at levels:

– system structure;
– working processes of system;
– transport system behaviors.

Designing and exploiting any transport system there should be every time dedicated for realization four – earlier mentioned – main goals of safety transport.

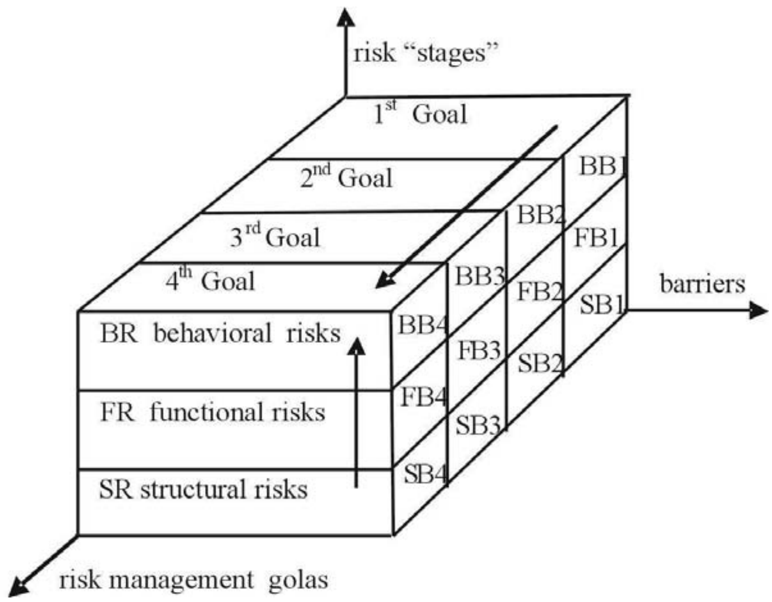

Fig. 2. General conception of "4G-3L model" of transport risks management

5. Methods of Transport Risks Analysis

Risk analysis methods allow to account (estimate) risk in systems “HF – TI – MT” and according PrPN-IEC 603000-3-9 norm risk estimation is a process used to create measure of analyzed risk level. From that norm and known multiplicative formula of risk estimation comes out that choice of risk analysis method comes to the choice of “the best” method which allow to:

1. danger identification (undesirable events);
2. frequent estimation (possibilities) of undesirable events;
3. consequences estimation (effects) of undesirable events;
4. reconstruction of possible emergency scenarios (accidental).

Above phases of risk analysis determine choice of risk analysis methods and are a criteria of such choice. There are not any directives for choice the risk analysis method; it relates also transport. Works on methodology of integrated risk management in transport still lasting.

Taking “4G-3L” conception we can propose idea of next criteria of selection risk analysis method:

1. for structural risks proper would be methods of “subject dangers” analysis, that is come from structure elements;
2. for functional risks proper would be methods of “process dangers” analysis e.g. Process Safety Analysis (PSA);
3. for system risks proper would be methods based on models and indicators of undesirable transport events; example are here methods from “Probabilistic Risk Analysis” (PRA).

The choice of proper risk analysis method is more “an art” than “science”. Below in table 1 there is presented first version of choose of common risk analysis methods for transport. In another version it would be published in [1, p. 294-295].

There is not placed helpful risk analysis methods such as: RM – result models; DM – delphic method; DI – danger indicators; ST – simulations techniques – e.g. Monte-Carlo simulation, others. The are also passed over the following norms: ISO 28000: managing safety in load chains, ISO 31000: Risk Management Guidance Standard; new ISO standard currently at the phase of project including directives in the range of general risk management implementation. ISO 17799: “practical rules of safety management information” was published in January 2007 as a PN-ISO/IEC 17799:2007. By practices is noticed as the best edition relates system approach to safety management information. And assume the following shorts of basic methods and other methods.

Basic methods:

SR – Safety Review; RR – Relative Ranking; PHA – Preliminary Hazard Analysis; WI – “What -if” Analysis; HAZOP – Hazard and Operability Analysis; FMEA – Failure Modes and Effect Analysis; ETA – Event Tree Analysis; FTA – Fault Tree Analysis; CCA – Cause Consequence Analysis; HRA – Human Reliability Analysis; QRA – Quantitative Risk Assessment.

Table 2

Conception of choice risk analysis method in general transport system, [2]

risk analysis methods	T R A N S P O R T S Y S T E M																							
	Object areas of risk *									Levels/layers of transport system *														
	HF	MT		TI	STS		EF		AR	CA		LG		TB		T		PCT						
	Structural risks (1-10, tab.1)									Functional risks										NET risks				
	SR									FR1			FR2					FR3						
See chapter 4.1,4.2, 4.3	1	2	3	4	5	6	7	8	9	1-1	1-2	1-3	2-1	2-2	2-3	2-4	2-5	3-1	3-2	1	2	3	4	5
Basic methods – quality																								
WI										X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CHL														X	X	X	X	X	X					
SR														X	X	X	X							
RR																X	X	X	X					
PHA														X	X									
HAZOP																				X	X	X	X	X
FMEA																				X	X	X	X	X
Basic methods – quantity																								
PRA/OSA/PSA													X	X	X	X	X							
FTA	X	X	X		X	X	X	X		X	X	X								X	X	X	X	X
ETA	X	X	X		X	X	X	X		X	X	X								X	X	X	X	X
CCA	X	X	X		X	X	X	X												X	X	X	X	X
HRA	X				X	X	X																	
Other methods																								
BA: Barrier Analysis										X	X	X	X	X	X									
BSA: Black Spot Analysis										X	X	X	X	X	X	X	X							
B-TA: Bow-Tie Analysis														X	X	X	X							
ChA: Change Analysis														X	X	X	X							
SChM: Swiss Cheese Model													X	X	X	X	X	X	X					

* areas of subject risk and layers of transport system according [2, Tab. 7.1, s. 281]

Other methods:

BA: Barrier Analysis – method introduced by energetic sector; identify barriers counteracted accidents, damages and injuries arise. Barrier analysis is a quality method for accidents analysis. It is connected with MORT.

