



UDC 656.56/625.7

A FUNCTIONAL MODEL OF THE INFORMATION TECHNOLOGY FOR MANAGEMENT OF NATURAL EMERGENCY SITUATIONS ON TRUNK ROADS

N. Fil', Ph.D. (Engineering), Associate Professor¹

¹Kharkiv National Automobile and Highway University, Kharkiv

¹E-mail: fil_nu@i.ua

¹ORCID 0000-0003-2081-7176

Copyright © 2014 by author and the journal "Automation technological and business - processes".

This work is licensed under the Creative Commons Attribution International License (CC BY).

<http://creativecommons.org/licenses/by/4.0/>



DOI: 10.15673/

Abstract

A functional model of the information technology for management of natural emergency situations on trunk roads has been developed on the basis of the IDEF0 notation. The functional model of the information technology for management of natural emergency situations reflects the causal relationships between objects and operations.

Keywords

Methodology, modeling, decomposition, processes, management, operations, trunk road

Introduction

About ten natural emergency situations (NES) occur in Ukraine every year. They are landslides, avalanches, floods, glaze, etc. Therefore, the Decree of the President of Ukraine (№ 80 from 09.10.01) and the Order of the Cabinet of Ministers (№ 215 from 07.03.01), the main purpose of which is to create a government information and analytical system for prevention and liquidation of emergency situations to protect population and territories from NES [1-3], were adopted in Ukraine.

Such a system should provide for the use of the latest scientific achievements both in the sphere of ensuring health and safety of the society and in the sectors of telecommunications and software development [2].

By management of NES we mean a process of constant purposeful activity on implementation of the best possible measures to reduce risks of NES to a level that the society considers acceptable in view of the existing constraints on resources and time. In a general case the process can be divided into three stages: the monitoring of NES, prevention of NES and liquidation of consequences of NES [2].

The enormous complexity and dimension of such tasks, a large number of contradictory functional and economic criteria and restrictions along with uncertain and incomplete initial information have led to the fact that the existing information technologies do not allow to quickly make scientifically based and effective decisions on management of NES on trunk roads (TR) [2, 3].

Analysis of publications

The lack of information about the nature of NES can cause a situation with disastrous consequences. Under these conditions there become urgent the task of evaluating sources of NES on TR and the state of TR, analyzing and forecasting NES development, choosing necessary means and volumes of resources of technical, human and information support, optimal allocation of resources, which are involved in the prevention and elimination of NES on TR [2].

Studies and publications of many scientists and specialists are devoted to issues of management and building information systems for decision-making support under conditions of emergency situations (ES). So a mathematical model of propagation of external negative impacts across the structure of a complex system was built and described in [3].

The probabilistic and deterministic model is based on formalization of the system structure presented as a directed graph and propagation of external negative impacts on the system presented by impulse forces.



The information and software support for ecological monitoring is analyzed in [4]. The considered information support of the ecological monitoring system should comprise: ordered information flows (input, internal, output); infrastructure of the information database itself; methods of data collection from fixed and mobile stations; techniques of transmitting the data received from the stations of different levels; methods of data processing and calculation of integral indicators of the OS state; methods for determining sources of emissions; structure of user network organizations and operational services.

The methodology of systemic research of complex dynamic systems and management in the context of uncertainty, which is characteristic for NES on TR, requires the provision of decision-making support with regard to the regional aspect [6].

Presently there is no information technology, which could enable solving a complex task of monitoring sources of NES on TR, TR themselves, evaluating, analyzing and forecasting the development of consequences of NES on TR and choosing effective plans for liquidation of NES on TR as well as scheduling their implementation.

Under current conditions it is not possible to manage the plans and programs in the old manner as it is unreal to use the abovementioned methods of neutralizing risks in the context of the deficit of financial resources. The financial reserves for the plans implementation are being sharply reduced. It is not also reasonable to account on neutralizing risks by taking a credit. The prices of contractors, as it usually happens under crisis conditions, are growing and currency fluctuations make the situation uncertain. The schedule control has gained a more problematic nature than ever before. It has become difficult to observe the schedule because the contractors encounter the crisis influence as well [5].

