ECONTECHMOD. AN INTERNATIONAL QUARTERLY JOURNAL – 2015, Vol.4, No.3, 19-24

SYNTHESIS SYSTEM MODELS OF CHOICE THE PRIORITIES AT REALIZATION OF NATIONAL FORESIGHT-RESEARCHES

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Received July 09.2015: accepted August 14.2015

Abstract. The analysis of implementation technology foresight in various countries is carried out which showed that for today foresight is used as the system instrument of formation the future allowing to consider changes in all spheres of public life: science and technologies, economy, social, public relations, culture. Types and structural elements of technology foresight are separated. The necessity of further research the problem associated with increasing the efficiency of foresight-projects through its informatization is shown. The *aim of the article* is to describe process of synthesis the model of informatization as technologies foresight in general, and its specific variants (foresight-project). Informative and formal statements of problems synthesis system model (SM) choice of priorities in the implementation of national foresight-researches are given. Approach to construction of SM technology foresight in the form of the two-level hierarchical system consisting of the functional and methodical levels is offered. At that the functional level includes a set of types and purposes of technology foresight, and methodical - reflects a transition way from input elements to output. For a further concretization of SM, taking into account the selected properties of discrecity and determinancy, the mathematical apparatus of the automata theory is used. In this case the system is represented in the form of automaton which processes the discrete information and changes its internal states only in admissible timepoints. For computer implementation of model technology foresight is supposed to use network models which, in general, provide adequacy of the formal representation of foresight-researches. Reasonability of use the apparatus of Joiner-networks (JN) defines a connectivity and directivity of transmission of output results as input alphabets is shown.

Keywords: technology foresight, scientific and technical development, system model, national foresight-researches, types of foresight, structural elements of foresight.

INTRODUCTION

During a globalization era support of world leadership in the sphere of hi-tech productions and innovative technologies belongs to number of fundamental priorities scientifically - technical and innovative policies of the majority countries of the world. At that efforts of the states are directed both at stimulation of research and development works in the advanced areas of science and technologies, and on definition of national priorities of scientific and technical development [1, 2]. Practically in all developed countries the special programs of defining priority areas of development science and technique are periodically created. The methods used in development process of these programs received the generalized name foresight, from English - "foresight", and until now proved themselves as the most effective tool of a choice the priorities in the sphere of science and technologies.

The concept foresight arose in the 1950th years in the american corporation "Rand" where solves the problems definition of perspective military technologies. Having faced with insufficiency of traditional predictive methods (quantitative models, extrapolation of the existing tendencies, etc.), experts of "Rand" developed a method Delphi [3], which became a basis of many foresight-researches. In the 60th years large-scale operations on prediction were carried out Naval and air-force by departments of the USA. From 1980th years foresight has become used in the European countries [4]. Foresight reached the heyday as an analysis method in the mid-nineties within national programs of technological prediction which still remain the main scope of application foresights. For today foresight is used as the system instrument of formation of the future which allows considering changes in all spheres of public life: science and technologies, economy, social, public relations, culture.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Recently is observed the increase of number the publications devoted to research of theoretical and practical aspects application of foresight – technology of designing the future is [4 – 15]. Foresight started using actively since the beginning of the 90th years by the governments of the U.S., United Kingdom, Germany, Japan and Australia, and to 2000 years number of such countries exceeded 30. At the present time this technology has been adopted not only in Western Europe, U.S. and Japan, but also in a number of developing countries and countries with economies in transition (Poland, Czech Republic, Russia, Belarus, Ukraine, etc.) [16-26].

Under *foresight* understood the process of systematically identifying new strategic directions of scientific and technological achievements, which in the long run will have a serious impact on the economic and social development of the country [27 - 29]. Technology foresight has the following main characteristics:

– foresight is a systematic process;

– central place in this process, is taken by the scientific and technological directions;

– priorities are considered from the point of view of their influence on social and economic development of the country;

– time horizon considered in the average and long term.

In the context of foresight there is a question about an assessment of the possible prospects of innovative development connected with progress in science and technologies, outlines the possible technological horizons which can be reached in case of investment of certain funds and the organization of systematic work, and also probable effects for economy and society.

In practice, there are various types of the foresight [8, 27, 29] as each foresight-project differs from others in various parameters: to the contents, depth of analysis, scales, time frames, the territory of coverage, to number of participants, the available resources, etc. Types of foresight are shown in fig. 1.

On the basis of the carried-out analysis of realization the foresight in the different countries of the world it is possible to allocate its basic structural elements (fig. 2).

