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GOAL SETTING AND WORKING OUT OF THE STRATEGY OF DEVELOPMENT OF SOCIO-ECONOMIC OBJECTS

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Abstract: Present paper is dedicated to examination of goal setting and technique of structure and goal analysis and their application to working out of strategies of purposeful development of complex objects under instability.

Keywords: Goal setting, structure and goal analysis, cognitive science, cognitive technologies, economic systems, forecasts, modelling

In conditions of rapid technological changes the requirement to quality of control of purposeful development of complex social and economic objects (SEO) (states, regions, transnational corporations etc.) dramatically increases at all levels.

One of the most important stages of control of a SEO is the goal setting that represents a process of modelling of result of yet not carried out activity, submitted more often in the image, mental model of the future condition of a situation, qualitative either quantitative characteristics or system of symbols and concepts.

At a stage of a goal setting it is rather important to reveal contradictions in goals that can be caused either by really contradictions or by chosen ways of reaching of goals.

The aim of goal setting is revealing of laws of goal formation and working out of the most effective ways of their reaching.

Goal setting includes:

- determination of vectors of goals of SEO development;
- analysis of opportunities of the set goals reaching;
- selection of means and ways of goals reaching.

1. GOAL SETTING WITHIN THE FRAMEWORK OF DECISION SUPPORT TECHNOLOGIES

Computer modelling of goal setting processes is becoming one of the basic directions of decision makers support. There has been developed a great amount of software explaining the past, but not capable to produce recommendations on solving of problems that can arise in the future.

This situation has resulted in necessity of creation of integrated systems of support of goal setting process and making of administrative decisions when working out a strategy of SEO development. Making decisions involves processes of great complexity. Experience testifies that decision support systems (DSS) that include a goal setting stage provide decision making for shorter period. It becomes possible because a decision maker has a model he can refer to when generating various alternative strategies of purposeful SEO development (goal setting models), and only then he considers and estimates the variants of decisions. This shift to the initial stage (generation of alternatives guiding by models) considerably changes the whole paradigm of decision making.

The modern process of goal setting consists of the following stages:

The first stage – analysis of environment from the point of view of the circumstances that have caused the necessity of decision making, i.e. in other words reconnaissance;

The second stage – search, working out, and analysis of possible variants of actions (alternatives), in other words planning;

The third stage - determination of a concrete sequence of actions out of possible ones, in other words selection.

The stages boundaries are indistinct, and the stages can be detailed.

When setting the goals of SEO development the decision makers should simultaneously be engaged in reconnaissance, planning, and decision selection.

Complexity of analysis and forecasting (modelling) of purposeful SEO development under instability of environment is caused by the fact that any action directed to reaching of the set goals, causes a number of consequences that can in turn prevent from goal reaching.

The number of factors describing such situations can be measured by tens and all of them are plaited in a web of cause and effect dependences. It is extremely difficult to see and realize the logic of development of events on a such multifactor field and at the same time it happens to change the goals and make decisions on the measures providing development of a situation in the necessary direction.

In such conditions it is more expedient to have an opportunity to make a qualitative concept of a situation as a whole at a level of tendencies of evolution of the processes describing a researched situation instead of searching for correctly formulated but rather laborious precise solutions of the quantitative problems, concerning particular aspects of the situation under research. Such "qualitative" picture of a situation development as a whole is more useful when working out a forecast in order to substantiate the purposeful decisions, than attempts to construct exact, but particular model of happening changes. Thus, the shift to qualitative modelling, process structuring, and decision making on the basis of qualitative models is a reasonable alternative.

2. THE STRUCTURE AND GOAL ANALYSIS OF A SEO DEVELOPMENT

When setting the goals of a SEO development a decision maker doesn't always manage to trace if the goals he has set are inconsistent, i.e. reaching of a goal will prevent from reaching of another one. Inconsistency of goals can also be influenced by the chosen ways of their reaching.

It is caused by:

- First, that goal setting affects the interests of a situation participants that (interests) can not coincide with each other.

