

## **Creation of the System for Management of Technology-Related Risks at the Enterprise**

**Matvey A. Latkin**

Belgorod State Technological University named after V.G. Shukhov, Belgorod, Russia.

**Vladimir Yu. Radoutskiy**

Belgorod State Technological University named after V.G. Shukhov, Belgorod, Russia.

**Sergey A. Kemenov**

Belgorod State Technological University named after V.G. Shukhov, Belgorod, Russia.

**Maria N. Stepanova**

Belgorod State Technological University named after V.G. Shukhov, Belgorod, Russia.

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### **Abstract**

A problem of creating a technology-related risks management system at an enterprise has been considered. On the basis of applying system approach and system modeling, a set of interrelated structural and process models was built for using them in the technology-related risks management system of an enterprise. By means of the suggested models and matrix projections between them, we can carry out the organizational analysis of a technology-related risks management system of an enterprise, which allows determining the functional workload and responsibility of structural elements of the created system. The calculation procedure of personnel in accordance with the established posts list has been developed for the technology-related risks management system of an enterprise, which would allow cutting administrative costs for the functions of risk managers.

### **Keywords**

Industrial Safety, Risk Management, System for Management of Technology-related Risks.

### **Introduction**

The activity of any enterprise always involves certain risks, which are conditioned by ambiguity or incompleteness of source information in taking management decisions, probabilistic nature of the future events, or possible changes in the internal and external environment of the enterprise. At hazardous production facilities the technology-related

risks management is associated with industrial safety, following the occupational safety requirements, emergency prevention and recovery. The hazardous events include industrial accidents, which cause fires, explosions or casualties among the personnel (Goncharenko and Filin, 2007; Nikonov, 2016; Shaptala et al., 2010).

The technology-related risks at performing the production activity of an enterprise mean various unfavorable events, the occurrence of which causes accidents and material, social, economical and other losses. Implementation of a technology-related risks management system at an enterprise implies creating a separate unit for risk management in the sphere of industrial safety, developing the relevant structural decisions, standardized procedures and regulations. This results in carrying out the necessary organizational adjustments at the enterprise and additional financial expenses for providing the effective functioning of the technology-related risks management system.

In the international publications, concerning risk management, the main focus is usually on the processes of an enterprise's risk management (Crouhy and Galai, 2014; Hubbard, 2009; Marks, 2015), as well as on the analysis and quantitative assessment methods of enterprise risks (Coleman, 2011; Vose, 2008; Rees, 2015). But the problem of creating a technology-related risks management system at an enterprise is yet to be solved.

So, developing a set of interrelated structural and process models for a technology-related risks management system, to ensure the industrial safety of an enterprise, is a topical scientific and applied problem.

## **Research Methods**

The collaborative application of the theory of the complex systems, the system approach and the system modeling is the theoretical basis for solution of the formulated problem (Volkova and Denisov, 2017; Mesarovich and Takahara, 1978; Marca and McGowan, 1993; Waxman et al., 2012; Muller, 2018).

For the formalized representation of structural and process models of a technology-related risks management system at an enterprise the basic principles of set theory and graph theory can be used (Bourbaki, 2010; Harary, 1973; Ore, 1965).

For the computer-aided representation of structural and process models of a technology-related risks management system at an enterprise the Orgware software products are recommended, for example, a software package Org-Master, developed by the consulting

company “BIG” in St. Petersburg (Grigoriev, 2010; Kamennova et al., 2002; Odintsov and Romanov, 2012).

### **Building of the Structural and Process Models of the System for Management of Technology-related Risks at the Enterprise**

The system for management of technology-related risks of the enterprise is a separate unit for centralized risk management in the field of industrial safety, in which the risk management process is carried out on the regular basis. For full description of the various aspects of the technology-related risk management system activity of the enterprise, the following structural and process models should be developed:

- Target model  $\{Targ_i\}$  (Why?), which describes composition of objectives of the system for management of technology-related risks;
- Functional model  $\{Fun_i\}$  (What?), which describes composition of functions, required to achieve the objectives of the system for management of technology-related risks;
- Organization structure model  $\{Org_i\}$  (Who?), which describes composition of structural elements, required to perform the functions of the system for management of technology-related risks;
- Process model  $\{Proc_i\}$  (How?), which describes the composition of the processes and sequence of operations for implementation of the functions of the system for management of technology-related risks.