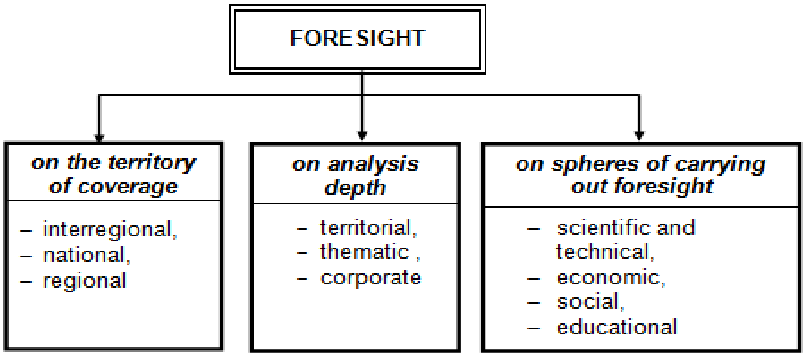

Fig. 1. Types of technology foresight

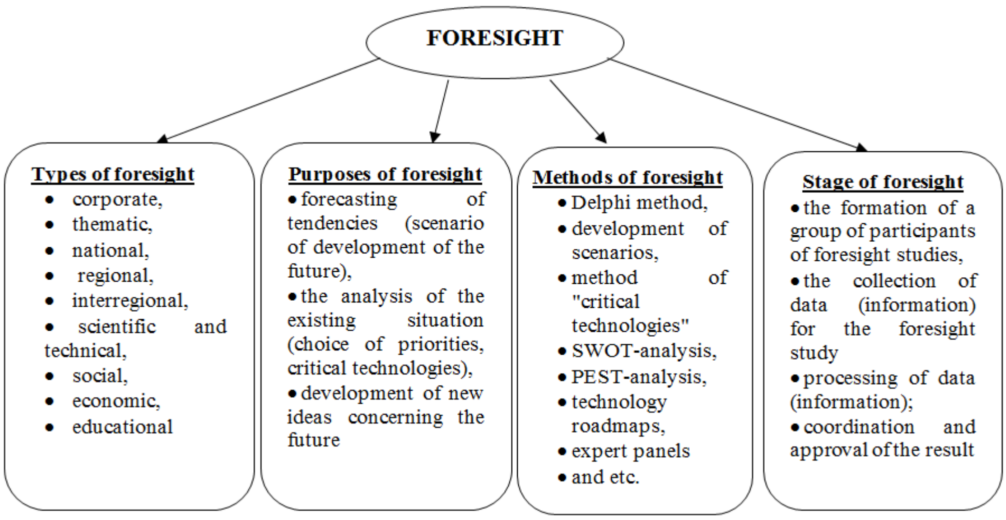

Fig. 2. Structural elements of technology foresight

Considering experience of various countries it is possible to claim that for today there is no uniform model of foresight, each country adapts this technology under their specific goals and requirements, and methods of its realization are badly formalized and mostly are expert, therefore, there is a need of further research of the problem connected with increase of efficiency of foresight-projects.

OBJECTIVES

The *aim of the article* is to describe process of synthesis the model of informatization as technologies foresight in general, and its specific variants (foresight-project).

STATEMENT OF THE PROBLEM

As initial data for informatization of technology foresight its mandatory constituent elements appear (a set of stages and methods of technology foresight).

To solve the problem it is necessary to develop a formal means by representation of decision-making process in the implementation of technology foresight, by use of adequate mathematical means.

As a result of the solution of the task the model of computer implementation of technology foresight in the form of a set of stages and collection methods of their computer implementation will be created. Implementation of the specified model will allow to increase efficiency of foresight-researches due to transition from heuristic procedures to their formal description, and also to informatization of technology foresight.

RESEARCH OF STRUCTURE OF TECHNOLOGY FORESIGHT, AS A DIFFICULT SYSTEM

For computer implementation of technology foresight it is necessary to formalize it, by development of the model, with a known level of adequacy reflecting all stages of the foresight-research. The technology foresight consists of a set of interacting components - subprocesses (foresight-research stages) and possesses the following row of the main properties:

– hierarchies - actions of subsystems of the top level depend on the actual execution by the bottom levels of their functions;

– discretizations - correlation between elements of system (subprocesses) is carried out sequentially;

– determinancies – all transitions between elements of system are strictly defined, i.e. transition to the next happens on condition of successful execution of the previous subprocess.

To select a special mathematical apparatus which would consider the selected main characteristics of foresight-researches, it is appropriate to conduct modelling which will allow to receive an holistic, systemic view model, allowing to reveal correlations of elements technology foresight, possible states of each element and the relation between them.

Technology foresight representable in the form multilevel structure described from positions of systems theory [30]. This structure should reflect the most important characteristics of the simulated system, namely:

- that the technology foresight consists of interrelated subsystems, which have a right to make decisions;
- that these subsystems form a hierarchy.

On the assumption of that, theoretical-system model of technology foresight represented in terms of functional-method relations [31], in which a function is understood as subject needs for receiving some result, and a method - some process by which this result is obtained. In this case, the upper level of technology foresight is set by the functional part and the lower - the methodical.

