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V.V. Glukhov, D.A. Siuniaieva

PROBLEMS OF MODELLING AS A TOOL OF ORGANIZATIONAL AND INDUSTRIAL ENGINEERING IN THE ENTERPRISE

В.В. Глухов, Д.А. Сюняева

ПРОБЛЕМЫ МОДЕЛИРОВАНИЯ КАК ИНСТРУМЕНТА ОРГАНИЗАЦИОННО-ПРОИЗВОДСТВЕННОГО ИНЖИНИРИНГА НА ПРЕДПРИЯТИИ

The article discusses the features of modelling in process approach. Process engineering and reengineering are considered to be the mainstream of this work. The article describes the problems that arise during the information transfer from the real object or business process to its model.

MODEL; MODELLING; BUSINESS PROCESS; SYSTEM DISCRIPTION; BUSINESS PROCESS MAP.

Рассмотрены особенности построения моделей при процессном управлении. Основными форматами при этом являются инжиниринг и реинжиниринг процессов. Описаны основные проблемы на этапе перенесения информации от реального объекта или бизнес-процесса к ее системной модели, а также последующего правильного отражения в бизнес-процессах.

МОДЕЛЬ; МОДЕЛИРОВАНИЕ; БИЗНЕС-ПРОЦЕСС; СИСТЕМНОЕ ОПИСАНИЕ; ОТОБРАЖЕНИЕ БИЗНЕС-ПРОЦЕССА.

Organizational and production engineering. The concept, principal stages and use. Process approach used in the organization is aimed to increase work efficiency by introducing the proper chain of interactions, by clear understanding of inputs and outputs at different stages of works and by ensuring the quality of the results obtained at each stage. The process approach is used to manage the entire system of production with its variety of business processes. Thus, companies focusing on organizational and business engineering recognize the need for engineering production systems as well.

The concept of engineering is closely related to the concept of quality management. The concept of engineering first appeared in the consortium of companies which included Polaroid and Boss. The centre for management quality introduces this approach and regards conceptual engineering as a process of identifying the customer requirements and selecting the product or service that best meet these requirements.[1]

Conceptual engineering consists of five principal stages: understanding the consumer environment, transforming this understanding into requirements, applying the requirements to the relevant operational level, and the selection and development of concepts.

In this paper, the concept of engineering is explained primarily in terms of developing conventional production business models and their subsequent implementation in operating activities based on process approach.

[1] Evans J. Quality Management. Moscow, Unity, 2007. 374 p.

Today there is a great number of different definitions and approaches to engineering found in textbooks and media sources. Let us consider the key definitions of engineering. Engineering (English «engineering» – from the Latin «ingenium» – ingenuity, invention, knowledge) is a form of international commercial relations in the field of science and technology, the main direction of which is the provision of bringing research and development to the production stage.[2]

Another definition of engineering is 'works and services, i. e. preparing technical specifications; doing research; drafting design proposals and feasibility study for industrial and other facilities; conducting engineering survey works; developing engineering designs and drawings for the construction of new buildings and reconstruction of existing industrial and other facilities; developing the in-plant and intradepartmental design proposals; designing machinery, equipment, installations, devices and products, such as composition development of alloys and other materials and their testing; development of technological processes, techniques and methods; counselling the process of installation, commissioning and maintenance of equipment and facilities in general; advice on economic, financial or other issues'.[3]

Engineering also includes consulting services, research, design and engineering of computational and analytical nature, preparation of feasibility studies, providing recommendations in the field of production and management. Such works and services are performed ad hoc by the engineering companies on a contractual basis.[4]

Let us consider the principal stages of business modelling: diagnostics, design, implementation. The current state of an organizational model («as is»), as well as the objectives and control of the organizational model changes, are described at the stage of diagnostics. The development of the organizational model options such as «as it should be» takes place at the stage of design followed by options modelling in answering the question «what if ...», evaluation and selection of options on the specified criteria and development and selection of the option implementation strategy. Implementation stage focuses on the reorganization and development activities, monitoring and evaluation of the results and management of change.

The above can be represented in Tab. 1.

Each of the above stages has its own level of significance, therefore, in order to develop sustainable management in the framework of the described processes, it is important to minimize the inaccuracy of data transfer and interpretation for modelling actions and situations.

