Long-term projecting in the local or territorial automation systems with alternative network models

A V Potudinskii\(^1\), A V Vlasov \(^2\) and D V Lysov\(^3\)

\(^1\) Military Training and Scientific Center of the Air Force "Air Force Academy named after Professor N.E. Zhukovsky and Yu.A. Gagarin", 54 "A" Old Bolsheviks str., Voronezh, 394064, Russian Federation
\(^2\) Voronezh Regional Clinical Oncology Center, 4 Vaitsekhovskogo street, Voronezh, 394036, Russian Federation
\(^3\) Voronezh State Technical University, 14, Moscow ave., Voronezh, 394026, Russian Federation

E-mail: csit@bk.ru

Abstract. When monitoring long-term target-oriented innovation programs where alternative stochastic network models can be determined and optimized within the period of the project's realization (e.g., transcontinental pipelines, developing oil/gas fields, creating new innovative industrial areas, etc.), we recommend applying the outlined basic structure of a long-term development model. Those models are based on the following concept: in all encountered situations within the progress of the project when the manager is faced with necessity to make a choice from the set of possible alternatives, he has to determine: deterministic alternative scenarios (fragments) which describe different ways to reach the desired target, and a stochastic system (usually a purely stochastic alternative network) with multi-variant outcomes of random nature. Such a stochastic system is fully determined by the chosen scenario and usually follows the latter.

1. Introduction

The complexity and importance of long-term innovative program planning in the framework of overall target-oriented construction programs (TOCP) underline the necessity to apply alternative network models (ANM) in conjunction with other optimization problems related to simulation and development forecasts in regarded economical systems. Without exhausting the full amount of models referring to justification of long-term innovation perspectives of regional development and its subsystems structure, we will commit ourselves in this paper to outlining the broader picture of relationships and connections between the regarded network model and its "closest" models and methods of long-term planning and forecasting [1-5, 7].

2. The structure of a long-term development model

To proceed, introduce the concept of a large-size industrial area (LSIA) comprising multiple innovation projects and construction activities. Consider the general outline of mutual relations...
between the comprised innovation models as part of determining the alternative network properties, its analysis and transformations (see figure 1).

**Block I** comprises general economical forecast models (see figure 1) thus enabling representation of the total economical and social environment to become the background of implementing the TOCP and particular elements' functioning. The block comprises a variety of national economy related forecasts (scientific and technical forecasts are singled out into a separate block) and above others demographical forecasts, employment and manpower utilization forecasts, natural resources forecasts by major types, social forecasts (shifts in social population composition, healthcare and education development, forecasted changes in labor conditions and leisure, etc.), various economical forecasts characterizing industrial requirements and production sector developments, territorial industry related changes, etc.

![Figure 1. Mutual relationships between LSIA's long-term development models and the alternative network model of TOCP enrollment](image)

**Block II** reflects the major influence of scientific and technical innovation progress upon long-term construction. In this framework scientific and technical forecasts of technical and technological improvements in the construction area are accommodated, as well as more specific forecasts related to predicted functioning of the particular LSIA.

Note that possible results of scientific and technical progress are of crucial importance, as well as their prompt implementation into construction practice, which is imperative to assure high economical and technical parameters of LSIA's functioning.

Alternative situations related to scientific and technical innovation events might be either incorporated into the network model straightforwardly (like measures to be taken for construction of experimental industrial enterprises, significant scientific and research studies related to the regarded problem), or be accounted for exegetically, by reflecting variants and events depending on future discoveries and technological innovations which influence construction routine as well as possible structure and characteristics of the regarded TOCP.

**Block III** assumes applying the methodology of structuring the problem of LSIA establishment by means of creating a target tree. Consider formalization of applying a target tree model for TOCP design and analysis in greater detail. The regarded model is based on general assumptions of the "Pattern" methodology [8] as well as the expert estimates method and is created by applying the principle of its maximal orientation to provide results compatible with alternative network environment.
3. **Target tree of a long-term development program**

Assume we are pregiven certain general (both quantitative and qualitative) targets of a long-term innovation program enrollment, as well as variant-related construction plans capable of determining a structural scheme of upcoming construction sub-projects identified with regard to their industrial branches belonging. Information of such kind might be obtained from an innovation program forecast and the general chart of deployment and development of the considered LSIA's complex resources, science- and technical progress forecasts, natural resources utilization, etc., in conjunction with solving a number of macro-economical problems of long-term planning and forecasting of issues like proportions and pace of economical development.

The problem boils down to determining a hierarchical structural scheme of mutual relationships between general and various partial targets and measures, on one side, and particular upcoming construction sub-projects as part of the LSIA, on the other side, including quantified data suitable for further implementation in the ANM.