For describing the processes within the technology for management of NES on TR, the methodology of functional modeling IDEF0 is of the greatest interest. The SADT (IDEF0) methodology is intended for the functional modeling, i.e., simulating the implementation of the object functions by means of creating a descriptive graphical model showing what operations are performed within the functioning of any organization, how and by whom. The developed IDEF0 models involve documenting the processes of management of NES on TR reflecting what information and resources are used at each stage of management of NES on TR. Application of functional modeling enables solving not only technical problems of customers associated with information technologies but those related to the sphere of their activities. It is recommended to use SADT at early stages of the life cycle of developing automated information systems: for a deeper and comprehensive understanding of the information system for management of NES on TR before its implementation. SADT allows reducing costly mistakes at early stages of creating the information system for management of NES on TR, improve the contact between users and developers, smooth the transition from analysis to designing. Therefore, developing the functional model of the information technology for management of NES on TR can neutralize the effect of unpredictability. It is possible to obtain a quite accurate forecast on the budget and schedule of the plan for the chosen risk level even at the early stage of its implementation. It allows evaluating in advance the chances to eliminate the risk and the time reserve for taking certain measures if the problems are obvious. The most important element for a successful management of NES on TR is predictability even in the context of uncertainty of all the plan parameters under crisis conditions.

Application of IDEF standards is the actual condition for obtaining by the organization the status of the one complying with ISO 9000, ISO 9001 requirements. In the recent years the interest to methodologies of the IDEF family has been continuously growing. The orientation to international standards contributes to the Ukrainian enterprises' entering the global information space.

Thus, modeling the processes of management of NES on TR by means of information technologies will provide for achieving main parameters of management of NES on TR with a preset probability [1, 2].

Setting the aim and objectives of the research

The aim of the work is to develop a functional model of the information technology for management of NES on TR and determine the expediency of SADT using. The object of the research is the information technology for management of NES on TR, the subject of the research is functional tasks and processes of management of NES on TR.

To solve the set objectives it is necessary to analyze tasks of management of NES on TR; develop elements of the information technology for management of NES on TR; elaborate a functional model of the information technology for management of NES on TR in the form of an IDEF0 diagram, carry out its decomposition.

The functional model of the information technology for management of NES on TR

BPwin is a powerful tool for modeling and documenting business processes. This product uses the modeling technology of IDEF0 (Integration Definition for Function Modeling) — the most common standard accepted for business process modeling [7, 8].

IDEF0 diagrams are clear and simple for understanding and at the same time they formalize the idea of simulated processes helping to easily find a common language between the developer and the future user of the application [9, 10].

Let us analyze the structure of the information technology for management of NES on TR. As is known the information technology is a combination of methods, hardware and software for information transformation [10, 11].

The elements of the information technology are presented in Table 1 according to the scheme: the considered operations on transformation of information (function) on the basis of theoretical principles; data or material objects transformed by the considered functions into input elements; data or material objects produced by functions (output elements); tooling used for implementation of the functions (elements of the mechanism); data used for controlling the process of implementation of the functions (control elements).

The structure of the information technology for management of NES on TR consists of the following parts: surveying



NES sources and sections of TR; choosing the goal and its decomposition into sub-goals; the application and updating of information and reference support; making decisions on management of NES on TR; implementing the accepted project; evaluating the results of management of NES on TR. It should be mentioned that Points 3 and 4 (Table 1) are divided into sub-points.

The general functional model of the information technology is presented in Figure 1 in the form of a diagram. To represent the participants of management of NES on TR, the ability of BPwin to switch at any branch of the model to the notation IDEF3 or DFD and create a mixed model is used. Let us describe main stages of implementing the developed information system.

Stage 1. The studying of sources of NES and TR sections at this stage is conducted to determine danger coefficients of NES sources and technical and operational parameters of TR sections. For this purpose it is necessary, first of all, to carry out the analysis of meteorological conditions for the past period or at the current moment based on the data of the electronic cadastre of sources of NES on TR. The results of surveying the sources of NES and TR sections are input parameters for Stage 2.

