Organization of Management of Social and Economic Systems of the Region in the Conditions of the Required Technosphere Safety

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Abstract. Management of social and economic systems, ensuring the technosphere security of the region uses models based on the analysis. The use of such models does not provide a guarantee of achieving the goal of forming processes with specified properties. The control model based on the synthesis and the law of preservation of object integrity allows to solve the inverse problem of management and to formulate conditions of application of program-target management.

1. Introduction

When managing the social and economic systems of the region in the conditions of the required technosphere safety (TS) of the region, it is necessary to be able to form processes with predetermined properties. Traditionally, models based on analysis are usually used for management. A sufficiently high level of risk when using the models developed on the basis of the analysis leads to the fact that the results of management do not fully meet the expectations of the decision-maker or body, since their use does not fully provide the conditions for guaranteeing the achievement of the goal of public administration. The article presents the concept of control based on synthesis, which allows to form processes with predetermined properties. The new approach requires the solution of the inverse control problem.

Management of technosphere safety (TS) in the region — the activities of public authorities in the region and their officials on the practical implementation of developed on the basis of appropriate procedures of management decisions in the field of management.

Despite the many mechanisms of management in the field of TS, Russia currently does not take into account the possible scenarios of development of the state, that is, it does not have a strategic forecast of the development of society, economy, technical and technological systems.

This situation is complicated by the trend of expanding the boundaries of the technosphere, and hence the increased risk of man-made disasters, especially disasters of critical and potentially dangerous objects. The scale of the consequences of accidents, their number is constantly growing.
The most important feature of disaster threats in the man-made sphere is the impossibility of their full prevention and guaranteed security with zero risk [1]. The analysis of the main threats directly related to the national security of Russia shows that their structure is heterogeneous.

In man-made accidents and catastrophes, there are both separate and combined damaging factors: poisoning by chemically dangerous substances, bacteriological contamination, radiation, explosive and shock waves, thermal radiation, mechanical damage, pulse acceleration, electromagnetic loads. These factors affect people, objects and the environment.

There are possibilities of current, tactical management, real-time regulation and advanced, strategic management of TS as an object of management.

It should be borne in mind that the technosphere is a super-complex, global, fast and nonlinear object with contradictory properties, including self-development, self-regulation, as well as the properties of a powerful generator and a multiplier of the development of civilization, which is not sufficiently studied. At present, the necessary knowledge, technology and material resources for the full effective management of TS are lacking. The real possibilities of TS management are significantly limited in intellectual, information, technological, economic and other aspects, which is largely due to the complexity of TS as an object of management, as well as the lag in solving organizational management issues.

The main approaches to TS management should include a systematic approach, socio-techno-economic approach; forecasting; balanced sustainable development. [2]

Management of technosphere safety (TS) in the region, like any other management, is based on the results of modeling of socio-economic development within the framework of the selected management concept. Model (FR. modele, from lat. modulus — "measure, analog, sample") is a system, the study of which serves as a means to obtain information about another system [3]. In system engineering there are only two approaches to system development (Ya G Neuimin, G H Gud [3, 4]):

1. Development of the system (model) based on the analysis.
2. Development of system (model) based on synthesis.

The dynamic model based on synthesis is formalized as a system of nonlinear differential equations. Three main system-forming indicators of activity of the region, corresponding by the law of preservation of integrity of object of V G Burlov to three basic interconnected properties ("objectivity", "integrity", "variability" or "object", "purpose", "action") [5, 6, 7]:

- the demographic indicator "x" (a measure of population),
- indicator of economic development "y" (gross regional product (GRP) per capita);
- the indicator of ensuring of TS in the region "z" (the costs of ensuring TS per capita).

All indicators are presented in the form of relative, reduced, dimensionless quantities. Dynamic model of management of TS in the region shown in figure 1.

The law of preservation of object integrity

\[
\frac{dx}{dt} = ax - bxy + qxz; a, b, q > 0;
\]

\[
\frac{dy}{dt} = -py + cyx + uryz; c, p, r > 0;
\]

\[
\frac{dz}{dt} = -\mu z - \delta xz - \gamma yz; \delta, \mu, \tau > 0.
\]

Condition of existence

Figure 1. The dynamic model of technosphere safety management in the region.
Modeling of control based on the synthesis and the law of preservation of the integrity of the object is presented in the works of M O Lepeshkin [8].

2. The output of the first differential equation
We introduce the following notations.

- \( x \) - demographic indicator, which is defined as
  \[
  x = \frac{x^*(t_0) + x^*(t)}{x^*(t_0)}
  \]  
  \( x^*(t_0) \), the current value of the demographic indicator at a time.
  \( x^*(t) \), the value of the demographic indicator of variability at a time.

The derivative of the indicator "\( x \)" is the rate of change in the human population. The rate of change "\( x \)" is proportional to the number of population in the region. That is, the larger the number of population, the greater its growth.

\[
\frac{dx}{dt} = ax
\]  
\( a \), the coefficient of demographic activity.

Determine the impact on the rate of change of the demographic indicator of the other two system-forming indicators.

"\( y \)" is an indicator of economic development. GRP per capita is quantified. The quantity "\( y \)" (GRP per capita) will reduce the rate of growth of the demographic indicator "\( x \)" by an amount proportional to the value of "\( bxy \)".

The differential equation describing the change in the demographic indicator "\( x \)" will take the following form:

\[
\frac{dx}{dt} = ax - bxy
\]  
\( b \), the coefficient of negative attitude to childbearing (1-2 children – acceptable; and 3-5 – already a lot).

