Tools for business processes simulation in rocket and space industry

A V Kukartsev¹,², V V Kukartsev¹,², V S Tynchenko¹,², A I Cherepanov² and S O Kurashkin¹

¹ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russian Federation
² Siberian Federal University, 79, Svobody pr., Krasnoyarsk, 660041, Russian Federation

E-mail: vadimond@mail.ru

Abstract. The article presents a set of tools for improving the system of enterprise business processes using computer-modeling methods. The widespread functional approach to management, based on the old paradigm, in recent decades, has ceased to correspond to the new economic conditions. The rocket and space industry enterprises entered the world market for high-tech products, and therefore the importance of effective methods for modeling business processes in a market economy determines not only the competitiveness of the organization but also often solves the issue of the survival of domestic enterprises in the conditions of fierce global competition.

1. Introduction
The rocket and space industry (RSI) is one of the leading MIC industries in modern Russia. Today, RSI of Russia is experiencing common problems for all MIC sectors: weakening human resources, increasing production costs, lowering its profitability, and ineffective approaches to enterprise management under the new conditions. The most important task of the transition of the RSI enterprise to a process-oriented management system is the development of a toolkit for managing business processes, and the process approach is the basic tool in choosing typical management tools for RSI enterprise business process.

One of the basic tools for managing business processes in an enterprise is a concept of value chains (added value chain). According to Michael Porter, the author of the concept, it is advisable to turn to the value chain (VC), in conducting strategic analysis and choosing an enterprise strategy.

M. Porter identifies five primary and four secondary actions (processes) that make up such a chain in any company. Among the primary processes, it includes material and technical support of the enterprise; production processes; sales logistics; marketing and sales; service. The secondary, or supporting, processes of M. Porter contain procurement; technology development; human resource management; maintaining the infrastructure of the enterprise.

2. Tools for improving enterprise business processes
RSI schemes of value chains make it possible to describe key business processes through product flows without using standards and modeling tools in an optimal form for a given enterprise and a given task to implement process management at a basic level of business process management of an enterprise.
The regulations, a key tool for managing business processes, help to develop an information and documentary base of business processes. Each employee is responsible or he takes part in business process development [1].

The regulation implies the development of normative and methodological documents that partially or fully establish the procedure for managing a business process, the procedure for its implementation, as well as the requirement for resources necessary for its implementation.

The development of the enterprise’s business process system is carried out at the tactical level of describing the process-oriented enterprise management of the RSI. The introduction of a process approach to enterprise management is impossible without the creation of a business process system in the organization, showing the structuring of the enterprise and linking business processes to a well-organized and efficient system.

The matrix of separation of administrative tasks of management (SATM) is compiled in order to clarify the composition of the service functions to be performed by management and maintenance personnel, and to distribute these functions between individual executors and structural units. The SATM matrix can cover both the entire personnel of the enterprise, and personnel in separate areas (functional blocks). Another method involves the preparation of a matrix, which horizontally lists the main functions of the organization, and vertically the structural units (or performers), which are responsible for the performance of functions reflected on a horizontal line. At the suppression of rows and columns, the unit that performs this work is revealed. If this corresponds to the intended management goals, then a plus is put in the cell, if not, a minus. Next, the reasons for the presence of minuses are analyzed and management decisions are made, under which staffing levels are adjusted. The results are correlated with the costs of the system as a whole, i.e., production costs plus business expenses and plus administrative and administrative expenses.

Further, expert estimates are processed. For this, individual assessments are recorded (the sum of points for the characters). The most acceptable method for obtaining collective estimates is to find either an arithmetic mean value or a mode, which undoubtedly differs from estimates obtained according to more accurate methods for processing expert data [2].

The complexity factors of solving managerial problems (K'i) are calculated in a manner similar to the above, i.e. using the preference matrix. Coefficient K'i is entered in the matrix column. Having calculated the weights of operations (V0) and labor-intensiveness coefficients for solving managerial problems (K'i), it is possible to determine the laboriousness of solving each problem:

\[ C_i = \sum_{j=1}^{y} V_{j0j} \]

where: K'i is a coefficient of the complexity of solving the problem j; V_{j0j} is a sum of the weights of operations of the j-th structural unit or official of the j-th task; \([1,2,...,y]\) is a list of officials and structural units.