Table 1. The elements of the information technology for management of NES on TR

№	Function	Input elements	Output elements	Elements of the mechanism	Control elements
1	Surveying NES sources and sections of TR	The electronic cadastre of NES sources. Technical and operational parameters of sections of TR. Meteorological forecasts	Results of surveying NES sources and sections of TR	Experts, decision-makers. The staff of units of Ministry for Emergency Situations and Ukravtodor (the governing body of automobile roads). Material and technical support of units of MES and Ukravtodor	The Constitution of Ukraine, Decrees of the President, Orders of the Cabinet of Ministers of Ukraine. Normative and technical documentation
2	Choosing the goal and its decomposition into sub-goals	Results of surveying NES sources and sections of TR. Reports on management of NES on TR	Technical specifications for management of NES on TR	Experts, decision-makers. The staff of units of MES and Ukravtodor.	Normative and technical documentation. National and international standards.
3	The application and updating of the information and reference support	Technical specifications for management of NES on TR. Reports on management of NES on TR.	Information and reference support	Experts, decision-makers	Specialized software packages. Normative and technical documentation. National and international standards.
4	Making decisions on management of NES on TR	Technical specifications for management of NES on TR.	The project on management of NES on TR	Experts, decision-makers. The staff of units of MES and Ukravtodor.	Decision-making methods Specialized software packages. Information and reference support



5	Implementing the accepted project	The project on management of NES on TR.	The report on implementation of the accepted project	The staff of units of MES and Ukravtodor. Material and technical support of units of MES and Ukravtodor	Information and reference support
6	Evaluating the results of management of NES on TR	The report on implementation of the accepted project	Reducing the expenditures of material and labor resources at management of NES on TR. Reducing the time for liquidation of NES consequences on TR.	Experts, decision-makers. The staff of units of MES and Ukravtodor	National and international standards. Information and reference support

Stage 2. Choosing the goal and its decomposition into sub-goals are substantiated. Technical specifications for management of NES on TR, which present the result of this stage, are determined depending on the situation.

Stage 3. Management of NES on TR is considered as an information process, i.e., functionally including the receiving, transmission, processing (transformation), storage and use of information and the hierarchy system of management of NES on TR – as an information system.

Figure 2 demonstrates the point of “The application and updating the information and reference support (IRS) for management of NES on TR” in the DFD notation.