For this value of the demographic indicator "\( x \)" the indicator ensuring of TS "\( z \)" will contribute to an increase in the rate of growth of the human population, in proportion to the value of "\( qxz \)". Therefore, the higher the cost of providing TS in the region, the higher the rate of growth of the quantitative composition of the population in the region.

The differential equation is converted to the following form:

\[
\frac{dx}{dt} = ax - bxy + qxz
\]  
\( q \), the security coefficient of the TS region.

3. The output of the second differential equation
"\( y \)" is an indicator of economic development, which is defined as

\[
y = \frac{y^*(t_0) + y^*(t)}{y^*(t_0)}
\]  
\( y^*(t) \), the current value of the indicator of economic development at a time;
\( y^*(t_0) \), the value of the economic development indicator at a time (GRP per capita).

The derivative of the indicator "\( y \)" is the rate of change in the indicator of economic development.
The rate of change in the indicator of economic development (GRP per capita) is proportional to the quantity of GRP in the per capita with a minus sign (the more GRP per capita is actually created, the more difficult it is to increase and increase GRP)

\[ \frac{dy}{dt} = -py \]  

(6)

\( p \), the coefficient of development of the real sector of the economy.

For this value of the indicator of economic development \( y \) demographic indicator \( x \) with the interest of people will increase the rate of change in the indicator of development of the real sector of the economy by an amount proportional to the value of \( cx \), where \( c \) – the coefficient of interest of people in the development of the economy.

The differential equation is converted to the following form:

\[ \frac{dy}{dt} = -py + cxy \]  

(7)

For this value of the indicator of economic development \( y \) the amount of \( z \) - the cost of providing TS will contribute to an increase in the rate of growth of the indicator of economic development by an amount proportional to the value of \( \gamma y z \). (The more expenses for provision of TS are received for the development of the real sector of the region's economy, the higher the rate of growth of the economic development index).

The differential equation has the following form:

\[ \frac{dy}{dt} = py - cxy + \gamma y z \]  

(8)

\( \gamma \), the coefficient of TS provision in the real sector of the economy.

4. The output of the third differential equation

"\( z \)" is an indicator of TS maintenance costs. It is defined as

\[ z = \frac{z^*(t_0) - z^*(t)}{z^*(t_0)} \]  

(9)

\( z^*(t_0) \), the value of the cost of providing TS at the initial time \( t_0 \);

\( z^*(t) \), the value of the cost of TS at the current time \( t \).

The derivative of this indicator "\( z \)" \( \frac{dz}{dt} \) is the rate of change in the indicator of costs of providing TS. The rate of change in the cost of TS "\( z \)" is proportional to the amount of money spent on TS. That is, the greater the amount of money spent on providing TS in society, the higher the rate of its increase.

\[ \frac{dz}{dt} = \mu z \]  

(10)

\( \mu \), the coefficient of increasing costs for TS provision in the region.

Demographically, the "\( x \)" index will reduce the rate of change in the TS provision index by an amount proportional to the \( \tau x z \) value. (As the number of population increases, the rate of change in TS provision decreases), where \( \tau \) is the coefficient of compliance of the population with TS provision.

The differential equation takes the following form:

\[ \frac{dz}{dt} = \mu z - \tau x z \]  

(11)

For a fixed indicator of the cost of providing TS "\( z \)" increase . GRP per capita contributes to a reduction in the speed of growth provide TS proportional to the magnitude \( \gamma y z \). That is, the more the
real sector of the region's economy develops, the less the cost of providing TS "accounts for" GRP per capita.

A differential equation takes the following form:

$$\frac{dz}{dt} = \mu e - \alpha z - \delta v z$$  \hspace{1cm} (12)

$\delta$, the coefficient of compliance of economic development with TS.

5. Model of management of social and economic systems of the region in the conditions of the required TS

$$\begin{cases}
\frac{dx}{dt} = ax - bxy + qxz; a, b, q > 0; \\
\frac{dy}{dt} = -py + cxy + \gamma vz; c, p, \gamma > 0; \\
\frac{dz}{dt} = \mu e - \alpha z - \delta v z; \delta, \mu, \tau > 0.
\end{cases}$$  \hspace{1cm} (13)

$x$, the indicator of the population of the region;  
y, the indicator of economic development of the region;  
z, the indicator of TS provision in the region.  
a, the coefficient of demographic activity;  
b, the coefficient of negative attitude of people to childbearing;  
$q$, the coefficient of the region TS;  
c, the coefficient of people's interest in economic development;  
p, the coefficient of development of the real sector of the economy;  
$\gamma$, the coefficient of TS provision in the real sector of the economy.;  
$\mu$, the coefficient of increase of expenditure on TS in the region;  
$\tau$, the coefficient of compliance of the population to TS of the region;  
$\delta$, the coefficient of compliance of economic development to the TS of the region.

The considered nine coefficients included in the system of differential equations are the essence of the components of the vector of regional control of TS provision. At the technological (practical) level of implementation of the model, the task of the regional TS management bodies is reduced to the formation of these coefficients according to specially developed by the authors of the model methods and ensuring their achievement through various management decisions and actions.

The model allows for the given values of the main system-forming indicators corresponding to the required level of TS provision in the region, to form the process of life of the region with guaranteed pre-set properties and to determine the necessary control actions to achieve them in the form of formation of coefficients in order to achieve the goals of guaranteed

6. Conclusions

The article deals with the first (basic) level of TS management in the region. Next, a system of models is built from top to bottom in the form of systems of differential equations, which consistently concretize the performance of the region to provide TS in the region at different levels of the hierarchy of control. The proposed concept allows to create conditions for ensuring the required level of TS in the region, taking into account the ensuring of social and economic systems of the region on the basis of a synthesized model of the management process.

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