INFORMATION, QUALITY MANAGEMENT, ENGINEERING MANAGEMENT: COMMON TASKS AND SOLUTIONS

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ABSTRACT

The principal aspects of existing approaches to management of organization, dominants of its sustainable development, allowing to form new additional competences for a specialist, to form a theoretical and practical basis for training of an engineer manager are considered. The generality of the accompanying tasks, solutions and synergy of their implementation are declared in the system of priorities of Total Quality Management (TQM) and modern innovation and communication technologies on the example of large, structurally heterogeneous, logistically complex infrastructural systems of the transport industry. The authors set a goal to show why these provisions acquire special significance precisely for infrastructure transport and logistics structures, where the price of risk, error, insufficient protection of information is too great.

Keywords: *transport, logistics, quality management, information, security, engineering management.*

Background. *Considering the synergy and dynamics of development of information technology (IT), it is necessary to clarify first of all what is meant by the term «information». There is a large number of alternative meanings of this term applied to various fields of knowledge. The founder of cybernetics and the theory of artificial intelligence N. Wiener, for example, considered information to be a fundamental term that could not be defined in simpler terms and, in turn, defined it as a certain substance capable of being transmitted between objects and systems, while not being matter or energy.*

The mathematical definition of information based on the opposition of the concept of entropy (ignorance, chaos, uncertainty), among other things, allows the mission of any IT specialist to be formulated as a struggle against uncertainty, opacity, unpredictability of the system as a participant in the automation process, moderator of the economic, technological mechanism of organization. The logical consequence of this understanding is that if, as a result of the activity of the Chief Information Officer (CIO), the number of failures of automated systems (a sign of unpredictability) has increased or remained constant for a certain time, but transparency and manageability of the business has not increased, then the management has a candidate for dismissal.

In turn, the main principles of the Total Quality Management (TQM) are aimed at decreasing entropy: a systematic approach, a process approach, decision-making based on facts and aimed at achieving long-term success by satisfying customer requirements and providing benefits to members of organization and society.

Objective. *The objective of the authors is to consider different issues related to information, quality management and engineering management.*

Methods. *The authors use general scientific methods, comparative analysis, evaluation approach, economic assessment methods.*

Results.

1.

It is easy to see that the missions of an IT specialist and a specialist in the field of quality not only intersect and are synergistically active, but in fact they should be harmonized and complement each other in their daily activities. This is particularly evident in reorganization or integrated implementation of information systems and technologies in any construction corporation or transport organization. The first step in solving such problems is description of business processes, which in future will form the basis of a quality management system, being a basis of an organization. Software and hardware automation tools, design automation tools, operation techniques, staff involved in performing process operations can change, but the process itself does not change.

Today, qualitative changes occur in all spheres of life and economic activity in connection with introduction of fundamentally new means of storing, processing and transmitting information, the economy enters the fourth phase of the industrial revolution, and the industry 4.0 (the power of the Internet of things) is determined by ten technological areas.

1. **Horizontal and vertical system integration of infrastructure and logistics structures.** *Industry 4.0 requires a review of the attitude to the data and networks used. Now this is means of interaction of not only departments within the enterprise, but also of various partner enterprises in the production cycle.*

2. **Internet of things***. Devices and built-in infrastructure sensors will exchange information in real time.*

3. **Cybersecurity.** *Without it, it is impossible to create a trusted environment (which is essential for large transport and logistics systems), in which billions of devices and intersecting information flows can work.*

4. **Clouds.** *The task of supporting many types of devices and sensors, as well as the mass of data generated by them, is best solved by using cloud services that can provide both the required processing speed and scalability of infrastructure solutions.*

5. **Analysis of big data.** *The availability of data for all phases and aspects of development, production and testing allows to more accurately plan business processes, innovation, marketing and development strategy.*

6. **Modeling.** *With the availability of big data and large processing capacity, enterprises can virtually simulate the use of a product or service, thereby speeding up their testing and expanding the innovation process: unsuccessful solutions will be identified quickly.*

7. **Additive production (3D printing).** *Additive production methods will be widely used for production of small batches of products on individual order, which are designed to combine the advantages of complex structures with minimum weight and will reduce transportation costs and reduce inventory.*

8. **Augmented reality***. Workers will receive instructions on how to replace a faulty node directly when they are reviewing it. The necessary information falls into the field of view of the performer with the help of devices of augmented reality, for example «glasses».*

9. **Robots.** *For the most part, they are realized in the form of mechanical hands working on assembly lines, but their intelligence grows, which allows solving more complex tasks than performing basic assembly or transport operations.*