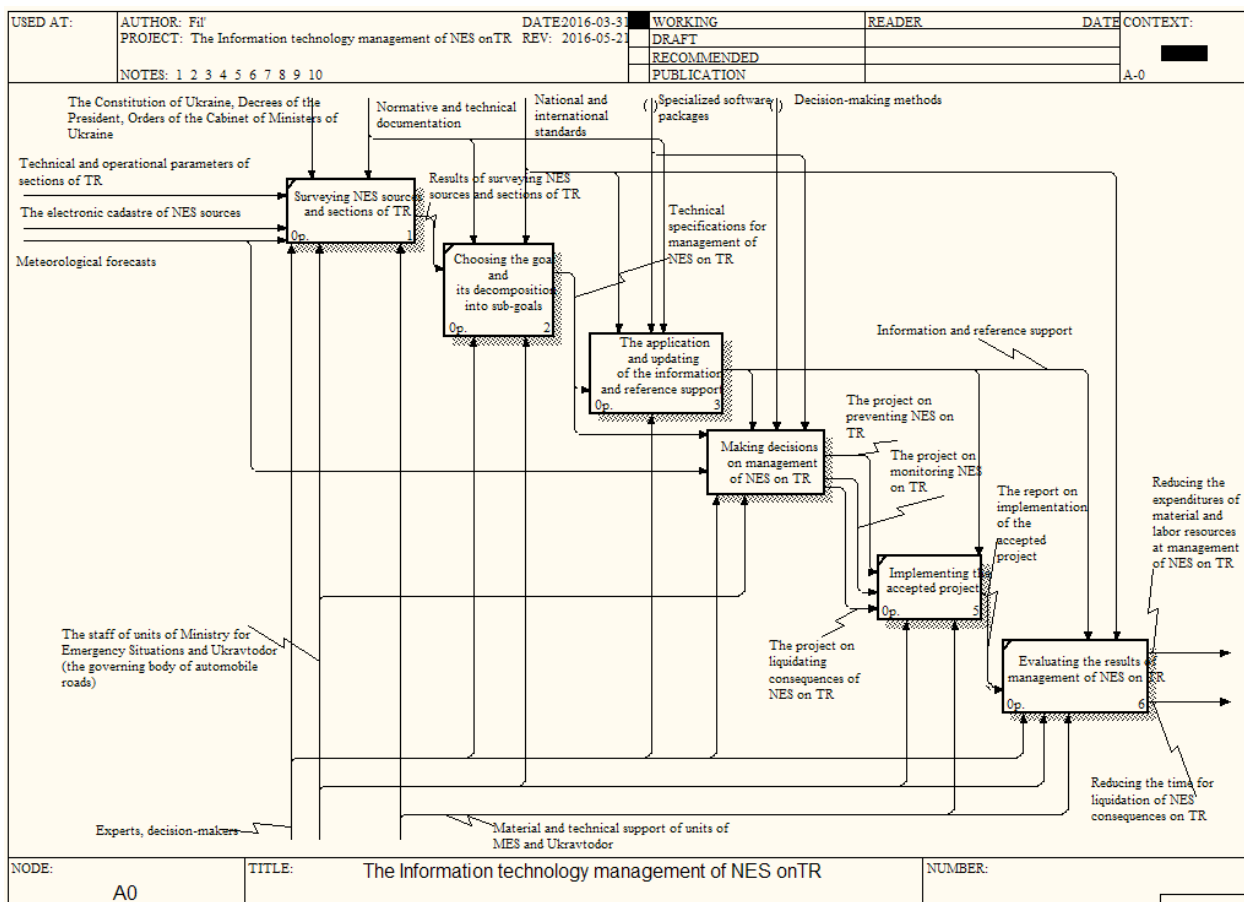


Fig. 1 – The functional model of the information technology for management of NES on TR.



The information and reference support (IRS) for management of NES on TR is a combination of the implemented decisions on the volume, placement and forms of organization of the information circulating in the management system at its functioning. It includes data bases (DB) of operational information, normative and reference information (NRI) and procedure information (PI). The DB of the operation information (DBOI) contains the information about a certain object and is stored during all the period of its management. The DB of normative and reference information contains the largest volume of information.

Stage 4. Making decisions on management of NES on TR with regard to a certain purpose and set granularity of the model. For this purpose the information obtained at Stages 1-3 is used. The result of the stage implementation is the structural model of “Making decisions on management of NES on TR” (Fig. 3).

