The Emergency Management: Decision Support Systems And The Role Of Poorly Formalized Information[1]

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Abstract

The significance of the emergency management has been increasing owing to several factors - societal processes have been becoming more complex with large degree of uncertainty in the causes of their origin and methods of resolution. In technological sphere operating conditions are becoming more severe, volume of energy stored in the equipment is generally increasing, management and control systems are more taxing and industrial plants growing in size (in general by a factor of 10). The result - an increase of the total number of emergency situations of various kind, major industrial including.

Experience has shown that it is meaningless to look for a single cause of major emergency situations, though for mostly legal considerations a "prime" and direct causes are usually identified, leaving indirect causes, largely of social character (e.g. "human factors") ignored,

A latest method for taking optimal decisions in emergencies has been the employment of the Decision support systems (DSS). An obstacle to their wide use has been a significant volume of poorly formalized information to be accumulated in the DSS.

A good case study of this difficulty could be supplied by the problem of the decision-making connected with the rational choice of personal for responsible positions in the industrial and economic spheres. A significant number of major industrial accidents should be directly connected with wrong decisions of unqualified managers and operating personnel.

This could be partly explained by the actual absence of any guidance or manuals describing the "correct" methods of the assessment and choice of the appropriate candidates for responsible positions both in the industry and economy. Practically, no criteria exist that could help to define "optimal" managers' or operators' performances.

The main reason of this situation should be explained by the fact that the information connected with these problems should be described as extremely difficult for classification, formalization and possibilities to accumulate in the information systems, including DSS.

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Introduction

A latest method for taking optimal decisions in emergencies has been the employment of the Decision support systems (DSS). An obstacle to their wide use has been a significant volume of poorly formalized information to be accumulated in the DSS. A good case study of this difficulty could be supplied by the problem of the decision-making connected with the rational choice of personal for responsible positions in the industrial and economic spheres. A significant number of major industrial accidents should be directly connected with wrong decisions of unqualified managers and operating personnel. This could be partly explained by the actual absence of any guidance or manuals describing the "correct" methods of the assessment and choice of the appropriate candidates for responsible positions both in the industry and economy. Practically, no criteria exist that could help to define "optimal" managers' or operators performances. The main reason of this situation should be explained by the fact that the information connected with these problems should be described as extremely difficult for classification, formalization and possibilities to accumulate in the information systems, including DSS [1]. Therefore, the most pressing task is the search for instruments and methods to assure the possibilities for the formalization of these types of information. The complication of the technological, social (in particular, economic and demographic), ecological and other processes, characteristic of the modern period in the development of the human society, inevitably dictates the research of the methods to optimize the processes connected with the decision making, practically in all the spheres of human activities. This is true when important various and diverse managerial decisions, often of radical character, are needed.

One of the decisive problems for the solution of this most important scientific and applied task has become the modernization, in particular the computerization of the informational "support" of the decision making processes. Massive automation of the collection, accumulation and processing of the needed information has become now a necessary precondition of the scientifically based responsible and complicated decisions. This refers practically to all aspects of the interactions inside the human society, as well as to interrelations with the environment. The employment of the specialized information systems, in conjunction with the computerized processing of the information more often than not is becoming the only method of the solution of the most complicated theoretical and applied problem which the civilization faces nowadays. It should be stressed that this tendency has been constantly acquiring momentum. An increasing number of the important, especially social, economic and technological processes (owing to their complexity) require for the analysis and search of the optimal decisions the employment of such information systems which are capable to process extremely large volumes of information with great speed. But this is possible to attain only in conditions if high computerization of the activities connected with processing of the information. The effective processing of rapidly increasing volumes of the most diverse and complicating information and the choice of the variants of the decisions most suited for the given conditions (that is optimal) among all possible ones could be realized only by the use of the advanced types of computers.