The documentation relevant for the analysis and the ability to communicate with all the involved participants of business processes are important at the stage of diagnostics. Thus, the stage of diagnostics can be conditionally divided into a sub-stage of «information gathering», and a sub-stage of «the analysis of findings». In practice, the findings often facilitate a better understanding of the main issues for further work.

Why it is more advisable to use the term «modelling» rather than «designing» can be explained as follows: designing is building a concept of the future facility; while modelling is reliable reflection of the current business processes, so that others could work with them and the process of updating and improvement of business processes would be as close to reality as possible.[5] In other words, designing is closer to re-engineering changes in the enterprise, while modelling is closer to engineering changes.

The very concept of engineering is connected with a process, phenomenon or object description. Thus, the concept of business engineering is focused on the business nature of the activities described. The description, in its turn, may have different gradations: description of the process vertically, horizontally, in more detail, in less detail, etc. Being an instrument for engineering the organization's activities, modelling is aimed at improving the quality and efficiency of its work, and, as a final result, at increasing customer satisfaction from the products and services.

[2] Big Encyclopedic Dictionary, edited by I. Lapin, E. Matalina, R. Sekachev, E. Troitskaia, L. Khaibullina, N. Iarina. Moscow, ASTREL, 2004.

[3] Prakhov B.G., Zenkin N.M. Invention and Patenting. Kiev, Tekhnika, 1981. 208 p.

[4] Raizberg B.A., Lozovskiy L.Sh., Starodubtseva E.B. Modern Dictionary of Economics. 2nd ed. Moscow, Infra-M, 1999. 479 p.

[5] J. Evans. Quality Management. Moscow, Unity, 2007. 374 p.

Table 1

Stages	Stage content	Methods, tools, actions
Diagnostics	1.1.1. Comprehensive functional and information analysis of the organization: interaction with the external environment; qualitative and quantitative indicators of the performance evaluation; composition, quality and degree of functions and business processes fulfilment; material, financial and information flows; structure of the organization (organizational, legal, financial, etc.); existing and required resources	SWOT and STEEP analysis. Development and analysis of functional and structural information model of the existing business processes organization (SADT-model). BPR tools. Conducting FCA to identify areas of imbalance «function – cost», definition of cost centres, etc. Dynamic analysis of load and resources allocation, etc. Methods to encourage creative activities («brainstorming», etc.). Working groups meetings with the assistance of external consultants («facilitators»)
	1.1.2. Detection and systematization of problem symptoms	
	1.1.3. Identification of the current problems of the organization	
	1.2.1. Definition of the hierarchy and priority of the reorganization objectives (the desired model state). 1.2.2. Development of constraints in order to achieve each objective: setting time and resource constraints (personnel, financial, material, etc.)	Development of objectives tree. Prioritizing in objectives definition. Expert methods of assessment Table 2
Designing/ modelling	2.1.1. Development of functional and structural information models of rational organization of business processes. 2.1.2. Design of various options of the organizational structure and related management systems	SADT- modelling. BPR tools. Comparison with other organizations Table 3
	2.2.1. Modelling various options of the organizational model («what if...») for all its components. 2.2.2. Prediction of the personnel response to the result of each option implementation	Modelling resources allocation dynamically. Modelling economic financial parameters. Conducting FCA
	2.3.1. Evaluation and selection of options using a consistent set of criteria and constraints	Multi-criteria expert estimation. Development of the «profile» of each organizational model option.
	2.4.1. Analysis of external and internal environment factors of the organization, influencing the development and selection of the change management strategy: deadlines; available resources; positions of the changes initiators; degree of personnel loyalty, etc.	Kotter and Schlesinger model of «strategic continuum». Lewin model of «force field analysis»
Implementation	3.1.1. Mobilization of the resources. 3.1.2. Provision of staff involvement in the process. 3.1.3. Coordination of actions of the process participants	Distribution of responsibilities. Ensuring effective communications. Mentoring and individual counselling. Analysis of the role and career planning. Process counselling and activities for team building
	3.2.1. Analysis of actual and expected values of the criteria for achieving objectives. 3.2.2. dentification of discrepancies and development of corrective actions	Working groups meetings with the external consultants. «Planned – actual» control. Auditing. Interviews with individuals or focus groups