On the functional level displayed the main purpose of the technology foresight (analysis of the existing situation (the choice of priorities, the search for critical technologies), prediction of tendencies (described of development scenarios), etc.), which in turn can be decomposed into sub-goals (stages), depending on the type of foresight (national, corporate, scientific and technical, social, etc.). The methodical level reflects the transition way from the input to the output elements and contains as methods of achieving the purpose (set of methods for technology foresight), and conversion technology from input to output elements (certain methods and order for their implementation).

The provided description of technology foresight is initial for its formalized description on the set-theoretic level, at that the general problem statement of synthesis the models of computer implementation of technology foresight, given on the set-theoretic level of description, is similar in its structure and content to the general problems statement of decision-making problems in the conditions of a multicriteriality. A formal set-theoretic description is carried out using the following model:

$$\Phi = \langle \Theta, G, \Lambda, \Omega \rangle, \quad (1)$$

where: $\Phi = \{ \varphi_g \},\ g = \overline{1,m}$ - the set of types technology foresight;

$\Theta = \{ \theta_i \}, i = \overline{1,k}$ - set of goals technology foresight that indicate a given state of technology foresight;

$G \subset G_0 \cup G_1$ - set of initial G_0 and final G_1 states of foresight technology, at that $G_0 \cap G_1 \neq \varnothing$;

$\Lambda = \{ \lambda_q \}, q = \overline{1,z}$ - set of stage of technology foresight;

$\Omega = \{ \omega_j \},\ j = \overline{1,n}$ - plural sets of methods technology foresight.

For the description of dynamic properties by means of system model, we will enter the following concepts:

1) Time T is a linear ordered by the relation "$\leq$" a set of timepoints t:

$$T = < T^O = \{ t \},\ \leq >: t \in [t_0, t], \quad (2)$$

where: t_0 - initial timepoint in the interval $[t_0, t]$;

2) the instantaneous state of technology foresight Φ for a period of time T:

$$\Phi^T \subset \Phi \times T : \Phi^T = \{ \Phi^t \} \wedge \Pi_T(\Phi^T) = \{ t \} \subseteq T, \quad (3)$$

where: $\Pi_T(\Phi^T)$ - projection of a set of the instantaneous statuses Φ^T to a set of timepoints T.

$\Pi_T(\Phi^T)$ is understood as a set of those elements from T which are projections of elements from (Φ^T)on *T*. For a couples $\Phi^t = (\Phi, t)$ projection element Φ^T on the set *T* serves the element t. Instant state of stage technology foresight $\Phi \in \Phi^T$ - making in a timepoint t some event (e.g. appearance of data at the input or output of stage technology foresight), relating to this stage.

The initial G_0^T and final G_1^T states of technology foresight represent the sets, including prehistory of its instantaneous states for the period of time *T* to some initial and final timepoints.

Using the introduced concepts, build the functional part $\Phi^{\Phi T}$ of a system model technology foresight as follows:

$$\Phi^{\Phi} \subset P(G_0^T \times \theta_i^T \times G_1^T) \quad (4)$$

In the particular case Φ^{Φ} it can be given mapping

$$\Phi^{\Phi} : (G_0^T \times \Theta^T) \to G_1^T, \quad (5)$$

where: G_0^T, G_1^T - initial and final states of technology foresight for the time period T;

Θ^T - set of goals technology foresight for the time period T.

Mapping (5) shows, that the final status of any of the stages of foresight - a function of its initial state and specified goal of this stage, specifying these states.

Methodical part of the model Φ^M is intended to describe the possibilities on any stage technology foresight to reach certain values of the output value for the fixed initial state and a specified goal, i.e. reflects a transition way from input elements to output:

$$\Phi^M : (\Theta \times \Lambda) \to \Omega, \quad (6)$$

where: $\Theta = \{\theta_i\}, i = \overline{1,k}$ - set of goals technology foresight that indicate a given state of technology foresight;

$\Lambda = \{\lambda_q\}, q = \overline{1,z}$ - set of stage of technology foresight;

$\Omega = \{\omega_j\}, j = \overline{1,n}$ - plural sets of methods technology foresight.

As a result, the system model (SM) of technology foresight will be the following:

$$\begin{aligned} &\Phi = (\Phi^{\Phi} \times \Phi^M), \\ &\Phi^{\Phi} : (G_0^T \times \Theta^T) \to G_1^T, \\ &\Phi^M : (\Theta \times \Lambda) \to \Omega \end{aligned} \quad (7)$$

where: Φ^{Φ}, Φ^M - functional and methodical parts of SM of technology foresight;

G_0^T, G_1^T - initial and final states of technology foresight for the time period *T*;

Θ^T - set of goals technology foresight for the time period T.