- Second, that it is rather difficult to take into account the structure of indirect influences between the factors of a situation that can be a source of latent contradictions in goals.

Thus, it is very important to reveal the contradictions already at the stage of goal setting.

The Institute Of Control Sciences of the Russian Academy of Sciences has developed a technique of the structure and goal analysis of a SEO development. The technique is a part of developed technology of cognitive analysis and modelling (Maximov V., 2001; Maximov V., Kornoushenko E., Makarenko D. 2001) and allows to determine integrated (direct and all possible indirect) influences of one factor on the other and due to it to reveal inconsistencies between goal and control factors. The structure and goal analysis also allows to determine the most effective controls, i.e. those from control factors which "are more effective" due to their integrated influence on the goal factors.

Thus, the structural analysis of cognitive model of a situation development under control consists of the following stages:

Stage 1 - analysis of goals (coordinates of a vector of goals) on mutual consistency in order to answer the question "whether the vector of goals (fixed or unfixed) is inconsistent, i.e. whether the reaching of any of goals (coordinates in a vector of the given goals) will prevent from reaching of other goals?".

Stage 2 - check of a consistency of the set of control factors with the given vector of goals, i.e. whether the change of the value of any control factor (with the help of the appropriate control) will promote reaching of some goals in a vector of goals and at the same time prevent from reaching of other goals of a vector of goals.

Stage 3 - estimation of efficiency of influence of control factors on all coordinates of the vector of goals. Such estimation is useful when choosing the most effective control factors the changes of which with the help of the selected control actions will provide the purposeful development of a situation.

The general technique of cognitive analysis and modelling and the structure and goal analysis is depicted on Fig. 1.

The structure and goal analysis enables the analyst:

- to remove the internal contradictions of strategies of a complex object development, i.e. to set consistent goals out of a set of goal factors and to select consistent controls out of the possible vector of control factors;

- to use the opportunities concealed in a situation structure in order to select the vector of control factors that is potentially effective in respect to goal reaching.

2.1. Analytical basics of the structure and goal analysis

The analytical basis of structural and goal analysis is made up by the cognitive approach (Maximov V., 2001) to structuring of knowledge of a SEO development. On the basis of such structuring one can create a cognitive map of a situation. The map determines the structure of interaction of factors of SEO internal environment with a boundary layer of environment.

Cognitive map represents a square table, in which:

- lines and columns correspond with the basic factors of a situation in terms of which the processes in a situation are described in a one-to-one manner;

- the element that is situated on crossing of line "*i*" and column "*j*" reflects the fact of direct influence of the factor "*i*" on the "*j*" one. Sign of this element displays a sign of influence (positive or negative), and the module - strength of such influence in the appropriate scale.

Cognitive map is the initial static representation (reflection) of connections between the factors existing in a situation under research. To solve the problem of a SEO purposeful development that arise in poorly structured situations it is necessary to construct a dynamic simulation model and on its basis to obtain a new knowledge of the structure and dynamics of a situation under research.

Analysis of a graph model of a situation associated with a cognitive map allows to reveal the structural properties of a situation. The basis of the model is a weighed digraph $G = (X, A)$, where X is a set of nodes that biuniquely corresponds to the set of basic factors, A is a set of arcs reflecting the fact of direct influence of factors. Each arc connecting some factor X_i with some factor X_j has the weight a_{ij} which sign depicts the sign of influence of the factor X_i on the factor X_j, and the absolute value of a_{ij} depicts the strength of the influence. Thus the cognitive map can be examined as a connectivity matrix A_g of the graph $G = (X, A)$.

While the situation evolves each factor is being influenced not only by "neighboring" factors, but also by more "distant" ones and these indirect influences are transferred through chains of the appropriate factors and graph arcs that connect them. Set of influences as direct, and indirect to which each factor in a situation is subject is described with the use of concept of transitive closure of a cognitive map of the situation, determined as the sum of infinite power series

$$E_n + A + A^2 + \ldots + A^t + \ldots \qquad (1)$$

of matrix A. Each element of this row characterizes passage of routes of length "*t*" in the graph, i.e. realization of direct and indirect interferences through one factor, two factors, etc.