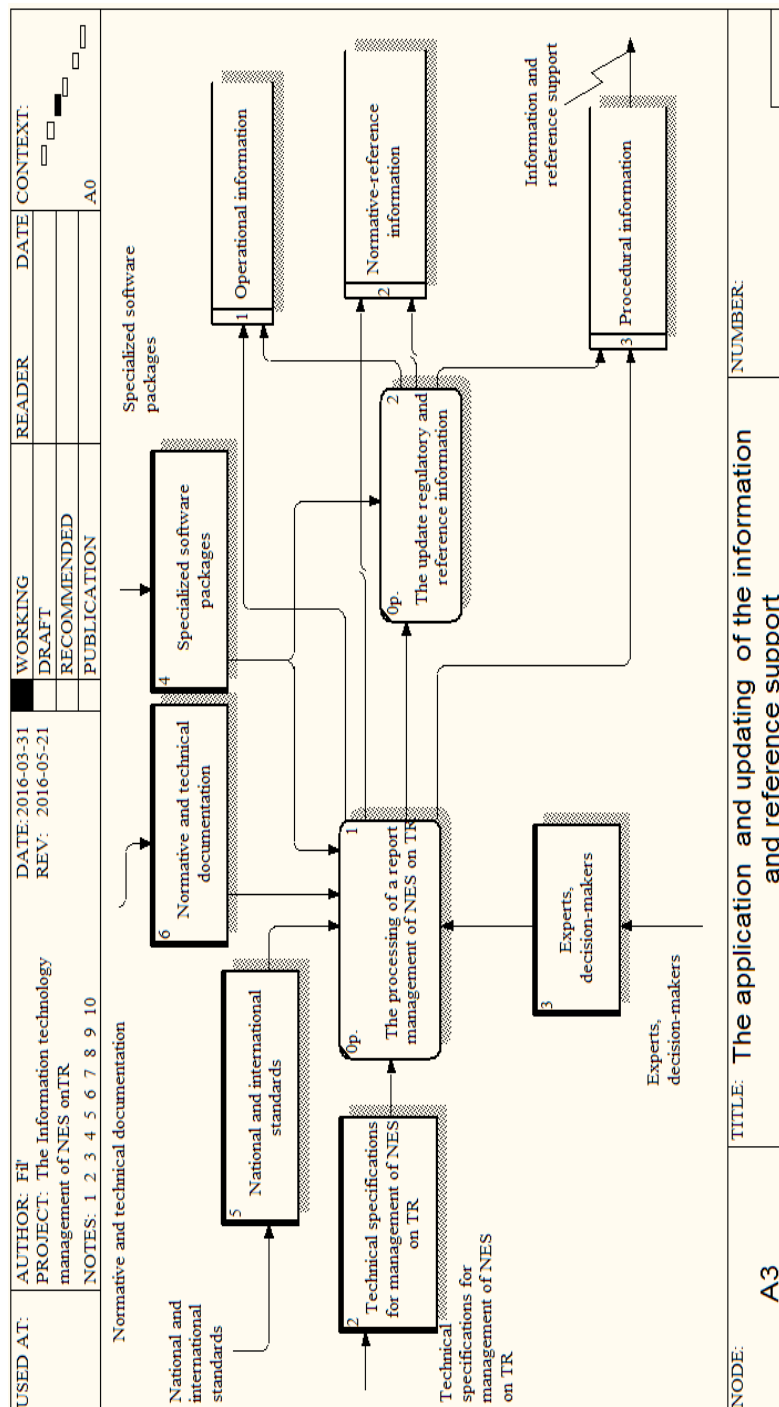


Fig. 2 – The functional model of the stage “The application and updating of the information and reference support” (Stage 3)