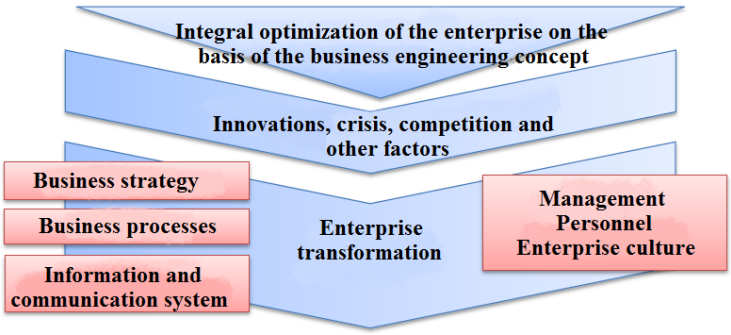

Fig. 1. The representation of the concept of business engineering

Business engineering aims to produce the optimal solution taking into account all the constraints and requirements. This may be the most reliable solution within the given constraints, the simplest one in terms of safety, or the most effective one according to the economic indicators. Therefore, the search for solutions, associated with the analysis of various options in this process, is certainly connected with expert modelling.

The representation of the concept of business engineering is shown in the diagram (Fig. 1).

The components of business engineering include the following: management of transformations at the enterprise, differentiation of solutions level and integrity. So, the principal methods of enterprise transformation within business engineering include: 1) multiperspective enterprise modelling, i. e. information systems of the enterprise, which are closely aligned with the enterprise's strategy, are used and maintained upon this method; 2) Gallen's principles of business engineering; 3) architecture of integrated information systems (ARIS), i. e. work with the enterprise transformation through five prospects of ARIS to consider the business process in different terms, perspectives of organization, performance perspectives, perspectives of data, functional perspectives, perspectives of process management; 4) a semantic model of a three-dimensional object that includes a plan of the enterprise (external perspective), business process model (internal perspective), specifications model of application system (resources perspective).

Thus, the attention should be paid to every stage of engineering modelling that is used in any enterprise, management and production activity within the process approach.

Modelling in modern production systems. General concepts. Generally, modelling implies the study of knowledge objects in their models, the development of models for real objects, processes and phenomena in order to find the explanation of these phenomena and to forecast the various states of these phenomena in the future. Today, there are more than twenty kinds of modelling, each of which is aimed at solving some specific problems.

The Encyclopaedic Dictionary gives the following definition of the model and modelling:[6] Model is a device reproducing and imitating the structure and operation of any other «modelled» device for scientific, production or any other purposes. In a generalized sense, the model is any image or analogue (conceptual or conventional: image, description, diagram, drawing, chart, plan, map, etc.)

Modelling implies studying any phenomena, processes or systems of objects by building and studying their models; models are used to determine or specify the characteristics and rationalize methods for building newly constructed objects. Modelling is one of the main categories of the theory of knowledge: any method of scientific research – theoretical (which uses different kinds of symbolic and abstract models) and experimental (using the subject model) is substantially based on the modelling idea.

The key definition of those given above is the fact that the model is a certain image of an existing phenomenon. The image, in its turn, is inextricably connected with the subjective perception of an expert creating this model, while the perception is connected with the description or, more precisely, with the opportunity and ability to describe the image seen. From this, it follows that the modelling process involves three basic elements:[7]

[6] Big Encyclopedic Dictionary, edited by I. Lapin, E. Matalina, R. Sekachev, E. Troitskaia, L. Khaibullina, N. Iarina. M.: ASTREL, 2004.

[7] Kleiner G.B. Modelling of decision-making mechanism in the enterprise // Economics and mathematical methods. 2002, no. 3.