SM of technology foresight is shown in fig. 3. On the input of stage technology foresight when he is in some initial state, incoming input action in the form of given purpose, which upon reaching of it this stage should go to the desired finite state.

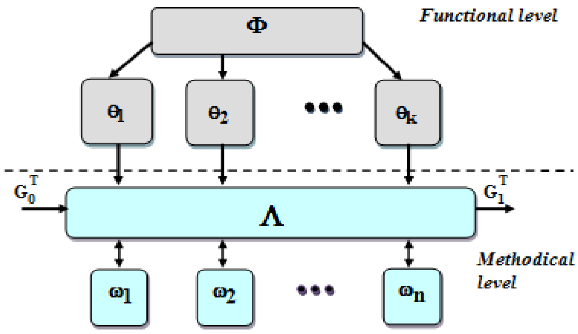

Fig. 3. Structural diagram the system model of technology foresight

For a further concretization of SM, taking into account the selected properties of discrecity and determinancy, the mathematical apparatus of the automata theory is used. In this case the system is represented in the form of automaton which processes the discrete information and changes its internal states only in admissible timepoints [32]. For computer implementation of model technology foresight is supposed to use network models, namely, the apparatus of Joiner-networks (JN) defines a connectivity and directivity of transmission of output results as input alphabets. JN is extension of Petri nets and differs in existence of special starting and flag functions which are formed by arbitrary boolean functions and allow to describe logic of network functioning [33, 34]. Each transition in JN (technology foresight stage) with a set of input and output positions compared automaton:

$$A = \langle \psi, \varphi, P, R \rangle, \quad (8)$$

where: $P(p_1,...,p_n)$ - a set of input and output positions;

$\psi(p_1,...,p_n)$ - starting function, defining conditions of start transition and the corresponding subprocess (a stage of a foresight-research). $\psi(p_1,...,p_n)=1$, where value of position $p_i=1$ - the appropriate event arose, $p_i=0$ - the event didn't arise, or was "erased" from memory of a position;

$\varphi(p_1,...,p_n)$ - the flag function giving new values to all positions (input and output) after the end of process;

$R(r_1,...,r_n)$ - a register memory of positions where are remembered the values $\{0, 1\}$ signaling about emergence (not emergence) of the appropriate events.

Operation of the elementary automaton is gives by the boolean equations for each transition *S*:

$$S:\psi(p_1(t),...,p_n(t))\rightarrow\varphi(p_1(t+1):= \\ =\{0,1\},...,p_n(t+1):=\{0,1\}) \quad (9)$$

The system of the logical equations compared to each transition $S_i\ (i=\overline{1,k})$ between stages of a foresight-research sets a network of automata which is obtained by identification of the appropriate positions of these automata:

$$\begin{cases} S_1:\psi_1(P_1(t))\rightarrow\varphi_1(P_1(t+1)) \\ S_2:\psi_2(P_2(t))\rightarrow\varphi_2(P_2(t+1)) \\ ... \\ S_k:\psi_k(P_k(t))\rightarrow\varphi_k(P_k(t+1)) \end{cases}. \quad (10)$$

The automaton launches subprocess if the vector of positions *P(t)* corresponds $\psi=1$, and by finishing of its operation change of a vector *P(t+1)* happens according to flag function.

Each stage of a foresight-research presents itself separate subprocess, representable in the form of a network, which controls "switching on" of own process and delivering of the synchronizing events to other elements of a network. Fig. 4 shows the internal structure of any of foresight-research stages in the form of JN. The beginning of a stage - S_0, and an event $\psi=1$ controls the beginning of the stage S_0. The termination of a stage *S* - S_P, and event $P=1$ controls its termination. Formally transition in JN will respond the elementary finite state machine, with the states: S_0 - process in a standby mode; S_p - process in an operation mode.

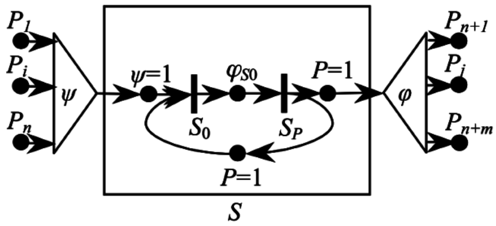

Fig. 4. The internal structure of a typical stage foresight-research in the form of JN

CONCLUSION

1. Shows the informative and the formal statement of the problem of synthesis the model of computer implementation of technology foresight.
2. Create the system model of implementation the foresight-researches based on event approach to decision making that unlike the existing allows to display the difficult nature of foresight and provides transition from heuristic procedures to their formal description for further informatization of technology foresight.
3. It is shown that network models, generally, provide adequate formal representation of foresight-researches and the most appropriate instrument of representation foresight-researches is the JN.

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