10. **Smart management**. *A sharp increase in the mobility of any employee. An engineer manager can work in the ERP-system from his smartphone, and the production process can be managed remotely. Due to the fact that 3D-printing (also called additive production) transfers production closer to the source of raw materials or components, the ability to create a product and manage its production from a mobile device becomes quite real.*

All this imposes new demands on a specialist in the field of quality and engineering management, the processes of its preparation, and the introduction of IT into the management systems of the organization of the transport and construction complex involves, first of all:

- *determination of the impact of the organizational and functional structure of the organization on the architecture of the corporate information system (CIS);*
- *the structure and set of IT that are needed to improve the efficiency of business processes in the catalogs of IT services;*
- *evaluation of the possibility of maintaining the IT services of the current CIS, the rationale for its parameters and cost;*
- *calculation of the efficiency of applied IT-services and IT costs;*
- *evaluation of the impact of disruption (interruption) of IT services on the main business processes;*
- *assessment of the risks of violation of IT services, methods and cost of information protection;*
- *development of the IT services metric and metrics of automated business processes;*
- *establishment of organizational structures to support IT services, information security management systems and the company's IT infrastructure in general.*

It is clear that for the effective solution of the above tasks specialists are required who have both professional engineering competencies and competence in the field of quality management, economics, and IT technologies.

Professional competences of an engineer manager are system thinking, inter-industry communications, project management, lean manufacturing, information and communication technologies, robotics, artificial intelligence, programming, relationships with people, work in uncertainty, risks, skills of creativity, ecological thinking.

Unfortunately, the current state of Russian education is characterized by an insufficient level of training of engineering specialists in the field of economics and management. This leads to numerous attempts to transfer the leading managerial positions in high-tech areas to so-called «*professional managers*»*, most of whom do not possess the necessary engineering knowledge and system thinking, which adversely affects the effectiveness of complex technological production, information systems and quality management systems.*

In our opinion, the educational program for training of such a specialist along with the classical engineering disciplines of the transport and construction complex, quality management and IT should include the following «*not very engineering*» *sections:*

- *trends in development of information technology management;*
- *information resources, information as an object of work;*
- *quality theory, a cycle of continuous improvement, the Pareto toolkit;*
- *maturity model of production processes (CMMI);*
- *basics of analysis and design of complex systems;*
- *analysis and modeling of integrated business processes;*
- *management of IT-services;*
- *information security, risk management.*

2.

Let's consider some aspects of modern approaches to management of an organization, the study of which will allow an engineer to take a slightly different look at his place in the company's IT infrastructure, to form new additional competencies for a specialist and to make a theoretical and practical training base for an engineer manager.

In modern conditions, the large-scale tasks facing programmers are sometimes so complex that the automation of processes at the current level of technologies is either not possible or not cost-effective. That is, the complexity of the processes and objects of the infrastructure that have been processed has reached a level at which it is difficult to obtain a quick and guaranteed result in automation, and processing automated systems, including the servicing staff, demonstrate unpredictability, due to their complexity, in terms of reduced reliability.

This phenomenon in the information technology industry began to manifest itself quite a long time ago and by now has become a crisis that led to identification of two areas of development: development of management methods for information systems with special emphasis on their «human» component and application of methods of formalized description of real world objects in languages, on the one hand, close to the natural, on the other – rigorous in order to provide a facilitated «machine» representation (programming).

The logical result of the first trend of «resistance to the crisis» was the emergence of standards, sets of recommendations and models of management of IT services – ISO 20000, COBIT, Information Technology InfrastructureLibrary (ITIL), Capability Maturity Model, etc. In general, the ideology of this trend is reflected in the words: «best practice – this is adherence to the best practices». At the same time, «best practices» are fixed in constantly updated standards, this process is accompanied by completion of appropriate methods of objective assessment of organizations' compliance with their requirements.

Within the framework of the second trend of IT technologies development, a significant reserve has been created in the form of the paradigm of object-oriented design of automated systems and the universal modeling language UML (Universal Modeling Language). Work continues on development of universal formats for document description – XML.

In the system of best practices, a special place is given to maturity models of production processes. In the mid-1980s, the first model of the company's maturity, the Capability Maturity Model (CMM), was developed by Carnegie Mellon University (SEI) at the initiative of the US Department of Defense. The purpose of its creation is to provide a predictable level of quality of third-party software by means of their ranking by the efficiency of internal production processes. The ideology of the project is the basic postulate of the theory of quality: a quality product can only be produced if there are qualitative production processes. The basis of the initial version of the model is the maturity matrix of quality management (Quality Management Maturity Grid – QMMG), proposed in [1]. In November 2011, the next version was released – 1.3 CMMI (I–integration or combined), which contains five levels of maturity of the organization:

- *– initial;*
- *– managed;*
- *– defined;*
- *– quantitatively Managed;*
- *– optimizing.*

The growth of the organization's maturity implies an increase in the quality of services or products, reducing risks and personal dependence, reducing internal and external conflicts, and moving from project management to process management.