Computerization of the informational support of the decision making processes and the deployment of the decision support systems (DSS) has become now a specific feature not only of the management practice in the technological sphere with its propensity for innovative, rapid and radical changes, but of the whole array of the environmental systems as well. The current period in the evolution of the civilization has also been characterized by the more often (in comparison with other periods) appearance of various extreme situations (in the everyday parlance usually called "crises"), that is situations which are beyond the limits of the accumulated experience. They usually

demand extraordinary measures for their prevention or the elimination of them or their consequences. Such situations often transform into dangerous deviations of the normal processes, becoming the obstacles for the evolution of the society and environment as well. It should be noted that the emergency situations in the society and in its interactions with the environment in the overwhelming majority of cases are the result (direct or otherwise) of not taking necessary - and what is important, timely organizational, managerial, social or political decisions. If especially to take into consideration that the advance of dangerous tendencies express themselves often long before their real transformations into real emergencies. One of the main specific features of such "crises" situation has been the necessity to take decisions in the rigidly limited time frames. Often for the appropriate preventive or defensive measures if not hours, then only days are left.

Optimization of the social or environmental management and the avoidance of "tensions" in the society or the environment, which precede the emergency situations, or in other words, the deviations from normal functioning of any complex systems, require, as a rule, of extraordinary and responsible decisions. The experience demonstrates that to correct unreasonable, or moreover erroneous decisions very often either impossible or requiring unreasonably high material or intellectual expenses. The development of the optimization methods of the decision making processes for the emergency situations in par with the necessity to modernize information support procedures requires also the employment of a whole array of the technological means, which could assure necessary speed of the information processing and its effectiveness. Only in close conjunction all these methods could assure the creation of the necessary conditions for the choice of optimal variants of the solutions of the complicated societal, technological, environmental and other appropriate problems.

The optimization of the informational support of the decisions and issues connected with them

Substantial complexities are practically inevitable while developing the methods of the optimization of decision making processes. Overlooking them might negatively affect the "quality" of the decisions to be taken, in particular, the effectiveness of the informational support, that is timely distribution of the information needed for taking optimal decisions and, naturally, of the results of the effectuated measures [2].

First. All these complexities should be connected with the necessity of the timely availability of the information, its accumulation and effective processing of incessantly increasing data entering the information system.

Second. The availability of the results of information processing to the persons taking the decisions in the form which they can properly understand to exclude any possibility of the erroneous interpretation of the transmitted information and, thus, any possibility of the erroneous assessment of the real situation. That is, in the final count, any possibility of the irrational or wrong decisions.

Third. The complexities connected with the necessity of the formalization of the information to be accumulated and processed in the system impede the optimization of the informational support. This directly and negatively affect the depth and accurate processing of the accumulated information. The transmission of poorly processed information to the administrative or other levels where the decisions are taken might result in the negative (up to catastrophic) consequences. The Chernobyl and other serious industrial accidents as the direct results of the absence of the necessary data or of the erroneous interpretation of the information transmitted from the information systems are illustrative in that respect.

Fourth. The complexities of the informational support of the decisions to be taken are especially specific of the majority of the problems and applied tasks which possess low possibilities of their formalization and structuring and, correspondingly, insufficient possibilities of the accumulation and processing of the appropriate information. In connection with the complication of the social and environmental problems and the appearance of new and potentially dangerous tendencies a substantial necessity arises in the classification and classification of the tasks which are more frequent and in the search of the algorithms of their solutions. This could substantially facilitate and expand the possibilities the employment of the modern computers and the means to optimize the decisions to be taken. This could substantially facilitate and expand the possibilities the employment of the modern computers and the means to optimize the decisions to be taken.

At present it is possible to select only some most general aspects, which give basis for the development of the methods assuring sufficiently satisfactory processing of the poorly structured information, social in particular. Informational support of the decisions in the social sphere. Among the problems to be solved with the help of the computerized processing of the information one of the first places according to their role and significance should be allotted to the SOCIAL problematique. That is, to the solution of the tasks which directly, or otherwise, are connected with the processes taking place in the society as well as with its connections with the environment. The number of such tasks is constantly growing and the processes requiring solution (in any case rational decisions) are now so numerous that it is extremely difficult to find out general approaches, correspondingly, also the possibilities for the standardization of the informational support of the decisions. That is necessary for the increasing its effectiveness.

The complexities here are becoming specifically evident, if to select certain types of the human activities where the role of the informational support is especially important. Among them a special place should be given to the types where one of the preconditions for the effective decisions is maximally quick search of the optimal (OPTIMAL, indeed) variants of the decisions and the development of the specialized information systems with databases built on the "knowledge". Only then it is possible to expect to receive the objective tested and scientifically proved information.