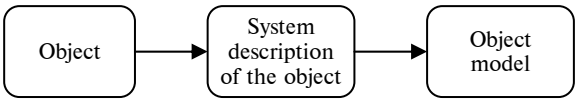

Fig. 2. Problems of modelling in modern production systems

Nowadays the trend can be observed worldwide, according to which everything that happens in the organization is modelled and represented in different terms and formats. However, in practical management, modelling is not always an effective means of describing the objects and phenomena, which is pointed out by the specialists in the field of engineering and mathematical modelling.[8]

The model development should be inextricably connected with the objectives pursued. As a rule, enterprises resort to modelling due to the fact that problems with production, management and strategy that can not be solved for a long period of time entail financial losses and, finally, destabilize the enterprise. Another aspect of the same issue is the fact that building models allows enterprises to predict the development of the current state of an object or phenomenon, and, thus, gives them a chance to change this state in their favour. Thus, two main closely related problems of modelling are the following: the analysis aimed at dealing with the crisis and the reduction of uncertainty in making future decisions. Both of these problems form the basis of modelling, i. e. search and reception of information about the object in due time.[9]

The model understood as a simplified representation of reality requires some measure or criterion to assess its adequacy. Search for this criterion in most cases is a problem that is neglected by enterprises in a number of modelling issues.

It should be noted that there is always a certain discrepancy between the real object and its model. A model is a theoretical entity in some way related to reality that can be independently discussed and analysed.[10] This fact refers to philosophical problems described in the numerous works of I. Kant,[11] the essence of which can be summarized as follows: the researcher is unable to reliably and confidently judge the object as he perceives it subjectively. Each new researcher will perceive this object in his own way.

The relationship between an object and its model in Fig. 2 is indirect, since there is a system description of the object between them. In this case, the gap between the object and its system description can be very significant. For example, the system description of the enterprise may actually reflect only production processes, while the processes of reproduction of resources are not reflected as they are beyond the interests of the researcher.[12]

Following the logic of difference in objectives definition in modelling, it should be noted that restrictions and assumptions are necessarily introduced in model development, and only few parameters that can fully describe the object are selected from the entire set of parameters. It follows from this, that prior to the preparation of any kind of model all (in an ideal system of model development) parameters must be converted into a matrix. This matrix will have transposing properties in view of the fact that, in terms of the purposes, the elements will change places and therefore change their priority.

In practice, it is impossible to fully identify all the parameters of the object, especially when it comes to large production systems. It is much easier to model the operating principle of gears than to create a model of implementation of design on development and implementation of a corporate geographic information system. In addition to the inability to identify all the parameters of the object, there is a problem connected with the fact that, given the large number of variables of the object, the model will be unmanageable and difficult to implement. This may result in a setback from the original

[8] Astakhov A.S. Whether the economic estimates have been specified with the methodology development. *Economics and mathematical methods*, 2000, no. 4; Goldshtein G.Ia. Problems of using mathematical models in the management of economic and production systems. Collected works «System analysis in the economics». Taganrog, Publishing Office of TSURE, 2000; Rapoport B.M. Optimization of Management Decisions. Moscow, TEIS, 2001. 249 p.

[9] Tychinskiy A.V. Problems of modelling application in SES. *Materials of the VI All-Russian scientific conference of students and post-graduate students*. TSURE, KRES-2002.

[10] Ayres R.U. Technological Forecasting and Long-range Planning. N.Y.: McGraw-Hill Book Co, 1969.

[11] Immanuel Kant. Critique of Pure Reason. Translated from German by N. Lossky, verified and edited by Ts.G. Arzakanian and M.I. Itkin; Notes of Ts.G. Arzakanian. Moscow, Eksmo, 2007. 736 p.

[12] Tychinskiy A.V. Innovation management of companies: modern approaches, algorithms, experience. TSURE, KRES-2006.

goals of modelling and the loss of the modelling contents in its simulation. In this case, the following question is relevant: is it always necessary to take into account all the parameters of the object to obtain the desired model?

We suggest that it is necessary in the case of specific production and technical tasks associated with the work of any tools, machines and industrial complexes. As for modelling companies' activities or individual directions of their development, there are some specific features such as:[13]

– instability of statistical characteristics, variability of composition and non-stationary nature of factors that effect the course of the processes modelled at microeconomic level;

– instability of the external environment of the enterprise;

– presence of significant subjective component (influence of decisions taken at the enterprise) in the composition of factors of microeconomic processes;

– difficulty of applying statistical methods and approaches to modelling micro-objects, in particular, difficulties of forming a uniform general population of similar objects;

– possibility of adding «external» quantitative statistical information about the values of modelled indicators of «internal» quality information obtained directly from the insiders;

– absence of continuity in modelling, which is characteristic of macroobjects modelling, insufficient number of publications describing the progress and results of modelling this micro object.