Based on the primary descriptive characteristics of the levels, the CMM model provides a relatively simple tool for rapid assessment of the current state of *the organization and the development of primary recommendations for a development strategy. The model pays much attention to the phenomenon of «conflict», which can manifest itself at various stages of project implementation and process implementation. At the same time, the conflict is viewed as a phenomenon inevitable, often useful and requiring management. Moreover, conflict management is the management of the organization's adaptation process to changing external conditions, as well as its elements to each other. The presence, size and effectiveness of conflict resolution are directly related to the achievement of a certain level of maturity and serve as its characteristic.*

This approach fully corresponds to the provisions of the theory of complex systems, where conflict is considered as a natural process of their interaction within the development process.

What is a complex or simple project, a complex or simple system?

Between simple and complex systems, there is a boundary: if the system consists of less than eight objects, then it is simple, and for more than eight elements it is complex. The criterion in this case is the ability of the human brain (observer) to control a number of objects at a time [2].

In mathematical theory, there are two main indicators of complexity: static complexity and dynamic complexity. A static complexity is a number of objects entering the system, and a number of connections between them. Dynamic – takes into account the processes that change over time, occurring in the system (between constituent objects) and with its participation. An additional problem in the analysis and design of complex systems is the fact that when two or more of them merge (join) two or more of them, the combined system receives a set of so-called emergent properties and parameters that is not the sum of parameters and properties of the constellations included in it. Often, from the presence of these properties, the definition of the system as a synergetic entity consisting of a number of elements is derived, which, when combined, ensure the appearance of new significant system-forming qualities. That is why in engineering practice there is often a situation when the combination of effectively operating subsystems leads to a violation of the correct functioning of the system as a whole.

3.

From an engineering point of view, it is important that almost any functioning system (organizational, information, mechanical, electronic, etc.) is a complex system and, as a result, it cannot be effectively analyzed, forecasted and controlled, since it often consists not even of dozens, but of millions of elements dynamically interacting with each other. Quality management systems, business process systems of the organization, CIS unconditionally belong to the class of complex systems. Therefore, approaches to their analysis and design are always invariant. And in this case, one cannot do without a methodology, which is often called systemic thinking, which assumes the combination of a vision of the complexity of any object and its inclusion in other systems, depending on the purpose of the examination. In this case, the division of the real world into separate systems and the level of detail are determined in accordance with the understanding of the limitations of consideration, solely by the will of the observer, based on the short-term goals of his activity, and should change with the changes in the initial settings.

Actually, therefore, when developing functional requirements for an automated system, it is necessary to choose the level of consideration (level of detail) correctly. At this design stage, the system appears as an integral entity that interacts with other automated systems and users – the so-called «black box». However, the description of the individual elements of the system being designed in the requirements would be redundant, since the limitations of the ability of the author of requirements and other interested persons (the customer, the executor, etc.) are effectively ignored, with minimal errors, to analyze the real needs of the domain and be able to agree on the project document at several levels of detail at the same time.

The described approach in engineering methodology is called **abstraction**. *In general, abstraction is an exception to the consideration of the details of the system (or its links) that are not relevant to the designer at the current stage of work.*

A frequent design error is an attempt to perceive the system without an exact binding by the time or stage of the life cycle of the project (product). In this case, it is difficult to realize the idea of the system without fixing the target state of the project, it is as if stretched in time, and for an unlimited perspective. It is in this situation that the functional requirements contain clauses on «flexibility of user customization», «universality», «support for heterogeneous perspective platforms», etc. It turns out, the designer or the project manager considerably complicates the task at the expense of increase in dynamic complexity.

In general, it should be noted that abstraction involves a conscious and justified imposition of a maximum number of restrictions on the projected system or the project being implemented, proceeding from the priorities of the operational objectives existing at the current time.

The next approach – **the hierarchy** *– is the opposite and at the same time the addition of abstraction. When abstracting, internal parts of the system are not taken into account and analysis or design cannot be fully implemented. Hierarchy allows to eliminate this flaw. Considering the system as a whole, we can perform its decomposition into a limited number of elements (subsystems), which in the next stage will be subjected to individual analysis as «black boxes». Given the existence of a boundary between simple and complex systems, the number of such elements at each stage of detailing should not exceed a certain limit in order to preserve the idea of their interaction in the process of work.*

Such a decomposition is carried out repeatedly until the required level of detail is achieved, thus creating a hierarchy of representations that are accessible to the analyst at each level. This analyst may in turn be a part of a hierarchical organizational structure in which, for example, a general designer appears at the top level of detail, or perform his work, moving consistently between «top–down» levels or decomposition elements within a single level of detail.