The development and employment of the decision support systems

A number of scientific institutions in Russia (the Institute of systems analysis, including) are engaged in the development of the specialized information systems, in particular, based on the "knowledge" with the general aim to improve the decision making processes, including those for the solution of numerous social problems. The creation and the employment of decision support systems (DSS) based on the accumulation and analysis of the specialized and structured information has been closely connected with the solution of numerous tasks of the social character (discussed earlier). Therefore, it is the development and the basic components and the "architecture" of the information systems that are the object and the aim of the research of the scientific efforts of Russian institutions dealing with these problems. The systems approach to the solutions of these problems dictates the necessity of the consideration (analysis) of ALL the aspects and components of the information systems, the selection of the decisive factors, the modeling of the whole cycle of the information processing, and the development of the methods of the rational procedures of the structuring of poorly formalized information. Only then it would be possible to speak about the existance of a wide and reliable informational basis securing the optimal decision of the complicated, in particular social, problems. It is desirable to mention that the databases built on the "knowledge" could be divided in three categories [3]:

universal (or general), used for the solution of ANY complicated problems despite their origin or substance;

oriented for the solution of specific problems, appearing before the persons taking the decisions;

special (specialized) databases, connected with the solution of some particular problems (or specific situations).

It is useful to add that one of the most important features of the computerized information support systems is the possibility to use modern telecommunication networks and highly developed computer programs. This is one of the main difference of the developing (DSS) systems from other now employed information systems oriented at the solution of complex particular problems, that is of the "tasks-objects". The existence of the telecommunication channels and their use by the DSS assure the possibility to build united (joint or central) databases connected with "local" databases situated on particular institutions (foe example, large plants or municipal councils) at large distances from central databases. Accumulation of diverse and multi aspect information, in particular in the form of "knowledge", in the central database (in particular, on analogous objects and tasks) gives the users the possibilities an immediate and direct access to the information in the central database from any terminal or to consult qualified specialists.

Two spheres of human activities are illustrative in that in many cases the rational decisions could become possible as a result of processing poorly formalized information. This specifically refers to such a social phenomenon as the negotiations. They serve as an important means to resolve conflicting situations which confront the society more and more frequently nowadays. The negotiations are giving the sides chances to obviate the object of their disagreements and to find the way out of the conflicting situation without compromising both of them (to put aside the issues which one of them could in fact become a "winner" or to derive a certain benefit). The possibility of a complete discord between them - in that case any negotiations would be practically useless, though very often the sides nevertheless agree to proceed with the negotiations at least from the formal point of view.

A conclusion could be suggested:

First, an enormous sphere of international relations with its specific sand an increasing significance for the society needs the resolution of issues connected with the processing of insufficiently formalized information. In particular, it applies to the processes connected with diplomatic and foreign trade negotiations and conclusions of the diplomatic treaties and agreements.

Second, the analysis and assessment of the role and significance of the social factors (in particular, the so called "human factor") in the measures directed at the raising the degree of the industrial safety and prevention of the emergency situations especially on the hazardous plants and installations (nuclear, chemical, aerospace, etc.)

The prevention and resolution of international conflicts with the help of negotiations

The informational support of the solution of applied issues in the sphere of interstate relations has recently been acquiring a first rate significance dew to several reasons in the existing complicates international situation in the majority of cases the decisions that are needed should be not only

merely reasonable, but optimal in direct sense of this term. A special importance cold be explained by a considerable international political and political instability, so specific of the modern period in the developments in the international sphere. Possible deficiencies here in the final count affect to considerable degree political positions of the states and find the expression in the reduction of the possibilities to avoid the conflicts and to defend their legitimate national interests. Haste decisions, moreover defective or erroneous decisions, on the regional or even global levels might result in serious political, economic or military damages; for example, hardly compensated material or territorial losses for the countries involved in the serious international conflicts (in this context the term "conflict" should be interpreted as a certain "crises" situation as the result of disagreements between two or more sides on issues which are considered differently by the parties involved).