Estimation of the sum of this series can be obtained only if the graph G adjacency matrix is stable. Then all elements of this series approach to finite limits at unlimited increase of t.

To determine the transitive closure it will suffice to consider N terms in a power series of matrix A, where N - the order of matrix A, i.e. number of basic factors in a cognitive map of a situation. Then the transitive closure of matrix A is estimated by matrix:

$$Q = E_N + A + A^2 + \ldots + A^N \cong (E_N - A)^{-1} \qquad (2)$$

Therefore it is necessary to stabilize graph G of formal description of a situation (Maximov V., Kornoushenko E., 2001).

The goal of a situation development is described by a subset of goal factors of cognitive model. That means that the vector of goals of a situation development is a vector of values of goal factors (fixed goal), or a vector of directions of change of these values (unfixed goal).

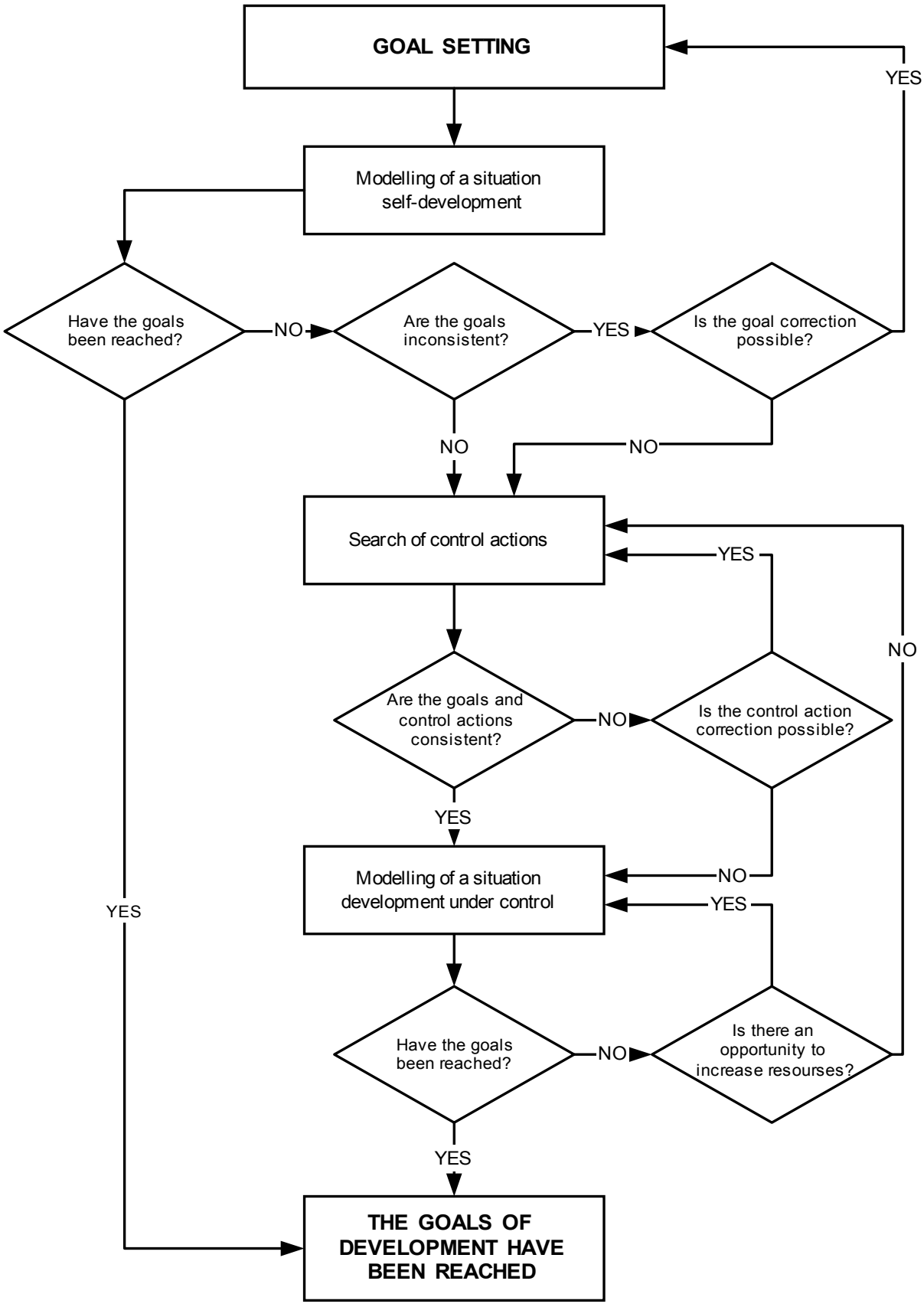

Fig. 1 The general technique of cognitive analysis and modelling

Definition 1. The fixed vector goal includes vector of goals Y^* and preset values of trends of change of each goal Y_i^*.

The fixed vector goal is a point in *m*-dimensional space of trends of goal change. In other words, goal is a vector of some "ideal" values of trends of goal factors change.

Goal setting hypothesis: a decision maker or an analyst can determine what direction of a factor change (the most significant factors for them) is desirable. The desirable direction of change of the factor x_i is determined by a parameter (estimated value) r_i, that possesses the value +1 if the increase of value of the factor x_i is desirable, and -1 if reduction of the factor x_i is desirable.

If the analyst finds difficulty in determination of a desirable direction of the factor x_i change, r_i is considered to be equal to *0*. The parameter r_i refers to as the estimation of the factor x_i change (EFC).

Definition 2. The unfixed vector goal includes vector of goals Y^* and directions of favourable trends of change of its coordinates according to their EFCs.

Vector of favourable trends is a vector of interests of a decision maker (analyst). Restrictions are not imposed on the value of favourable change of goal factors (the more - the better).