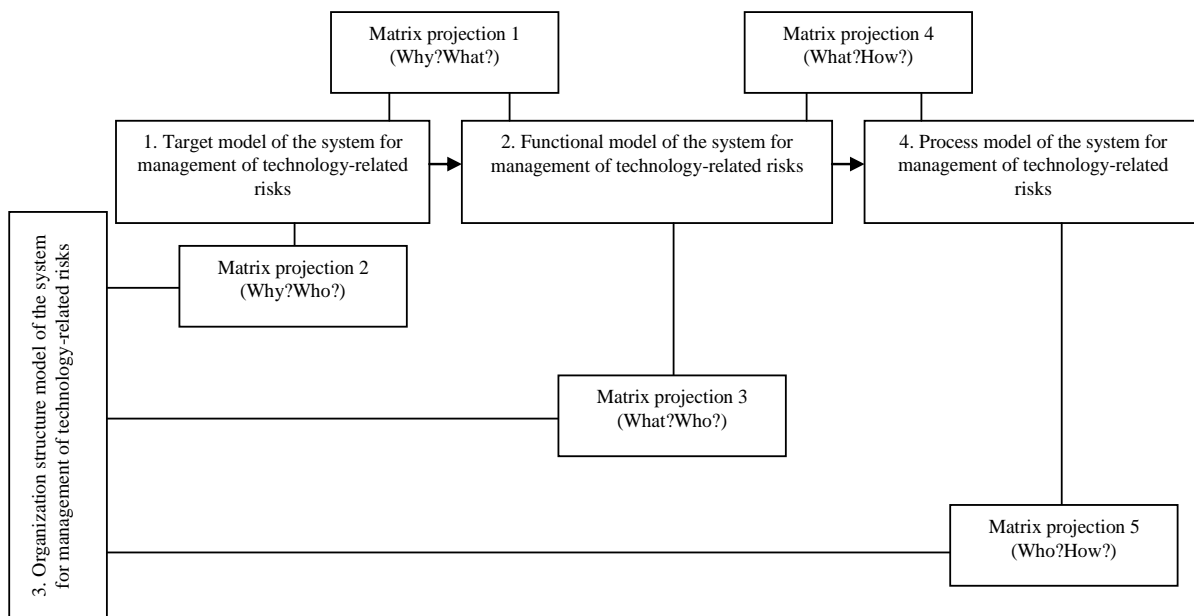
To establish the relationship between the structural and process models of the system for management of technology-related risks at the enterprise, we introduce the following matrix projections:

- Matrix projection between target and functional models  $P(Fun, Targ)$  (Why?What?), which establishes the conformity of functions with the objectives of the system for management of technology-related risks;
- Matrix projection between target model and the model of the organizational structure  $P(Org, Targ)$  (Why?Who?), which establishes responsibility of structural elements for achieving the objectives of the system for management of technology-related risks;
- Matrix projection between the functional model and the model of the organizational structure  $P(Org, Fun)$  (What?Who?), which establishes the responsibility of

structural elements for performance of the system for management of technology-related risks;

- Matrix projection between the functional and process models P(Pr oc, Fun) (What?How?), which establishes compliance of processes with the functions of the system for management of technology-related risks;
- Matrix projection between the model of the organizational structure and process model P(Pr oc, Org) (Who?How?), which establishes the responsibility of structural elements for performance of the processes of the system for management of technology-related risks.

The composition and sequence of building structural and process models and matrix projections between the models of a technology-related risks management system at an enterprise, are presented in Fig. 1.



**Figure 1 The composition of models and matrix projections between the models of a technology-related risks management system at an enterprise**

The structural and process models and the matrix projections between models in a technology-related risks management system of an enterprise have a hierarchical structure. Let us single out the following decomposition levels and determine their relationship degree:

$$\text{Sys} \rightarrow \text{GrEl}(m) \rightarrow \text{El}, \quad (1)$$

where Sys – system; GrEl(m) – group of elements of level system m; El – system element.

For organizing a technology-related risks management system at an enterprise let's consider building a functional model, an organization structure model, and a matrix projection between a functional model and organization structure model.

The well-structured composition of the functions of the system for management of technology-related risks at the enterprise by decomposition levels (1) is given in table 1.