Ultimately, the main problem in modelling is the probabilistic nature of the object parameters used to build an adequate model. This is expressed by a number of factors: irregular production; internal organizational changes that may adversely affect the production; irregular supplies of productive resources; unstable political and financial situation in the country of manufacture; changing market conditions, etc.

In this case, most companies resort to the analysis of trends and dynamics of the phenomenon considered. However, this leads to some averaged estimates, which can not provide the better quality of the model. When developing virtual models of the enterprise, the researcher will inevitably come to the need to take into account the economic system and conditions in general. Taking into account that any economic system is multidimensional and the real conditions are constantly changing and do not always meet the standards, mathematical programming can not fully reflect the conditions of practical implementation and, thus, can not always predict possible losses with sufficient certainty.[14]

To illustrate the difficulties of building the model at the enterprise, let us consider the following example.

The end product is obtained following several principal stages, from the product design on paper to its delivery to the consumer. After the approval of the technical task, it is given to the production department for the development of this product. The production department will send requests to the warehouse for spare parts and other necessary raw materials, or contact the procurement department with the same request. At the final stage of production, the sales department or distribution department will proceed with the delivery of the end product to the consumer.

Today, if the researcher has the task to develop the most beneficial model for a manufacturer, the number of states of each subsystem is so great that the search for the optimum is possible only through the methods of mathematical alignment using moving averages of the initial function.[15]

Production department. Possible load time of equipment, sequence of processes performed on the equipment, amount of work in progress, number of spoiled products and performance of quality department.

Warehouse. Available stocks of raw materials, limitations of products stock.

Sales department or distribution department. Sales figures projection, advertising, distribution facilities, competition.

Thus, it is practically impossible to achieve the optimum that would be the basis of the described model. In this regard, some researchers believe that this approach may be replaced with an approach that uses approximate solutions.[16]

[13] Kleiner G.B. Modelling of decision-making mechanism in the enterprise. *Economics and mathematical methods*, 2002, no. 3.

[14] Skurikhin V.I., Zabrodskiy V.A., Kopeichenko Iu.V. Adaptive control systems for machinery production. Moscow, Mashinostroieniie, 1989. 199 p.

[15] Greshilov A.A., Stakun V.A., Stakun A.A. Mathematical Methods for Forecasts Building. Moscow, Radio i sviaz, 1997. 112 p.

[16] Motskus I.B. Multiextremal problems in designing. Moscow, Nauka, 1967.

In this case, there is a search for areas most closely resembling the optimum, but not the optimum itself.

Even in the late 1960s, scientists noted that the law of the objective function distribution in designing a system with a large number of arguments tends to converge to normal if the objective function (or its monotone transformation) is expressed by a number of terms, each of which depends on a limited number of variables. This condition is satisfied in most cases of EPS management. This enables us to use such optimization methods in managing companies' activities, which minimizes the foreseeable risks associated with the company's management and the possible losses due to finding the solutions (control system engineering costs).

To summarize, it may be concluded that high level of importance of modelling inevitably involves uncertainties and assumptions that are assumed at the initial stages of model development and accompany the modelling process to the very end. Thus, we can conclude that building a model is the process of adaptation. Any modelling involves the following stages: problem identification, problem settlement, the model development and its verification.

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GLUKHOV Vladimir V. – St. Petersburg State Polytechnical University.
195251. Politechnicheskaya str. 29. St. Petersburg. Russia. E-mail: vicerector.me@spbstu.ru

ГЛУХОВ Владимир Викторович – заведующий кафедрой «Экономика и менеджмент технологий и материалов» Санкт-Петербургского государственного политехнического университета, доктор экономических наук, профессор.
195251, Политехническая ул., д. 29, Санкт-Петербург, Россия. E-mail: vicerector.me@spbstu.ru

SIUNIAEVA Diana A. – St. Petersburg State Polytechnical University.
195251. Politechnicheskaya str. 29. St. Petersburg. Russia. diana_syunyaeva@mail.ru

СЮНЯЕВА Диана Анатольевна – аспирант Санкт-Петербургского государственного политехнического университета.
195251, Политехническая ул., д. 29, Санкт-Петербург, Россия. E-mail: diana_syunyaeva@mail.ru