Conflicts could occur dew to various causes. The main among them are the disagreement on territorial, economic or similar reasons (frontier disputes, foreign occupation, terrorist activities, etc.). Recently, ecological disputes are becoming more frequent. Sometimes, internal political, religious or ethnic disputes became the causes of international conflicts. In this context it would be sufficient to make an analysis of only one aspect of a large and complicated problem, such as informational support of decisions in the international sphere - namely, of a process of negotiations and the possibility to use insufficiently formalized and structured information got taking decisions for the resolution of a particular critical situation. It is possible to single out several main components which are specific of any negotiations and which are of interest from an informational point of view. Among them:

Participants of negotiations. The formalization and structuring of the information concerning them practically do not create any difficulties.

Choice of the most important problems or issues, which should become the object of negotiations. This, as a rule, leads to serious disagreements in the opinions between the negotiators about the interpretation of the problems or particular issues. And, accordingly, in the contents and the character of the needed information, its structuring and formalization.

Procedures of the negotiations - could also lead to serious contradictions and, consequently, to difficulties in relation to the structuring and formalization of the information which could greatly affect the process of negotiations and the choice of "optimal" decisions in the process of negotiations.

The development of possible variants of drafts of agreements

This should include also the drafts of agreements on the procedures of the decisions entering into force, that is to become legally obliging. This aspect is usually one of the most complicated problem, connected with the formalization and structuring of the information, needed while the negotiations are coming to the end. It should be necessary to consider one more element of the negotiations, namely the text of the agreement, which is actually the final aim of any negotiation process and closely connected with structuring and formalization of information. In the course of negotiations the participants almost incessantly suggest various alternative variants (or "corrections"), either are accepted by an opposite side or rejected. Accordingly, the contents of the text (or its character) also incessantly are changing, as changes also the needed information. In the result, a multi aspect and changing document ("rolling text"), from any point of view presenting a basis for a possible resolution of a conflict.

Therefore, any information, transmitted by the information system, could become very useful and "support" the position of the appropriate side. As a consequence, optimal informational provision increases the effectiveness and curbs the expenses connected with the negotiations. But at the basis of the effective informational support of negotiations there always lies thoroughly processed and analyzed information, preferably in the form of "knowledge". The attempts to use the computer possibilities and the decision support systems in the international sphere have up to present time been numerous and required considerable expenses, but, as far as it is known, did not bring any sensational results, though sometimes the contrary is suggested. The diplomatic practice has not been confirming this. It would, rather, provide the examples of how important it is not to ignore the informational support of the suggested decisions during the negotiations.

Prevention of technological and natural disasters and mitigation of their consequences

An important role of societal factors in creating "favorable" conditions for the occurrence of major industrial accidents is now well established. This conclusion rests on the results of the analyses of many calamitous accidents, which took place in recent years. It seems, however, desirable to put this thesis in a more general context. All these catastrophes are actually the results of numerous factors acting in close conjunctions with each other, mainly technological with numerous factors of societal nature (regulatory and controlling, economic conditions, legal factors, motivations of people in the course of industrial activities and many others). All of them often exert significant influence on the state and tendencies in the development of socially acceptable levels of technological safety in any country with industrial activities.

One of the main conclusions from the analyses of industrial incidents of any type and kind, especially those with catastrophic consequences, which happen from time to time in the industrial countries, is that various accidents do not arise there in isolation from other, non-technological, factors. In that respect societal dimension of technological activities, is, in particular, of exceptional significance. It adds a new and important aspect to the industrial safety problem per se, turning it into a complex multi-aspect phenomenon with an important and significant societal connotations. It follows that the role of the informational support of the technological activities should take its appropriate place. Short-term consequences (economic, social, ecological) of industrial accidents could now be assessed with the help of latest analytic techniques with sufficient degree of reliability. This cannot be said, however, of probable long-term societal consequences, including a wide range of lasting harmful impacts on the health and welfare of the population and plant personnel. They very often remain outside the attention of the appropriate authorities and public institutions. In real life the whole array of causes usually cannot be easily discovered, as many important data are often either irrevocably lost, ignored or even intentionally hidden. The experience demonstrates that specifics of serious industrial accidents compel to look at the phenomenon from a much broader point of view: major technological accidents with unpredictable a priori causes and consequences usually have other, more concealed and deep-rooted causes than direct technological, engineering or managerial faults, however decisive they might look. Regrettably, INDIRECT causes of major technological accidents, which appear to a cursory observer not to be connected with the industrial safety.