**Table 1 Example of composition of functions of the system for management of technology-related risks at the enterprise**

Function description	Designation
Functions of the system for management of technology-related risks	Fun <sup>Sys</sup>
1. Management functions	Fun <sub>1</sub> <sup>GrEl</sup>
1.1. Organization of functioning of the unit of technology-related risk management	Fun <sub>1</sub> <sup>El</sup>
1.2. Formation of the plan and budget of the unit of technology-related risk management	Fun <sub>2</sub> <sup>El</sup>
1.3. Organization of carrying out of measures in response to technology-related risks	Fun <sub>3</sub> <sup>El</sup>
1.4. Submission of reports of technology-related risk management to the enterprise's management	Fun <sub>4</sub> <sup>El</sup>
2. Basic functions	Fun <sub>2</sub> <sup>GrEl</sup>
2.1. Detection and identification of technology-related risks	Fun <sub>5</sub> <sup>El</sup>
2.2. Analysis and assessment of the level of negative impact of technology-related risks	Fun <sub>6</sub> <sup>El</sup>
2.3. Development of measures in response to technology-related risks	Fun <sub>7</sub> <sup>El</sup>
2.4. Monitoring of occurrence and development of technology-related risks	Fun <sub>8</sub> <sup>El</sup>
2.5. Generalization of the received practical experience on management of technology-related risks	Fun <sub>9</sub> <sup>El</sup>
3. Auxiliary functions	Fun <sub>3</sub> <sup>GrEl</sup>
3.1. Development of corporate methodologies and standard procedures for management of technology-related risks	Fun <sub>10</sub> <sup>El</sup>
3.2. Data base maintenance on the occurred technology-related risks	Fun <sub>11</sub> <sup>El</sup>
3.3. Training of employees of the enterprise for management of technology-related risks	Fun <sub>12</sub> <sup>El</sup>

The well-structured composition of the unit for management of technology-related risks at the enterprise by decomposition levels (1) is given in table 2.

**Table 2 Example of composition of the unit for management of technology-related risks at the enterprise**

Description of structural elements	Designation
Unit of management of technology-related risks	Org <sup>Sys</sup>
1. Group of the unit management	Org <sub>1</sub> <sup>GrEl</sup>
1.1. Head of the unit	Org <sub>1</sub> <sup>El</sup>
1.2. Manager on measures in response to technology-related risks	Org <sub>2</sub> <sup>El</sup>
2. Group of management of technology-related risks	Org <sub>2</sub> <sup>GrEl</sup>
2.1. Expert on detection and monitoring of technology-related risks	Org <sub>3</sub> <sup>El</sup>
2.2. System analyst on analysis and evaluation of technology-related risks	Org <sub>4</sub> <sup>El</sup>
2.3. Developer of corporate procedures and standard procedures on management of technology-related risks	Org <sub>5</sub> <sup>El</sup>

The matrix projection between the functional model and the model of the organizational structure of the system for management of technology-related risks at the enterprise for El decomposition level is given in table 3, where “+” means responsibility of the structural elements for the performance of their functions.

**Table 3 Example of assignment of responsibility of the structural elements for the functions of the system for management of technology-related risks at the enterprise**

	Fun <sub>1</sub> <sup>El</sup>	Fun <sub>2</sub> <sup>El</sup>	Fun <sub>3</sub> <sup>El</sup>	Fun <sub>4</sub> <sup>El</sup>	Fun <sub>5</sub> <sup>El</sup>	Fun <sub>6</sub> <sup>El</sup>	Fun <sub>7</sub> <sup>El</sup>	Fun <sub>8</sub> <sup>El</sup>	Fun <sub>9</sub> <sup>El</sup>	Fun <sub>10</sub> <sup>El</sup>	Fun <sub>11</sub> <sup>El</sup>	Fun <sub>12</sub> <sup>El</sup>
Org <sub>1</sub> <sup>El</sup>	+	+		+								
Org <sub>2</sub> <sup>El</sup>			+				+					
Org <sub>3</sub> <sup>El</sup>					+			+			+	
Org <sub>4</sub> <sup>El</sup>						+			+			
Org <sub>5</sub> <sup>El</sup>										+		+

Let us write matrix projection between the functional model and the model of the organizational structure of the system for management of technology-related risks at the enterprise for El decomposition level (see Table 3), where on i-m rows of matrix the list of structural elements is given, and on j-m columns of matrix – functions in the form as follows

$$P(\text{Org}^{\text{El}}, \text{Fun}^{\text{El}}) = \begin{pmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \end{pmatrix} \quad (2)$$

By means of the suggested structural and process models and matrix projections between them, we can form a set of the required organizational-administrative documentation, that is, regulations for the technology-related risks management unit, its rules and job descriptions.