It is possible to rank all the tasks according to the degree of difficulty in their implementation determining the complexity of solving managerial problems. One can identify the busiest departments and optimize the functional structure, taking into account, for example, the payroll of structural divisions (Fj) determining the workload of officials and structural divisions of the management apparatus.

Calculate the rate of workload units [3]:

\[ A_i = \frac{C_i}{F_j} \]
It is necessary to calculate the total complexity of the tasks of the unit to determine the workload of officials and structural units:

$$S^{i_3} = \sum_{i=1}^{y} V^{i_0} i K^{i_1},$$  \hspace{1cm} (3)$$

where \(i[1, 2, \ldots, y]\) is a list of managerial tasks solved by the management apparatus.

It is necessary either to change the wage funds of structural divisions, or to transfer some operations of the busiest departments to less busy ones in order to equalize the workload standards of departments.

The enterprise scorecard should measure operational effectiveness regardless of the business strategy. It is necessary to measure the operational efficiency of the enterprise’s business processes regardless of whether the enterprise has a clearly formulated strategy [4]. The scorecard should make it possible to measure customer satisfaction with the products of the RSI enterprise. The measurement of the customer satisfaction is very important in terms of understanding the company's position in the market and its development prospects.

At the strategic management level, a Balanced Score Card (BSC) should be applied to improve the efficiency of the enterprise business process management. The developed indicator system using BSC helps to evaluate the effectiveness of the implementation of the enterprise strategy and formulate measures for its improvement [5]. It is advisable to use key performance indicators (KPI), with which you can evaluate the effectiveness and efficiency of business processes at the tactical level.

At the operational level, it is necessary to apply a system of international standards ISO 9001: 2008 to assess the management of business processes. When managing individual business processes at the lowest level, cost, technical, and temporal indicators of their achievement are established. The ISO 9001: 2008 system of standards reveals the essence of the process approach in enterprise management, providing a methodological and regulatory framework for its application at the RSI enterprise. Modeling business processes of any enterprise is an effective tool of developing a knowledge base concerning business processes using modern information technologies. It allows visualizing a description of the enterprise’s activities [6].

It is customary to use graphical schemes (notations), with the help of which the structure of the organization's business processes in the process approach to enterprise management for modeling business processes. The appropriate software tools are used to automate work on modeling business processes based on notations.

Structural and functional modeling helps to describe a static system of business processes visually using a set of modeling standards (SADT, IDEF, DFD, BPMN), and software tools like BPWin, Business Studio, ARIS (figure1). Thus, the application of methods to manage business process for RSI enterprises is impossible without the use of modern information technologies.
Figure 1. Modeling business processes of the workflow of the design office for the RSI enterprise in the BPMN environment.
It is possible to build the most accurate and efficient methods for analyzing and forecasting the indicators for business process performance based on the simulation model. Typically, simulation models are built to find the optimal solution in conditions of resource constraints, when other mathematical models are too complex. Today there exist some new tools specifically designed for of business processes simulation. They are as follows: tools for discrete-event simulation (Service Model, SimProcess); Dynamic modeling tools (ReThink, PowerSim, Ithink); Flowchart based simulation tools (Process Charter, Optima, ARENA). It is optimal to use a set of notations that display information, functional and simulation models and software tools for structural, functional and simulation modeling for a more complete presentation of the studied business processes of the RSI enterprise [7].

CALS-technologies (Continuous Acquisition and Life-cycle Support - continuous supply and product life-cycle support) is the ideology of creating a unified information environment for business processes of designing, manufacturing, testing, supplying and operating RSI enterprise products.