Analysis of a goal vector coordinates on consistency. Let $Y = \{y_1 ... y_m\}$ be a set of goal factors and *r(Y)* - a vector of desirable EFCs.

Definition 3. Vector of goals *Y* is consistent if

$$r_j r_k = sign(q_{ik}) \text{ for any } y_i, y_k \in Y. \quad (3)$$

where q_{ik} - *(i, k)*-th element of matrix Q.
If (3) is fulfilled for goal factors y_i, y_k they refer to as consistent, otherwise these factors are inconsistent.

When the consistent vector of goals is formed the desirable integrated change of any of goal factors will not result in undesirable integrated change of other goal factors in a vector of goals.

Analysis of coordinates of a vector of control actions on consistency with a vector of goals. The concept of an EFC is inapplicable for control factors, as the analyst initially (before realization of the structure and goal analysis) does not know how the change of one or another control factor will affect the integrated behaviour of goal factors.

Definition 4. Vector of control factors is consistent with a vector of goals *Y*, if for each coordinate of a vector of control actions $U = (u_1 ... u_p)$ it is possible to determine such sign, that for a resulting sign vector *sign (U)* it will be fair:

$$r_s = sign(q_{st}) sign(u_t) \text{ for any } u_t \in U, y_s \in Y \quad (4)$$

When control factors are consistent with the vector of goals and (4) is fulfilled, any change of control factors according to a vector *sign (U)* will not cause the change of any coordinate of a vector of goals *Y* in undesirable direction. Let *U*(0)* be a vector of control actions the signs of which are selected according to (4), and $|U^*(0)|$ - vector $U^*(0)$ in which all coordinates are replaced with their absolute values. The concepts entered above allow to formulate the following statement.

Statement. If the selected vector of goals *Y* is consistent and the set of control factors is coordinated with a vector of goals it is possible to choose such vector of control actions *U* for which it will be fair

$$|U^*_1(0)| \le |U^*_2(0)| \to Y(U^*_1(0)) \le Y(U^*_2(0)), \quad (5)$$

where $Y(U^*_i(0))$ is a vector of changes of goal factors caused by activation of vector of control actions $U^*_i(0), i = (1...m)$, i.e. property of "domination" by modules of control transfers into property of "domination" by results of their influence on goal factors.