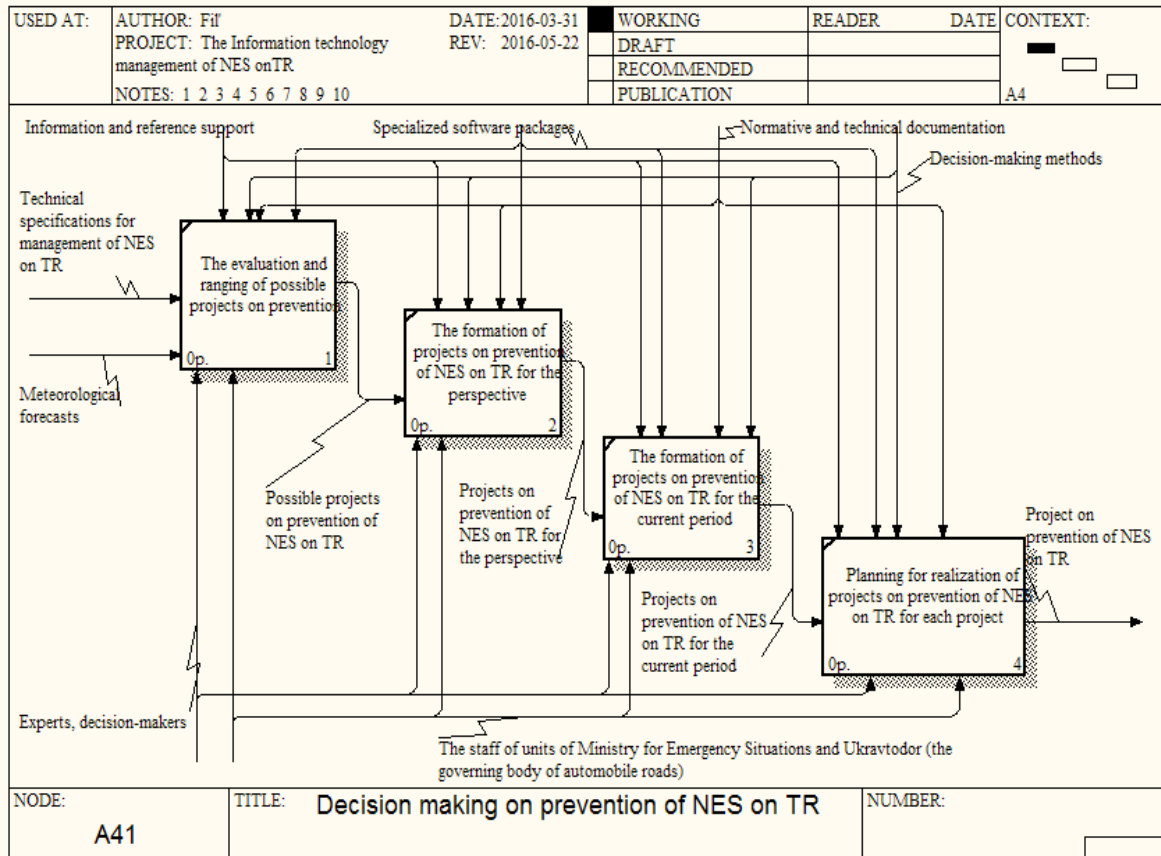


Fig. 4 – The functional model of the stage “Preventing NES on TR” (Stage 4.1)

