Method to improve Information Assurance Quality for Research and Development at Knowledge-based Enterprises

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Abstract

The article considers the need for improving the quality of knowledge-based enterprise information assurance at the current stage of high-technology product manufacturing. It suggests the method to improve the quality of R&D information assurance at knowledge-based enterprises based on advanced mechanisms of their production organization system information assurance. The method was tried out on the basis of the Scientific and Technological Center of Unique Instrumentation (Russian Academy of Sciences).

Keywords: *information assurance quality; knowledge-based enterprise; information technologies; information system.*

1. Introduction

One of the priority areas of improving the activity of modern knowledge-based enterprises is reaching the higher quality of their information assurance (IA).

IA means the combination of information resources and services required to solve management, creative and scientific-technical problems in accordance with the stage of their implementation (Brezhneva, V.V., Minkina, V.A., 2004). Latest advances in the IA of knowledge-based enterprises should focus on providing continuous information assistance for high-technology production processes.

The quality of IA in accordance with the terminology adopted in the fundamental ISO 9000-2015 standard for quality management systems (ISO 9000:2015) means the degree of IA specific features conformity to established requirements.

The existing specificity of high-technology production implies a number of special requirements to the IA quality of knowledge-based enterprises such as:

- The possibility to process large quantities of data by personnel simultaneously in groups;
- High integratability of various information systems (IS) and automated control systems (ACS) within the shared information space (SIS) of an enterprise;
- The possibility to ensure continuous information monitoring of production processes by the top management of an enterprise;
- Speed and timeliness of data acquisition by personnel at any stage of high-technology production, etc.

Most existing measures taken to achieve the required IA quality are based on the local informatization of structural units of companies. Such measures often give no desired result since they are not systematic enough and feature the following problems associated with them:

- High risk of irrecoverable data losses in case of multiple data transfer;
- Long time of data exchange between company personnel;
- Insufficient effectiveness of production process supervision and monitoring by the top management of the company.

Such problems are mainly caused by the low efficiency of IA mechanisms along with the insufficient systematization of information management by company structural units. The low level of certainty and the absence of existing mechanisms for data exchange between the elements of the enterprise production organization system adversely affect the IA quality. The major factor in this process is that the issues of IA integration with production organization systems of knowledge-based enterprises have a relatively low theoretical and practical coverage.

Despite a significant number of studies (Carlock, P.G., Fenton, R.E., 2001; Overby, E., Bharadwaj, A., Sambamurthy, V., 2006; Grodzensky, S.Y., Grodzensky, Y.S., Kalacheva, E.A., 2014; Asanov, A.N., 2013) focused on the comprehensive investigation of implementation and provision of effective company information assurance, the issues related to improving the IA quality and providing its high integratability through the development of data exchange mechanisms are still virtually unexplored. One can observe a general insufficiency of measures taken to develop effective informatization management systems and methods for knowledge-based enterprises

(Litvinenko, O.A., 2011). All these facts lead to a conclusion about the systematic nature of the problem considered within the knowledge-based industry.

In this connection the studies focused on the development of measures to improve the quality of information assurance at knowledge-based enterprises become relevant, and these measures are based on the improvement of IA mechanisms. Since the key feature of knowledge-based enterprises are their advanced research and development (R&D) field, the primary and most important measure within the entire chain of a knowledge-based company is to improve the quality of R&D information assurance.

The objective of this paper is to develop a method for improving the quality of IA at the R&D stage of a knowledge-based enterprise based on the improvement of IA mechanisms for its production organization system.

2. Structural content of the method to improve IA quality

The proposed method for improving the IA quality of R&D includes 3 consecutive stages:

1. Displaying existing R&D IA mechanisms of a knowledge-based enterprise and analyzing their effectiveness.
2. Reorganizing exiting information mechanisms of the R&D stage based on the principles of systematic and continuous personnel information interaction.
3. Practical implementation of improved IA mechanisms in the R&D production organization system based on IS selection and introduction.

Let's consider in more detail the stages included in the proposed method.

2.1. Displaying the existing R&D IA mechanisms

An initial step of the method is to display the existing IA mechanisms including personnel and communication channels (information flows) used for data transfer.

Information flows within the production organization system of an enterprise can be implemented as follows:

1. “Man / Man” flow – determines direct information interaction among company employees using IT.
2. “Man / Process” flow – determines information interaction consisting in technical and organizational management, monitoring and supervision of ongoing processes by company personnel using IT.
3. “Man / Process / Man” flow – determines reciprocal information interaction consisting in technical or organizational management, monitoring and supervision of processes by company personnel and possible personnel teamwork using IT.