### **Directions of Organizational Analysis of a Technology-related Risks Management System at an Enterprise**

The structure of an enterprise should correspond to the strategy of ensuring the industrial safety. For this purpose it is necessary to perform the organizational analysis of the technology-related risks management system at an enterprise, on the basis of which the shortcomings of an existing industrial risks management department can be identified and the relevant decisions in organizational adjustments can be developed.

By means of a matrix projection between a functional model and organization structure model we can perform the organizational analysis of the technology-related risks management system of an enterprise in the following areas:

- Checking the completeness of the unit's structural elements, necessary for performing the system's functions;
- identifying the superfluous structural elements of the unit, which don't participate in performing any of the system's functions;
- excluding the duplication of the unit's structural elements' responsibility in performing the system's functions;
- determining the superfluous functional workload of the unit's structural elements.

According to the results of the carried-out organizational analysis of the technology-related risks management system of an enterprise the following decisions in organizational adjustments can be suggested.

1. Identifying the superfluous structural elements of a technology-related risks management unit that don't participate in performing any of the system's functions.

For each  $i$ -th row of matrix  $P(\text{Org}^{\text{El}}, \text{Fun}^{\text{El}})$  we check the condition:

$$\sum_{j=1}^m \rho_{ij} = 0, \quad (3)$$

where in the  $i$ -th rows of matrix  $P(\text{Org}^{\text{El}}, \text{Fun}^{\text{El}})$  the structural elements of a unit are denoted, and in the  $j$ -th columns – the functions of the system;

$\rho_{ij} = 1$  or  $\rho_{ij} = 0$  for presence or absence of link in the matrix projection;

$m$  – number of system's functions.

If a certain structural element doesn't participate in a certain system's function, i.e. the condition (3) is true, this element should be removed from the unit's structure.

2. Checking the completeness of the technology-related risks management unit's structural elements, necessary for performing the system's functions.

For each  $j$ -th column of matrix  $P(\text{Org}^{\text{El}}, \text{Fun}^{\text{El}})$  we check the condition:

$$\sum_{i=1}^n \rho_{ij} = 0, \quad (4)$$

where in the  $i$ -th rows of matrix  $P(\text{Org}^{\text{El}}, \text{Fun}^{\text{El}})$  the structural elements of a unit are denoted, and in the  $j$ -th columns – the functions of the system;

$\rho_{ij} = 1$  or  $\rho_{ij} = 0$  for presence or absence of link in the matrix projection;

$n$  – number of structural elements in a unit.

If nobody is responsible for performing a certain function, the condition (4) is true, and the necessary structural elements should be added to the staff composition of the unit.

3. Determining the superfluous functional workload of the technology-related risks management unit's structural elements.

For each  $i$ -th row of matrix  $P(\text{Org}^{\text{El}}, \text{Fun}^{\text{El}})$  we check the condition:

$$\sum_{j=1}^m \rho_{ij} > \text{Fun}_{\max}, \quad (5)$$



where in the  $i$ -th rows of matrix  $P(\text{Org}^{\text{El}}, \text{Fun}^{\text{El}})$  the structural elements of a unit are denoted, and in the  $j$ -th columns – the functions of the system;

$\rho_{ij} = 1$  or  $\rho_{ij} = 0$  for presence or absence of link in the matrix projection;

$\text{Fun}_{\text{max}}$  – maximum possible number of functions, assigned to one structural element, allowed at this enterprise;

$m$  – number of system's functions.

If a certain structural element participates in performing several functions over the permissible quantity, the condition (5) is true, and the possibility of reassigning part of functions to other structural elements of the unit should be considered.

4. Excluding the duplication of the technology-related risks management unit's structural elements' responsibility in performing the system's functions.

For each  $j$ -th column of matrix  $P(\text{Org}^{\text{El}}, \text{Fun}^{\text{El}})$  we check the condition:

$$\sum_{i=1}^n \rho_{ij} > \text{Org}_{\text{max}}, \quad (6)$$

where in the  $i$ -th rows of matrix  $P(\text{Org}^{\text{El}}, \text{Fun}^{\text{El}})$  the structural elements of a unit are denoted, and in the  $j$ -th columns – the functions of the system;

$\rho_{ij} = 1$  or  $\rho_{ij} = 0$  for presence or absence of link in the matrix projection;

$\text{Org}_{\text{max}}$  – maximum possible number of structural elements, participating in performing one function, allowed at this enterprise;

$n$  – number of structural elements in a unit.