A target tree is, in fact, one of the most detailed and developed techniques to enable a considerably formalized analysis of the TOCP problem structure. Yet, the contemporary schemes of such kind have a number of drawbacks, to mention just a few of them:

- a) there might be restrictions preventing from straightforwardly representing in the corresponding structural graph horizontal links between targets, tasks and measures to be taken, as well as subordination of certain elements of a particular level to two and more elements (targets) of a higher "adjacent" level of the target tree;
- b) static properties of the target tree which is showing the entire program's structure in terms of final system states, without addressing its deployment in time, without taking into account and representing timely relationships of considered activities, events, variant choice situations, ultimate and intermediate targets.

Target trees are determined on the basis of the structural scheme of the regarded LSIA and should be considered out in parallel with creating the ANM; same expert teams should be recruited both for assessing relative importance coefficients of lower level elements entering the target tree, as well as determining various characteristics of activities simulated by the network model and corresponding to those target tree elements (upcoming construction projects). The results of calculating importance coefficients for the lower level target tree elements are subsequently incorporated into the ANM as additional estimates for the corresponding network activities [9].

Mutual relationships and succession between the target tree and the ANM may be also provided by the following approach. Its substance boils down to consecutive transition from the hierarchical scheme of target taxonomy to a branching tree oriented to the process of achieving successive targets and reflecting possible system development trajectories in conjunction with its critical turning points - which are, in fact, alternative decision-making situations. It can be well-recognized that such a scheme is nothing else but the program's outcome tree which is similar by its structure to the target tree.

At the next stage on the basis of network planning methods the outcome tree is being transformed into an ANM, while in the process of program variants detailing new unaccounted for alternative situations and partial variants are singled out, thus leading to new implementation variants of the entire TOCP. The transition procedure from target tree to outcome tree involves in general terms the following stages.

Assume an appropriate detailing level of the construction program and single out elements (targets) from the corresponding level of the target tree. Order those targets in time and determine their mutual relationships (achievement sequence). For each stage of the program, i.e., time interval between a pair of "adjacent" targets, "bunches" of development trajectories are being determined, which are, in fact, nothing else but TOCP partial variants. Local "bunches" of variants are further on united into alternative branching trajectories structure, which represents possible paths and methods to achieve the ultimate target alongside indicating the variant branching points.
4. Optimization models

As the result of the above stages, the TOCP outcome tree is being established and it may further on be transformed into an enlarged alternative network. The latter might serve an expedient tool of the ahead-of-plan simulated program structure justification as well as providing information for optimization models (see Blocks IV, V, VIII on figure 1). Optimization models, in their turn, provide data for determining a detailed (project related) alternative model of the innovation program.

Block IV corresponds to a generalized LSIA's long-term development model, for instance the general scheme of production forces development and deployment within an economical region or national-wide, with the LSIA being part of them. The general scheme's data is being utilized for determining the network model of the innovation program. At the same time the network model might become an efficient tool for justifying long-term construction related parts of the general scheme.

Block V might comprise either a dynamic inter-branch LSIA balance (or that of a bigger economical system) or static models referring to the inter-branch balance, when the latter are set for a number of moments within the planning horizon. On the basis of the information provided with this block innovation program restrictions for the LSIA are set, either in terms of general volume restrictions or with regard to particular construction projects within elementary planning horizon intervals; also, certain target-oriented characteristics (the so-called "vitally important targets") of construction programs are set up.

Block VI comprises various project documentation (technical and economical reports, project-related assignments, various technical and cost-related calculations) with regard to projects decided to be executed within the considered LSIA. The network model resulting solutions, namely, a full list of the program's construction projects and their most expedient timings to be set up, should also enter the input data package when determining detailed construction documentation.

Block VII comprises information (due dates, cost, etc.) for determining a network sub-graph related to LSIA's construction sites remaining from previous planning horizons. Parameters to be taken into account in this block should include data on past construction history as well as expected output to the beginning of the new planning horizon related to the upcoming innovation program.

Block VIII represents such optimization models of LSIA’s sub-systems long-term development whose results might be utilized in the network model (as, for example, production- and transport-related problems). Should the results of optimizing those models contradict the corresponding ANM results, the block should provide an iterative process of their correction.

The list of optimization models referring to the functional and territorial LSIA structure which enter the framework of Block VIII may include the following models being formalized as linear programming problems in their static or dynamic version:

1) optimization models of industrial cycles (either multi-branch or single-branch);
2) the static model of LSIA's agriculture deployment;
3) optimization model to outline LSIA’s major public communication and transportation networks;
4) a model to determine the optimal territorial deployment of the regarded LSIA;
5) a model to optimize industrial deployment within the LSIA;
6) a model to determine establishment of combined agro-industrial enterprises;
7) partial models to determine development of particular infrastructure elements as well as sub-LSIA territorial units aside models of LSIA resource regeneration; the latter may include:
   • the model of population growth and inside-LSIA population migration;
   • the model to determine public service creation;
   • the model of territorial organization of total development areas;
   • models of particular industries agglomerations, etc.