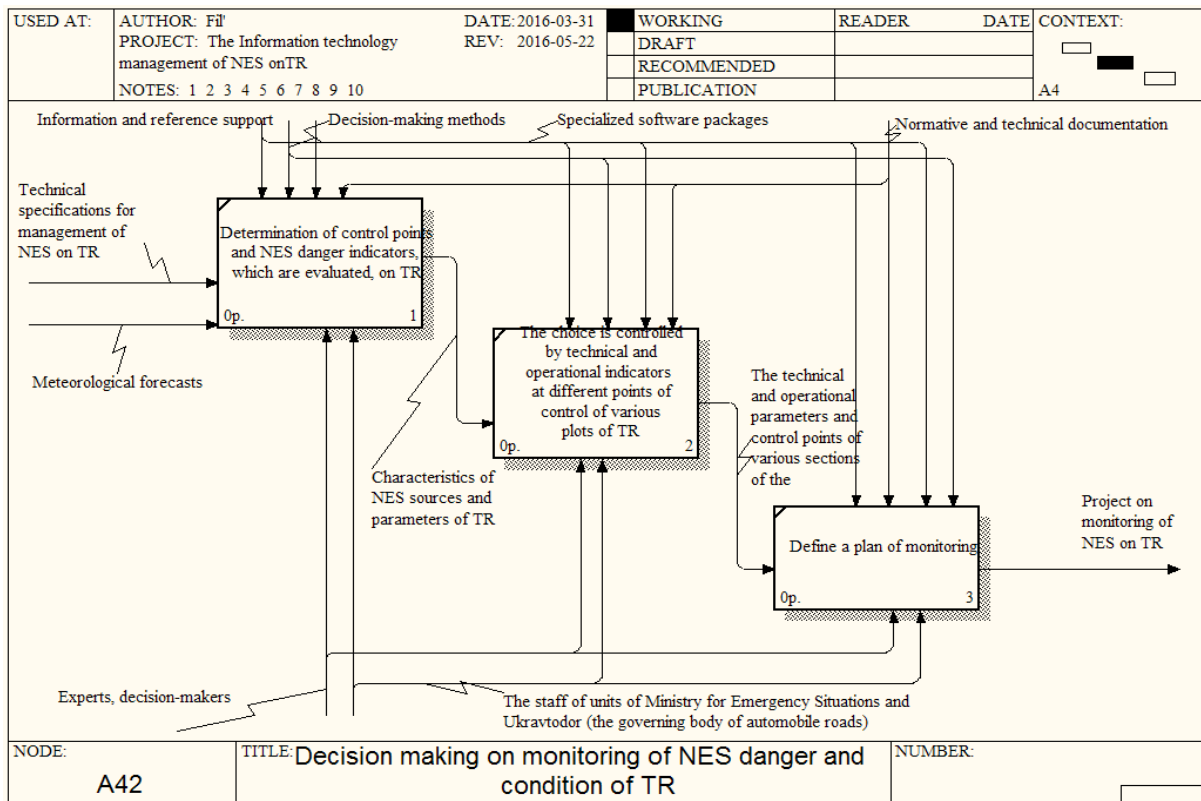


Fig. 5 – The functional model of the stage “The monitoring of NES on TR” (Stage 4.2)

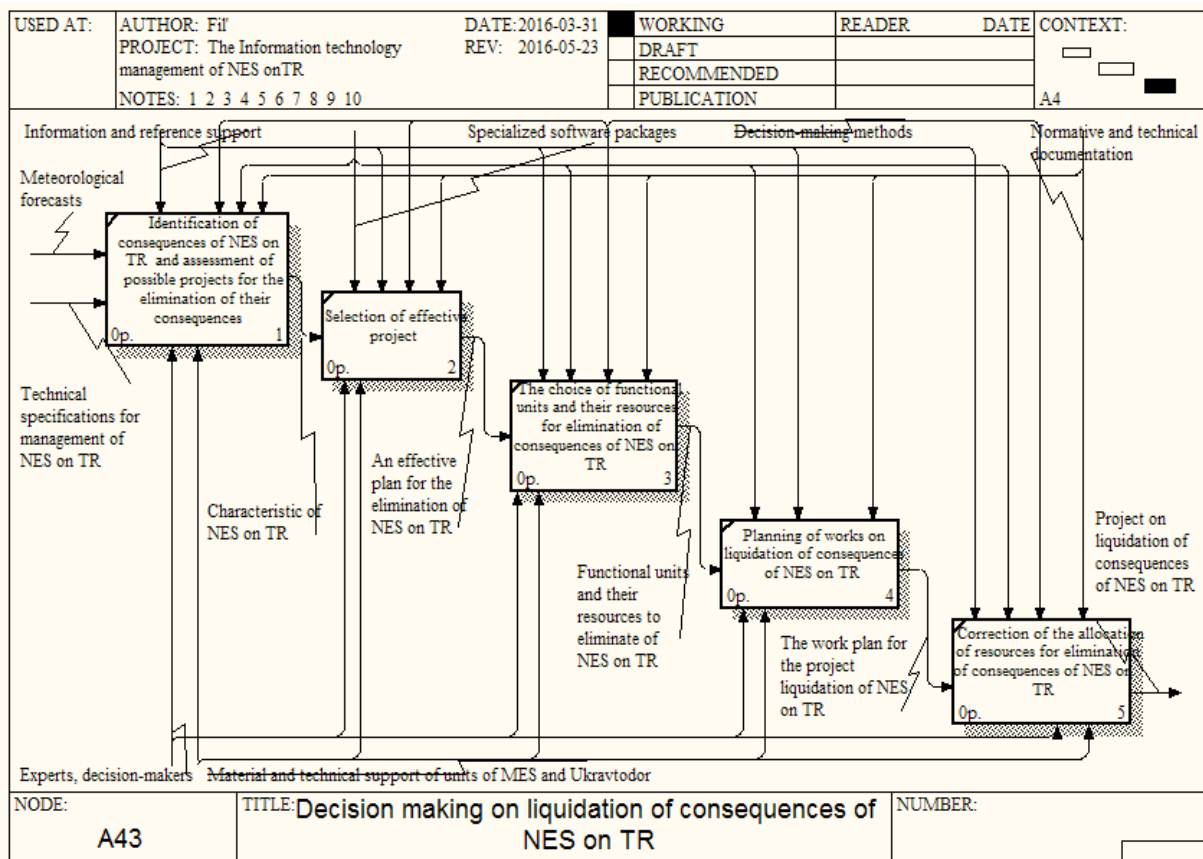


Fig. 6 – The functional model of the stage “Liquidation of consequences of NES on TR” (Stage 4.3)

Stage 5. The decision made is realized at this stage. The result of this stage is the report about the implemented project of management of NES on TR.