In case of decomposition at different stages and levels of detail, different principles and criteria can be used. In engineering practice, decomposition is most often performed according to a functional feature, taking into account the possibility of evolution or the individual life cycle of an element as an independent product. For example, when developing a complex software package, elements that can be upgraded and sold as stand-alone software products are highlighted. Another engineering approach to decomposition uses the criteria for maintaining an equal level of complexity of shared elements while minimizing the interrelations between them. A typical example of such a decomposition is the automatic arrangement of electronic components and conductors on layers of printed circuit boards.

The limit of decomposition in analysis or design is the achievement of a level at which the constituent subsystems can be represented by standard unified entities. This is actually the third most important approach in the engineering methodology of complex systems – **unification**.

At the same time, an effective tool for analysis and design is **visualization**, *which allows to activate the intuitive and imaginative thinking of the analyst and the designer. Visualization involves, along with the creation of graphic images of material objects of various levels* *of detail, the development of abstract schemes of various types, for the analysis and optimization of which the formal mathematical methods of graph theory are successfully applied. The main things here are the structural diagrams that contain information about the elements of the system and their relationships at the current level of consideration, and functional diagrams that detail the information about the functions of the elements and the relationships between them.*

4.

In practice, a large number of standard schemes are used to illustrate the processes. These include, for example, IDEF0-diagrams, which allow the standard graphical language to describe the sequence of operations.

At the stage of the primary description of automated systems, the use of so-called standard «case diagrams» or «use case diagrams», which are part of the universal modeling language UML (Universal modeling language), is also considered quite effective.

Fundamentally, the system of the organization includes performers, tools and equipment used by them, methods and procedures of work. These components are amenable to replacement – an expert can take a vacancy and leave it, equipment is replaced in connection with real or moral depreciation, individual procedures and technological methods, forms of services can be improved, replaced or excluded. At the same time, the functioning of the organization, the provision of services and the release of products from its side are maintained by maintaining a component that unites all the components of the process. That is, the process approach remains the basis for management and organization of IT services, IT-services aimed at ensuring quality and meeting business needs.

Management of IT-services is realized by their suppliers by using the most rational combination of people, processes and information technologies.

As the range of tasks that can be solved with the use of information technology and the transfer of an increasing number of business processes into digital form expand, the role of IT departments is radically changing. The success of the company today depends to a large extent on how effectively and qualitatively its IT service helps to solve management problems, maintain competitiveness and satisfy the growing demands of consumers. For quality service, it is necessary to clearly identify the range of services provided and make them available to those who need them.

Moreover, the very concept of IT-service is inextricably linked with quality management and is based on measurable metrics, reliable information. Do not consider IT services as something static – they naturally change in accordance with the tasks and needs that they generate and accompany throughout the life cycle.

And one of the mandatory fields of activity in the field of engineering management, IT technologies and quality management is the provision of information security, the level of synergetic interaction with the transport safety system. Although often the security of information technology and its correlation with transport security is not fully understood by both the management of organizations and employees. Meanwhile, the organization of security and quality control are two primary tasks for any enterprise. Security organization is protection against threats, and quality control – ensuring the planned and stable production of products or services.

Let us emphasize: on the way of the transition of society from an industrial society to a knowledge society, information is fundamental. Therefore, it must be protected [3, 4], which for many enterprises will also mean fundamental changes in people's minds, because in this sphere no one has canceled the so-called human factor. It is impossible to imagine the implementation of business processes without information support, and information technology is not considered a guarantee of entrepreneurial success.

Conclusions. *For infrastructure transport and logistics structures, where the price of risk and error is too high, the provisions discussed in this article are of particular importance. To provide information security means to move from an unspecified level of security to a predetermined one by introducing organizational measures implemented throughout the company. It is necessary to include in such measures, first of all, development of a policy of local security at each level of the organization's hierarchical ladder. Constantly applied at the professional level, quality control mechanisms should ultimately contribute to the strengthening of security. At the same time, the integrated information security management system, although consists of similar organizational and technical components, will be different for different companies depending on business models, the degree of formation of the process of electronic turnover of IT infrastructure, communication facilities and security structure, and general performing discipline.*

It is clear that the goals of information security and the requirements for the quality of products and services should be harmonized and mutually linked at the technological level.

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