The “Man / Process / Man” information flow implemented in a company is the most perfect form of information interaction when running production processes and making management decisions at any stage of knowledge-based production.

Existing IA mechanisms need to be displayed by modeling. In our opinion, one of the most suitable modeling methods is the structural algorithm presentation in a graphical form. Structural algorithmic modeling methods are widely applicable in various industrial activities of people such as production system automation, software development, multiple multiprocessor machine engineering, corporate business process re-engineering, etc. The structural algorithm presentation consists in successive displaying of processes and operations required to achieve the planned result.

Since structural algorithms in their initial forms are only aimed at displaying the sequence of operations (processes), in order to reflect as many as possible elements of the production organization system, at the R&D stage as well as their specific relationships, a typical block of each system process should include the following items involved at this stage:

- Special equipment (if any);
- Documented information;
- Personnel (in a hierarchical sequence).

In order to visualize existing IA mechanisms, the structural algorithmic model of the stage should also include graphic representation of information flows.

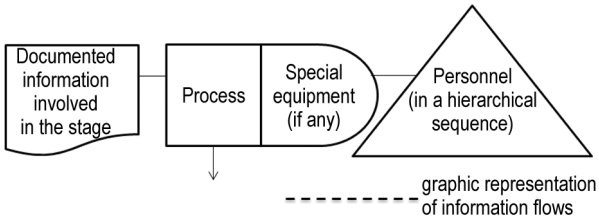

Figure 1. Graphic representation of the composition of a typical structural algorithmic model block

Fig. 1 shows graphic representation of the composition of a typical structural algorithmic model block.

The final operation at the first stage of the method is the analysis of existing IA mechanisms for their effectiveness and the need for further reorganization.

2.2. Reorganizations of existing IA mechanisms

The second stage of the method is to reorganize of existing IA mechanisms. It becomes possible based on creating a system of interrelated and reciprocal information flows providing the possibility of group information interaction between the participants within each process implemented. In this case, a significant number of information flows should be implemented in the “Man / Process / Man” form. The result of the second stage should be an improved R&D model with reorganized information flows and perhaps an improved structure.

2.3. Practical implementation of the improved R&D IA model

The third, final, stage of the method is the practical implementation of the improved R&D IA model based on selecting and introducing IS with relevant software and hardware.

Currently, the global market of information technologies (IT) is represented by a vast number of IS and software packages with various functions that provide information assurance for any kind of human activities. Such systems include: ERP (Enterprise Resource Planning), CMS (Content Management System), BPMS (Business Process Management System), etc.

Now it is quite difficult to ensure a comprehensive effectiveness analysis of the introduction of all IS offered on the market. Nevertheless, an IS that completely meets the requirements of continuous information assurance of business processes and electronic data representation can be implemented in two most effective ways:

1. Implementing PLM system (Product Lifecycle Management) as a basic component of CALS-technologies.
2. Implementing EDMS (Electronic Document Management System) in combination with CAD system (Computer Aided Design).

Table 1 shows a comparative analysis of the feasibility of using PLM or EDMS + CAD depending on R&D stage features of a specific production organization system at a knowledge-based enterprise. Despite the limited nature of IS comparison criteria, there is a number of attempts to create integrated methods for IS selection and their introduction effectiveness assessment depending on production organization system

features of knowledge-based enterprises (Porsev, K.I., Esaulov, N.P., Kuznetsov, V.V., 2016).

No.	R&D stage feature	PLM	EDMS + CAD
1	Number of employees involved	Most effective with 100 persons and more	Most effective with up to 100 persons
2	Process complexity level	Involves a significant number of complex design and production processes	Mostly oriented at electronic document flow with additional design options
3	Expenditures	Minimum IS price on the Russian market starts from RUB 900,000	Minimum IS price on the Russian market starts from RUB 480,000
4	Document flow volume	Most feasible at high document flow volumes	Feasible at any document flow volume

Table 1. Comparative analysis of the feasibility of IS introduction depending R&D stage features of a knowledge-based enterprise

Once the most suitable IS is selected, it can be further introduced taking into account reorganized information mechanisms by the company itself or a company providing IS introduction services.

3. Example of practical implementation of the proposed method

To exemplify the practical implementation of the provisions composing this method it was tried out on the basis of the R&D stage of the production organization system at the Scientific and Technological Center of Unique Instrumentation (Russian Academy of Sciences) that has global priority in conducting fundamental and applied research in the field of scientific instrumentation and optics (Neimark, V.M., 2002).

The first stage of the method was to determine the structure of the Scientific and Technological Center R&D and build a model of the stage indicating existing information flows as shown in Fig. 2.