A specific property of the process of utilizing optimization modeling results to enhance the alternative network boils down to the fact that not only characteristics of the optimal sub-system
variant structure but also those of several variants being close to the optimal are to be taken into account. This circumstance stems from the necessity to unify partial model results into a global TOCP model as well as variant efficiency assessment from the viewpoint of their timely structure optimality (taking into account mutual relationships of network project activities).

Block IX sets restrictions (in the dynamic form) upon construction-related activity volumes to be executed by the LSIA with regard to the planned enhancement of the local construction industry capacity growth. The network model of the long-term TOCP, in its term, enables determining data regarding construction-related activities distribution by time (and, correspondingly, regarding the required increase in construction capacities) which is imperative to its successful implementation. The interrelation between both two models is extremely deep and should by all means be taken into consideration amidst long-term planning of the innovation program.

Note that the outlined above general scheme does not imply to fully represent the entire multitude of long-term planning models to describe a target-oriented construction program within a large-size industrial area by means of alternative network modeling [10]. It rather comes to demonstrate possible paths of including TOCP-type ANM into processes of long-term forecasting and planning of future LSIA establishment and development [11]. Besides, it illustrates the importance to develop and apply ANM methods whilst setting up target-oriented construction programs.

5. Conclusions
The following conclusions can be drawn from the study:

1. The alternative network model representing the innovation program becomes an efficient technique for planning long-term construction and its control whilst creating large-size industrial areas (LSIA).
2. The network model should represent alternative variants of the program's deployment, especially major alternatives related to the entire innovation process. Not to miss such major alternatives, the model might be supplemented by a retrospective network representing the initial period of the LSIA creation.
3. Because of the possibility that the simulated process might comprise stochastic situations, examination of the construction program should be carried out.
4. It is expedient to incorporate into the network model not only "proper" construction activities but also events related to other stages of the innovation process (scientific research and developments, experimental and test activities, related project activities, on-site surveys, test running of newly constructed industrial facilities). Thus, the systematic approach would be facilitated at its utmost.
5. There is need to enhance research related to carrying out "inter-variant" optimization of the construction program, in particular, to tackle problems regarding coordination of the planned construction activities volumes with available regional possibilities of the construction industry. When carrying out such an optimization, it is also imperative to appropriately justify the optimization objective.
6. We have outlined various essential results in long-term innovative projecting. Practically all techniques that have been utilized comprised two basic concepts:
   • deterministic alternative scenarios (fragments) which describe different ways to reach the desired target, and
   • a stochastic system (usually a purely stochastic alternative network) with multi-variant outcomes of random nature.

Such a stochastic system is fully determined by the chosen scenario and usually follows the latter. Moreover, such combinations of a group of alternative scenarios each of them to be linked with a stochastic system may arise several times within the progress of the innovation program.
References

[1] Cooper D F and Chapman C B 1987 Risk Analysis for Large Projects (NY) 260
[2] Ippolito R 2020 Private Capital Investing (John Wiley & Sons Ltd.) 312
[3] Golenko D I 1972 Statistische Methoden der Netzplantechnik (Leipzig: BSB B.G. Teubner Verlagsgesellschaft) 182
[4] Lee J-W and Song K-S 2013 Understanding Business Model and R&D Project Selection The Journal of the Korea Contents Association 13(6) 401-11
[5] Zhai X, Zhou W, Fei G and Hu G 2019 Edge-based stochastic network model reveals structural complexity of edges Future Generation Computer Systems 100 1073-87
[6] Golenko-Ginzburg D and Blokh D 1997 A generalized activity network model J. Oper. Res. Soc. 48 391-400
[7] Azar Y, Bartal Y, Feuerstein E and Rosén A 1999 On Capital Investment Algorithmica 25(1) 22-36
[8] Smith M J 1980 Social R & D: Research and Development in the Human Services Social Service Review 54(4) 607-9
[9] Gauff A and Barona H M 2020 Probabilistic Fuzzy Neural Networks and Interval Arithmetic Techniques for Forecasting Equities Decision Making under Constraints (Springer, Cham) DOI: 10.1007/978-3-030-40814-5_13
[10] Memeti A, Azizi A and Luma-Osman S 2019 Human Resources Management System: SoA Reference Model International Journal on Information Technologies and Security 4(11) 29-38
[11] Mihaylov D 2019 A Way to Accelerate the Process of Gathering Information for Decision-making International Journal on Information Technologies and Security 4(11) 39-50