BSA: Black Spot Analysis – method of black point analysis; the philosophy relies on giving the sources there where are the lowest.

B-TA: Bow-Tie Analysis – Bow-Tie: left side wing shows danger for that factors which allow to avoid entering in accidents chain; right side wing shows consequences. Bow-tie is constructed in that way – "risk approach" should be minimal or impossible.

ChA: Change Analysis – technology of designing danger identification, which arise as a result of planned or non planned changes; used among others in post-accidental investigation.

SChM: Swiss Cheese Model.

Following shortcuts mark:

HF – human factor; MT – means of transport; TI – transport infrastructure; STS – surrounding of transport system; EF – external factors (floods, terrorist actions); AR – accident research; CA – central authorities; LG – local governments; TB – transport boards; T – transporters; PCT – production companies for transport.

6. Usefulness of "Entropy Model of Risk" to 3rd Level Risks Analysis in Transport

Interesting approach to risks modeling of 3rd level, that is NET-s risks in transport systems can the entropy model of risk, (EMR), [42].

In system type "organization" so big and complicated hierarchic systems are considered among others entropy risk, that is risk of losses in system caused by system degradation or system disorganization. This process known first of all from natural systems can be described by system factors. Those indicators describe system changes at structure level and processes of system and its surrounding (environment). Entropy risk model shows risk system dependence from entropy system changes and dependence this phenomenon from system factors degradation. Adaptation of entropy risk for transport is shown on Figure 3 there are presented changes of four values of system indicators for three systems: ideal, organization (e.g. transport), natural. Here: SF – system factors; IE – increase entropy; CA – corrective actions; DE – decrease entropy; SE – stability entropy.

Commenting entropy risk model we should ascertain that risk management in complicated systems should rely on:

– standard work practices;
– steering working process in system;
– monitoring of human factor management;
– controlling technologies;

Entropy risk model show that in case of system factors degradation the first step is corrective action, and next prevent future recurrences of this risk. It starts then proper program of maintenance, which has to prevent of getting worse of each system factor.

Entropy risk model modifying for needs of "3 planes conception" of transport risk management – can be shown dependences between entropy risk and system factors in multiplicative formula:

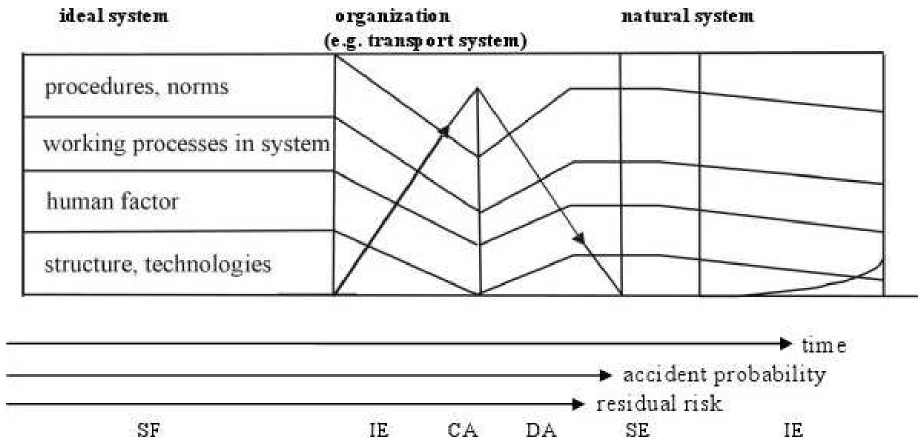

Fig. 3. Illustration of entropy risk model; (self work out on bases [43, p.12])

$$\boldsymbol{RE = R_S x R_P x R_{ENT} x R_{CL}} \quad (1)$$

where: $\boldsymbol{RE}$ – entropy risk of transport system; $\boldsymbol{R_S}$ – structural risk, technological, that is risk plane 1 – related structural elements of transport system; here because of weight of problem we can distinguish $\boldsymbol{R_{HF}}$ related with human factor; $\boldsymbol{R_{WP}}$ – risks come out from working processes in transport systems, that is 2 plane risk; $\boldsymbol{R_{NET}}$ – NET-s risks, that is plane 3 risk.

Formula (1) shows among others what weight for risk minimizing in system has minimization of system factors values. If three of four system factors have small values, but one is high then the possibility of accident arising stay high. It works here “product law” known for example from reliable theory.

Entropy risk model is a methodology example of “multidimensional” record of risk. In relation to transport system can be new equipment of risk management problems description.

7. Summary

The need of transport risk on “three levels” of each transport system seems to be natural – it comes out from three possible research to each system, also transport system. From presented here “4G-3L”conception follows the essential analysis of structural, functional and system risks. Such approach shows that there is not one transport risk, but at least three. Next issue in works on methodology of transport risk management would be wider than now results use from safety model domain and risk in systems of type “organization”.

The example – entropy risk model which can be adopted to risk modeling in transport systems. In contemporary researches of transport safety is needed wider look on interpretation problems, modeling and risk analysis. The need of looking for analogy and integration conception in safety researches of different technology systems is today a necessity.

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