If several structural elements of the unit over the permissible quantity participate in performing a certain function, the condition (6) is true, then their responsibility should be defined more accurately, and the relevant adjustments in assigning functions should be made if necessary.

So, by means of organizational analysis of the technology-related risks management system at an enterprise we can determine:

- Compliance of the technology-related risks management unit structure with the required purposes in the sphere of industrial safety;
- Functional workload and responsibility of the technology-related risks management unit's structural elements;
- Necessary organizational adjustments for the further improvement of the technology-related risks management unit's activity.

### **Determining the Number of Personnel for the Technology-related risks Management System of an Enterprise**

Normally a standard technology-related risks management unit of an enterprise implies one employee for each established post (see Tab. 2), responsible for performing the assigned functions (see Tab. 1 and 3). With the increase of the enterprise's scale of activity, or setting new hazardous production facilities into operation, the analysis of the possibility of proper functioning of the existing established posts list of the technology-related risks management system should be carried out and the necessary number of the additionally involved employees for performing the assigned functions should be determined.

To determine the necessary number of employees in accordance with the established posts list for industrial safety risk management, the built structural and process models and matrix projections between models in a technology-related risks management system of an enterprise can be used. Then the calculation sequence of employees according to the established posts list of the technology-related risks management system includes the following stages.

1. Preparing the input data, necessary for calculations.

At performing this stage the following actions are required:

- To describe the existing industrial risks management process at the enterprise;
  - To build structural and process models and matrix projections between the models of the technology-related risks management system at the enterprise;
  - To determine the workload of performing the technology-related risks management system's functions for this enterprise;
  - To identify the effective working time fund of one employee for a certain period (month, quarter, year).
2. Calculating the required number of employees for the technology-related risks management system of an enterprise.

At performing this stage the number of employees for each  $i$ -th established post of the technology-related risks management system of an enterprise is calculated with upward rounding in the following way:

$$N_i = \frac{\sum_{j=1}^m \sum_{k=1}^n \rho_{ijk} \cdot t_j}{F_p}, \quad (7)$$

where:  $t_j$  - workload of performing  $j$ -th function, m/hr;

$\rho_{ij} = 1$ , if performing the  $j$ -th function is assigned to an employee of the  $i$ -th established post;

$\rho_{ij} = 0$ , if performing the  $j$ -th function is not assigned to an employee of the  $i$ -th established post;

$F_p$  - the effective working time fund of one employee for a certain period (month, quarter, year), h.

3. Developing recommendations in adjusting the number of employees for the technology-related risks management system of an enterprise.

At performing this stage the following organizational solutions are possible:

- Adding on the basis of calculations by formula (7) more employees of an enterprise to the list of established posts of the technology-related risks management system;
- Leveling the workload and reallocation of responsibility for performing functions among the employees of established posts of the technology-related risks management system;
- Adjusting the plans of the technology-related risks management system functioning, if increasing the number of employees of the established posts is not possible.

So, by means of calculating the number of employees for the established posts list of the technology-related risks management system of an enterprise, the efficient risk management in the sphere of industrial safety can be organized, and the administrative costs for the functions of risk managers can be reduced.

## **Conclusion**

The main purpose of creating a technology-related risks management system at an enterprise is ensuring the integrated safety and improving the efficiency of the enterprise's activity, as well as providing the timely response to possible technology-related risks with minimum costs.

On the basis of applying system approach and system modeling the structural and process models were built, as well as matrix projections between models, for the technology-related risks management system, by means of which the existing industrial safety risk management process of an enterprise can be described and a set of required organizational-administrative documentation can be formed.

The main directions of organizational analysis of the technology-related risks management system at an enterprise were suggested, which allowed determining the functional workload and responsibility of the technology-related risks management unit's structural elements, and recommending the necessary organizational adjustments for the further improvement of the unit's activity.

The calculation procedure of employees in accordance with the established posts list for the technology-related risks management system of an enterprise was developed, which would allow efficiently using the industrial safety risk management personnel and cutting administrative costs for the functions of risk managers.

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