The analysis of the effectiveness of existing R&D stage IA mechanisms allowed us to identify a number of the following features:

- There are no system-oriented mechanisms of simultaneous information interaction between all the participants.
- Information interaction between employees is limited to two successively executed processes and features the absence of practical implementation of “Man / Process / Man” flows.
- The total time of the R&D stage (T_R) is an aggregate indicator of individual intervals of the time spent for executing stage processes (T_i) and features a significant dependence on the single indicator T_5. A negative solution as a result of the cyclic process can determine multiple duplicating of time and, as a consequence, economic expenditures at the R&D stage:

$$T_R = \sum_{i=1}^{n} T_i$$

The features of the existing R&D IA mechanisms enabled us to conclude about their relatively low efficiency in solving the problems of continuous information assurance for the stage process. A consequence of this is a significant excess of time and economic expenditures for production. It becomes necessary to improve the existing IA mechanisms.

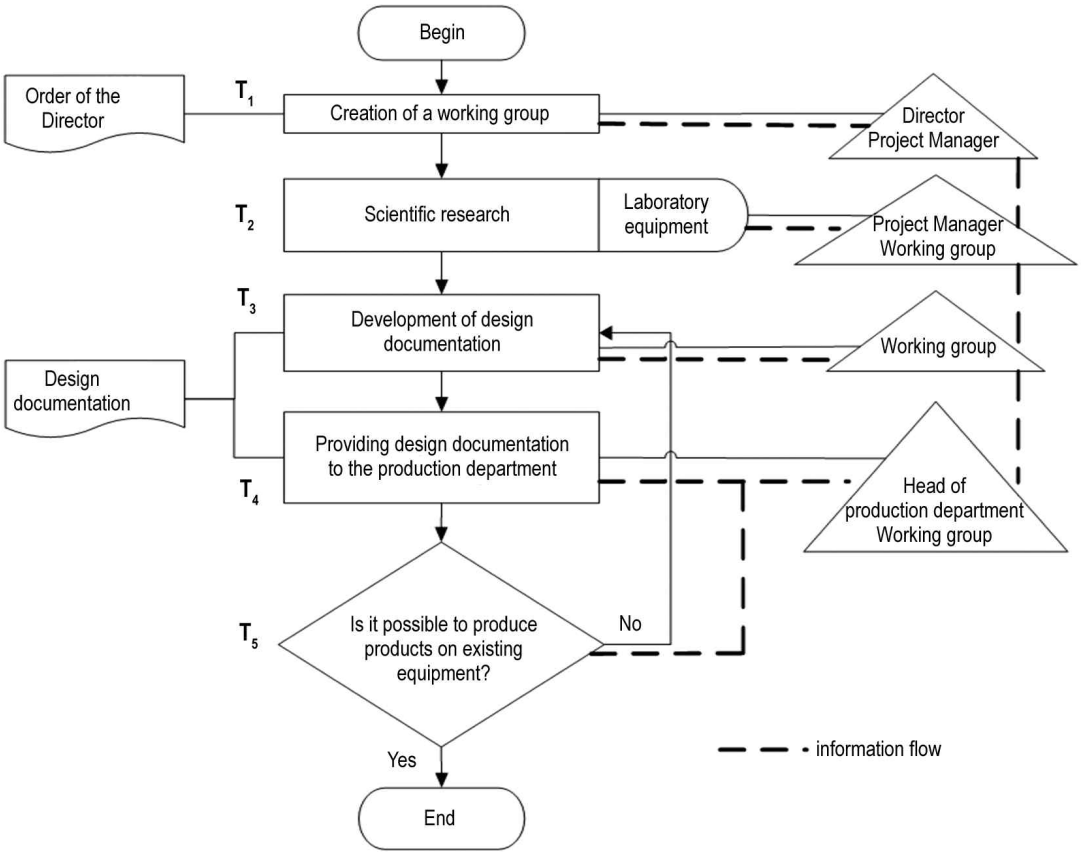

Figure 2. Structural algorithmic model of the R&D stage at the Scientific and Technological Center of Unique Instrumentation (Russian Academy of Sciences) with existing information flows