Table 1. Advantages and limitations of enterprise business process management tools.

| BP Management Tool | QMS principles | Tool application level | Key Features and Purpose |
|--------------------|----------------|------------------------|--------------------------|
| Value chain        | Customer focus; mutually beneficial relationships with suppliers | Higher (strategic) | Focus analysis on the result of BP; clarity and logic in determining control processes; value chains are cross-functional; The ability to build a system of business processes of the organization; VC schemes do not show BP dynamics. |
| Regulation         | Director Leadership | Higher (strategic) | It provides the transparency and order in carrying out activities; Significant organizational resources; Development of our own system of templates regulations is possible. |
| Business process system | Process oriented approach; Systems approach | Medium (tactical) | It helps to identify key resources and results of value to the consumer; It creates a knowledge base about the activities of the enterprise; It is the base for modeling and automation of BPs. |
| Matrix SATM        | Employee involvement | Medium (tactical) | It is possible to establish a measure of responsibility for the execution of BP by departments and officials; It helps to eliminate duplication in the performance of official functions; It helps to normalize (optimize) the workload of personnel when performing BP; The area of use is narrow. |
| Scorecard          | Continuous improvement; Factual decision making | Medium (tactical) | It helps to coordinate the interests of employees at various levels within the organization; It indicates the effectiveness of processes (operational direction) and customer satisfaction; It uses only financial indicators stimulates the achievement of only short-term results. |
| Business Process Modelling | Continuous improvement; systematic approach to management | Lower (operational) | It can dramatically increase the efficiency of BP management with a high level of computerization and automation; It is necessary for the implementation of projects of both a general nature and a private one. |
| CALS technology    | Continuous improvement; Factual decision making | Lower (operational) | The concept is implemented in accordance with the requirements of the ISO 9001: 2008 system, which regulate the rules of this interaction mainly through electronic data exchange; Significant financial costs of implementation and support. |
The purpose of applying CALS-technologies as a tool for managing innovative business processes is to increase the efficiency of their activities by accelerating research and product development processes, imparting new properties to the product, reducing costs in the production and operation of products, increasing the level of service in the processes of its operation and maintenance.

The application of CALS-technologies helps to solve the problems of ensuring the quality of the products, since the electronic description of the development processes, production, installation, etc. fully complies with the requirements of international standards ISO 9000 series; its implementation guarantees the release of high-quality products [4]. Table 1 shows the basic tools for modeling business processes of the enterprise RSI in accordance with the principles of the MK system, which is necessary for their implementation in practice. Each tool has its own area of destination, a hierarchical level of business process management (BP) and its key features.

At the initial stage of the implementation of the process approach to enterprise management, RSI, it is necessary to use tools of a strategic level: value chains and regulation of business processes help to develop a system of enterprise business processes and move on to their improvement.

Further, based on the tools database, a business process system, a matrix of SATM, a system of indicators of business processes should be used to improve the performance of business processes, improve the activities of the enterprise, organization management system [5]. At the operational level, you can use the modeling of business processes and CALS-technology to improve the efficiency of business processes, automation and computerization of jobs. Based on the instrumental complex presented in the table, the RSI enterprise can significantly increase the efficiency of its activities and increase its competitiveness.

3. Conclusion

Thus, the knowledge-intensive business processes of the RSI enterprise should be managed based on the set of tools presented in the article, each of them helps to solve problems, both at the operational and tactical, and at the strategic, highest level of organization management.

The rocket and space industry is one of the most complex and knowledge-intensive branches of engineering. Intersectional deliveries are widely used in it, where almost all sectors of the national economy participate. The development of rocket and space technology (RST) is characterized by high science intensiveness, considerable laboriousness, and long development and testing periods. In addition, continuous maintenance and development of expensive unique stands, special complexes and sophisticated equipment is required [3].

Changing the role of innovation in the development of RSI and the economy as a whole, as well as changing on this basis the goals and objectives of the industry development leads to the need to increase the value of innovative management, to reach its corporate level, which, accordingly, presents new requirements for management tools and methods [5]. The need to ensure the innovative development of enterprises of the RSI, the variability of the economic environment of its functioning and the high level of uncertainty of the decisions made necessitate the development, effective application and improvement of tools and methods of management of enterprises of the RSI, taking into account the innovative component.

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