In other words, more "intensive" control (with large absolute values of coordinates) will cause more "intensive" changes of coordinates of the goal vector in desirable directions.

The mentioned definitions are used in situation analysis and modelling. Thus, violation of conditions of consistency of the selected vector of goals can help the analyst to understand the interaction of goal factors and set his vector of goals "more correctly", conforming to the situation. Analysis of the vector of selected control factors on consistency with a vector of goals will allow to resign inconsistent control actions and, on the contrary, to more actively use "advantageous" control factors, the change of which according to control actions affecting them will result in great favourable changes of goal factors.

Analysis of efficiency of integrated influence of control factors on goal factors. The essence of realization of control actions consists in such change of control factors that their influence on goal factors will result in favourable changes of goal factors, i.e. to changes of goal factors in the direction of their EFCs.

In this connection it is important to answer the question "which of the control factors are the most "effective" for reception of a positive effect if compared by their integrated influence on goal factors?".

Formally, the parameter of efficiency $E(u_k)$ of the control factor u_k (i.e. the maximal positive effect from the change of u_k) is determined as absolute value of the sum of coefficients of influence of the given control factor u_k on the goal factors multiplied by EFCs of the goal factors, i.e.

$$E(u_k) = \left| \sum_{i=1}^{m} r_i q_{ki} \right|,$$

where r_i is the EFC of the goal factor y_i,

q_{ki} - *(k,i)*-th element of matrix Q.

Really, the maximal positive effect Δy from realization of control u_k on the factor x_k is estimated as

$$\Delta y = \left(\sum_{i=1}^{m} r_i q_{ki} \right) u_k,$$

where the sign of action g_k coincides with the sign of the sum

$$\sum_{i=1}^{m} r_i q_{ki},$$

and its value is equal to 1.

The above technique of structure and goal analysis as well as the technology of cognitive analysis and modelling of a SEO purposeful development (Maximov V., Kornoushenko E., Makarenko D., 2001) is supported by a dialogue software package (DSP) "Situation-2".

DSP “Situation-2” ensures:

1. Construction of cognitive model of a situation :

- selection and substantiation of the basic factors of a situation;
- establishment and substantiation of correlation of the factors;
- construction of graph model of a situation.

2. Structural interpretation of problems requiring solution in the situation.

3. Structural analysis of the situation under research.

4. Searching and substantiation of strategies of goal reaching in stable or changing situations:

- choice and substantiation of the desirable goals;
- choice of activities (controls) necessary for reaching of goals;
- analysis of basic possibility of reaching of goals from an initial state of a situation with the use of selected activities;
- analysis of restrictions on a possibility of realisation of the selected activities in reality;
- analysis and substantiation of a real possibility of goal reaching;
- development and comparison of strategy of goal reaching.

5. Substantiation of possible scenarios of the situation development.

6. Machine generation of the reports and systematisation of results of a problem modelling.

DSP “Situation” allows to examine two classes of analytical problems:

- structural analysis of a situation;
- scenario exploration of a situation development trends.

DSP "Situation-2" was successfully applied for modelling of the control of strategic development of regions, markets, companies, and other problems.

REFERENCES

Maximov V. (2001). Cognitive Analysis and Situation Modelling. *Proceedings of the 8th IFAC Conference on " Social Stability: The Challenge of Technology Development " (SWIIS'01). Sept. 27 - 29, 2001. Vienna, Austria.*

Maximov V., Kornoushenko E. (2001). Analitical Basics of Construction the Graph and Computer Models for Complicated Situations *Proceedings of the 10th IFAC Symposium on Information Control Problems in Manufacturing (INCOM 2001). Sept. 20-22, 2001. Vienna, Austria.*

Maximov V., Kornoushenko E., Makarenko D. (2001). Use of Cognitive Modelling for Analysis of Socio-Economic Processes and Estimation of Variants of the Regional Development *Proceedings of the 10th IFAC Symposium on Information Control Problems in Manufacturing (INCOM 2001). Sept. 20-22, 2001. Vienna, Austria.*