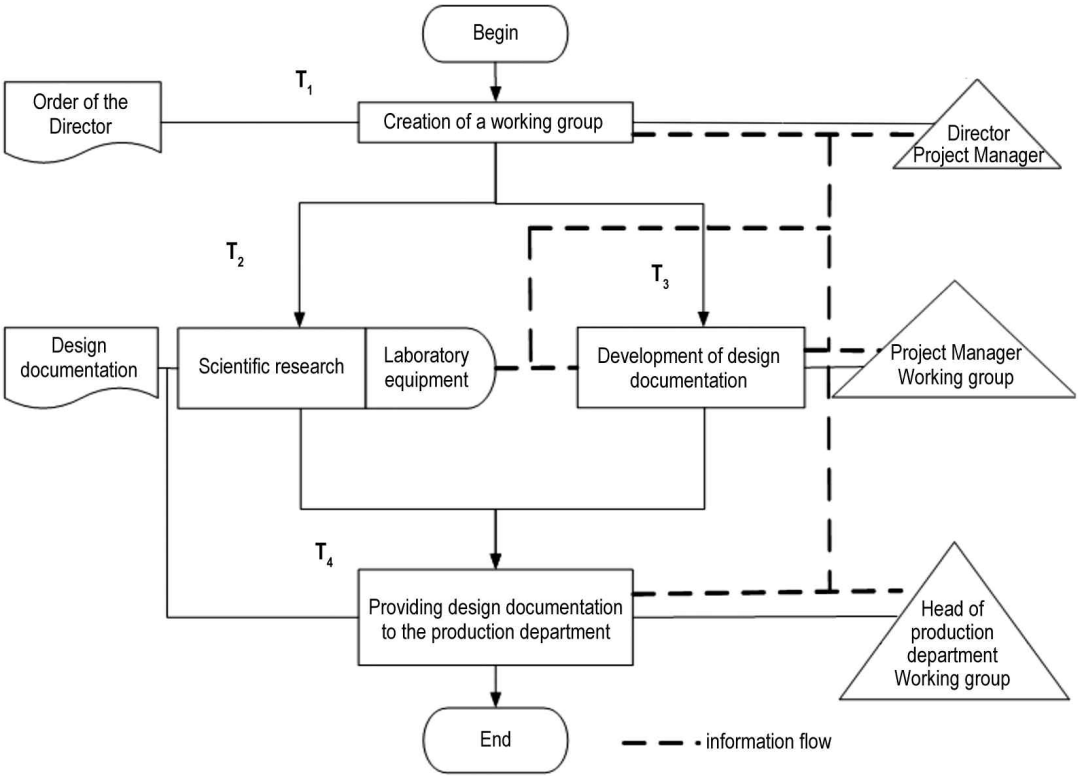

Figure 3. Improved model of the R&D stage at the Scientific and Technological Center of Unique Instrumentation (Russian Academy of Sciences) with reorganized information flows and structure

At the second stage, the existing information flows were reorganized and a system of interrelated and reciprocal information flows was created to provide the possibility of group information interaction between the participants during each process. The model improved in this way is shown in Fig. 3.

The features of the reorganized IA mechanisms at the R&D stage are as follows:

- Implementation of information flows in "Man / Process /Man" form allows us to provide continuous information support of the R&D stage processes based on the possibility of simultaneous group work of personnel with information.
- Ensuring effective R&D stage management and monitoring by the top management of an enterprise due to the ability to obtain data on information flows quickly.
- The absence of a cyclical process of assessing the possibility of production in accordance with the developed design requirements due to the continuous information interaction between R&D participants reduces significantly the risk of multiple duplication of time and economic expenditures.
- Reduction of the total R&D stage time (TR) due to the parallel implementation of research and development of design documentation based on continuous information interaction between them:

$$T_R = k_R \sum_{i=1}^{n} T_i$$

where k_R is a factor describing a reduction in the time of process implementation due to continuous information assurance and electronic data exchange. The value of the k_R factor depends on the type of the IS implemented and the capacity of software and hardware. It varies in the range between 0.4 and 0.8 for PLM and between 0.6 and 0.8 for EDMS+CAD that is confirmed by a number of empirical studies (Burtylev, I.N., 2013; Musman, M.A., 2014).

The third stage consisted in IS selection. The existing features of the R&D stage at the Scientific and Technological Center of Unique Instrumentation (Russian Academy of Sciences) were analyzed and it was found that the most feasible way is to implement EDMS with a required CAD package oriented at the manufacturing of a specific high-technology product.

4. Conclusion

Therefore, the tried out method allows us to conclude that it is sufficiently effective in solving the issues of ensuring the quality of IA and high-technology production processes. Along with its practical importance, the method is clear and simple and free to understand for both IT engineers and quality specialists.

The proposed method can serve as the development of the global study and solution of the existing informatization problems at knowledge-based companies and ensuring the required level of quality of high-technology production processes.

As further ways of research aimed at improving the IA quality of knowledge-based companies, one should note the need to try out the method at other knowledge-based enterprises and develop comprehensive IS selection methods considering all the enterprise features.

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