Thus, the main point is - SOCIETAL factors (in the broadest sense of this term) should be included (and analyzed0 in the number of probable, sometimes decisive, though not very noticeable, causes of major industrial accidents [4]. This should be understood in the sense that powerful factors of societal character (in conjunction with others) create general PRECONDITIONS for human-made technological calamities. In fact, each major industrial accident, should be treated as a complicated

SOCIO-TECHNOLOGICAL event, the end result of the interplay of many technological, societal and other factors, in particular the attitudes, motivations and actions of people participating in industrial activities, directly NOT connected with the industrial safety as such. The analysis of the causes of the emergency situations in the technological sphere, in particular, serious accidents on the industrial complexes, confirms the conclusion that the social factors play a considerable role in the whole array of the immediate causes of all the calamities accompanying the technological progress. The difficulties connected with the formalization of the information of social information should not be underestimated in this array. The informational support of the industrial activities do not correspond the modern demand in the industrial sphere. It is not by chance that the real significance of social factors and the appropriate social information in the issues of the industrial and other types of safety, as well as the prevention of all kinds of calamities, were not among the primary everyday tasks of managers and operating personnel. Centralization and automation, two general trends in the modern industrial activities, do not eliminate people from the technological processes, as such, they are usually moved only to other, more responsible functions, like supervisory, control and decision-making. This implies that human decisions and actions are becoming more authoritative and significant, affecting safe plant operation. At the same time the basis for human decisions becomes more fuzzy and vague with the time-span shorter. All this has sharply increased various stresses and psychological difficulties for the personnel, who by necessity are becoming inseparable components of "man-machine" systems, often without any regard to their psychological, physiologic and other human properties, and limitations. This separation in some cases of industrial accidents may explain unaccountable human actions, leading eventually to unpredictable emergency situations.

In this connection the issue of PERSONNEL SELECTION, in particular of operators, plays a significant role in the measures to prevent industrial, in particular major, accidents. There is not much guidance concerning the "correct" personnel selection methods, due mainly to the difficulty of defining criteria for optimal managers' or operators' performances. But among important societal factors DEFICIENT systems of personnel choice, especially for responsible managing and operating positions, should be accentuated. In some countries there are legally binding requirements that the operators, in particular in nuclear industries, should prove the competence and ability, permitting to occupy the position he strives to get (through examinations, for instance or some other methods). Human errors' contribution to MAJOR accidents appears to be greater than to less serious failures. Whereas the human errors resulting in general failures amount to 10-30% of all causes, in major accidents they are estimated to be in the range of 60-80 %.

Conclusion

The theory and practice demonstrate that the problems of safety, including societal, industrial or environmental may by successively solved only under the condition that in the course of taking responsible decisions the systems of the informational support with appropriate databanks and modern technical basis would be employed on a wide scale. And in addition, the information accumulating in the systems to a large degree would be in the form of "knowledge".

Only well organized societies with effectively functioning administrative, legal and other socially oriented systems, taking into consideration the "human factors" could assure the basis for the optimization of the decision making processes. In the complex processes of social and technological nature, particularly in the emergency situations, only the systems capable quickly accumulate and process the information in the form of "signals" in all the entirety and send it as realistic and objective assessments and conclusions which could assure various types of safety – technological, societal or ecological.

References:

[1] V.Britkov, G.Sergeev. Risk management: role of social factors in major industrial accidents. Safety Science, v.30, PERGAMON, Elsiver Science Ltd., Delft, The Netherlands, 1998, pp. 173-181.

[2] Vladimir B. Britkov, Gleb S. Sergeev. The role of societal factors in decision support processes of emergency engineering. In.: The international Emergency Management Society Conference "Disaster and Emergency Management: International Challenges for the Next Decade", Edited by J.Harrald and G.Shaw. Washington, DC, 1998, pp.413-420.

[3] V.Britkov, G.Sergeev. Social Factors And The Optimization Of The Technological Safety In.: The International Emergency Management Society Conference "Defining the Agenda for the Third Millennium" Edited by G.Beroggi, TU Delft, Netherlands, 1999.

[4] V.Britkov, G.Sergeev. Crysis management: optimal decision making as a method to prevent emergency situations and accidents in complex systems. Human Centered Processes'99. 10-th Mini EURO Conference, Brest, France, 1999.

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