Stage 6. Analysis of the results on the basis of the report, in particular, formation of conclusions concerning the goal of management of NES on TR is carried out at this stage.

The result of the realization of the given stage is either a conclusion about achieving the set goal or development of recommendations on revision of decisions on the basis of the evaluation results.

Conclusions

The analysis of the problem of developing an information technology for management of NES on TR as a complex technical semi-structured system based on the IDEF0 notation has been conducted.

The functional model of the information technology for management of NES on TR, which enabled describing the simulated system from several standpoints regardless of its temporal characteristics, has been developed in the article.

The building of the functional model of the information technology for management of NES on TR allows for an effective formalizing of properties and characteristics of the studied object in terms of its semi-elements and subsystems, which provides completeness of the description required for analysis of the object and synthesis of the management system.

References

- [1] Natsionalna dopovid pro stan tekhnohennoi ta pryrodnoi bezpeky v Ukraini u 2014 rotsi [Electronic resource] / Mode of access: http://www.mns.gov.ua/content/annual_report_2014.html
- [2] Nefedov, L. I., Fil', N. Yu., Gubin, Yu. L., Mel'nichenko Ye. M. (2011). Modeli i metody upravleniya chrezvychnymi situatsiyami na magistral'nykh avtomobil'nykh dorogach. KhNADU, 136.
- [3] Drobnohod, N. I. (2001). Ustoychivoye ekologicheskii bezopasnoye razvitiye: ukrainskiy kontekst. Zerkalo nedeli, 21, 15.
- [4] Matveev A.V., Kotov V.P., Mushkudiani M.I. (2005) Primenenie informatsionnykh tekhnologiy v upravlenii sredoy obitaniya: Ucheb. posobie: SPb.: GUAP,. 96.
- [5] Krysin, S. P., Sarychev, D. S., Skvortsov, A. V. (2005). Otsenka bezopasnosti dvizheniya s ispolzovaniyem informacionnoy sistemy IndorInfo. Nauka i tehnika v dorojnoy otrasli, 1, 29–30.



- [6] Leonovich, I. I., Kashevskaya, E. V. (2006). Osobennosti processnogo upravleniya kachestvom avtomobilnyh dorog. Nauka i tehnika v dorojnoy otrasli, 1, 8–11.
- [7] Dubeykovsky, V. I. (2009). Effektivnoye modelirovanie s ERwin® Process Modeler (BPwin; Allfusion Process Modeler). M.: Dialog-Mifi, 384.
- [8] Bick, C., Dynamical Origin of the Effective Storage Capacity in the Brain’s Working Memory / C. Bick, M. I. Rabinovich // Physical Review Letters. - 2009. - Vol. 103 (21). - P. 218101
- [9] National Institute of Standards and Technology. Integration Definition For Function Modeling (IDEF0). - Washington : Draft Federal Information, 1993. - 116 p.
- [10] Tomashevsky, O. M., Tsigelik, G. G., Viter. M. B., Duduk, V. I. (2012). Informaciyni tehnologiyi ta modelyuvannya bizness-processiv: navch. posib. K.: Centr uchbovoy literatury, 296.
- [11] Fil’ N. Modelling management processes under natural emergency conditions on highways (2015) Technology audit and production reserves, №3/2(23), 57-60.

Received by edition: 28.04.2016. Approved for the press: 15.06.2016

 QUOTE OF ISSUE

„It is necessary to be engaged in what you treat with enthusiasm. Otherwise you will never have forces to finish business.”

Steve Jobs