The introduction of information technology in business processes as a method of quality improvement

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Abstract Currently, there are a large number of approaches that allow developing a business, structuring business processes, maintaining and improving competitiveness, quality of goods and services, achieve a high level of efficiency and effectiveness of the enterprise. For example, such approaches as process benchmarking, FAST technique, which is deciphered as a technique for rapid solution analysis, process engineering, process reengineering, process redesign, contribute to process optimization. However, there are still companies that do not provide complete management of the organization’s business processes. Later, that can lead to certain problems. Therefore, today the current issue for organizations is the optimization of business processes. Such a process has a number of advantages not only for the internal management of the organization, but also for the external environment.

Keywords: quality management; business processes; labor potential; control system; research of operations; quality of business processes.

1. Introduction

Choosing the wrong approach in development, the wrong building business processes, setting the wrong objectives and tasks, choosing incompetent staff and others entail, first of all, loss of profits, quality of goods and services. For example, the company “Harley-Davidson”, which produces vehicles, suffered losses due to the decision of the manager to start producing daily-use goods, such as socks, toilet water, ties, T-shirts and other things. Why did it happen? The fact is that the company had a high level of popularity, but the consumer’s company name was associated only with vehicles, namely with popular motorcycles. Obviously, one solution entailed a lot of problems and loss of funds. Therefore, it is necessary to remember the risks before making a decision.

In some cases, in order to the company maintains its market position, it needs a cardinal rethinking and redesign of processes - reengineering. The main reason for using such a popular approach as business process reengineering is information technology. At the moment, information technologies are used everywhere, they allow building business processes in a new way, namely, they provide automation of the working space of employees and business processes, reduction of production and service times, and other. Information technology acts in the reengineering of enterprises as a driving force, momentum
transformation.

In relation to management of the quality management system (QMS), the introduction of information technology is a process that satisfies the information needs of management at all levels to prepare management decision-making in the field of quality management, using a combination of means and methods for collecting, processing and transmitting information resources for obtaining information about the state of QMS. Instrumentation (tools) of information technology is one or more interconnected software products, the technology of work with which allows solving the task for the user [6]. The introduction of information technology in the quality management system:

1. Allows for more efficient implementation of targeted management of enterprise information processes.
2. Increases the quality and effectiveness of management decisions in the field of product quality management and QMS.
3. Allows more efficient management (register, store, process and transmit) information resources of the enterprise in the QMS field.
4. Ensures effective integration of heterogeneous quality information resources from various sources into the QMS information system.
5. Increases the effectiveness of information interaction of all concerned parties in the field of quality assurance.

Exploring the market for PLM-solutions, the successful implementation of PLM technologies considers by the example of Boeing companies. In 1986, the American corporation Boeing chose the French company Dassault Systèmes to deliver software, namely, the well-known CATIA 3D platform, a computer-aided design system that includes CAD/CAE/CAM for the design of its civil aircraft. At that time, it was known that there are problems of incorrect alignment of the parts and components of the aircraft, and the difficulties of precisely fitting them to each other are most common in aircraft manufacturing. Boeing experts came to the conclusion that only a radical approach to solving these problems would reduce the time and financial costs of production and ensure sustainable competitiveness (and in the long term - leadership) of the company's passenger liners in the global market [7-9]. Pilot projects clearly demonstrated the benefits of developing aircraft components in the form of three-dimensional components using CATIA software. Boeing engineers simulated the geometric parameters of a new machine on a computer. This led to cost savings, since the process of manufacturing a full-scale Boeing 777 was excluded. There was a real breakthrough in the companies Boeing and Dassault Systèmes, which caused a lot of noise in the world. Later partners of CATIA were Honda in Japan, Mercedes and BMW in Germany. However, this is not all the success of the company in the provision and implementation of PLM-technologies, it made a big impact on the statistics on the market for two years, concluding another large-scale contract with Boeing for the implementation of a software product called 3DEXPERIENCE. It is a platform for modeling objects of the surrounding world and related sensations working in the cloud or local area network of an enterprise. The cost of this product is for Boeing $ 33 million a year or a billion dollars for 30 years. Using the example of Boeing, we can confidently say that the introduction of information technologies has allowed raising the status of the company, gaining a competitive advantage and reengineering business processes.

2. Labor potential management system

Let us consider the system of management of labor potential of the enterprise, consisting of information tools and management tools. Information system (IS), possessing certain technical means, detects a candidate for the personnel reserve of the enterprise.
Let IS have various means that allow it to detect $v_1$ candidates per unit of time. It is natural to assume that the intervals between the moments of detection are random quantities. The detected candidates in time form a flow that is very close to the Poisson flow. The data of the information system goes to the data processing and management system, which has a limited capacity for processing the received information per unit time.

The intensity of the control system (CS) is denoted by $v_2$.

The processing time of the data about the desired feature is a random value. The data processed in the system about the signs are distributed further between the allocated forces and the means of solving the corresponding target tasks [10].

Let us consider the case when the time residence of the required features (facts) in the scope of the information management system is very limited and commensurate with the time required for their identification, processing of initial data and adequate actions for these features. Therefore, this complex system can be considered as a first approximation as a system with failures.

The probabilities of system states are denoted as follows:

- $P^{00}$ - the information system and the management system are free from the maintenance of features and do not manifest themselves.

- $P^{10}$ - the information system is busy receiving information about a single feature, the control system is free from maintenance.

- $P^{01}$ - the information system is free, and the control system is busy processing information about the feature and making a decision on the use of forces and means.

- $P^{11}$ - both systems are busy.

Let us make the differential equations of states of the information management system. We denote, respectively, the states of the system $A^{00}$, $A^{10}$, $A^{01}$, $A^{11}$.

Condition $A^{00}$ is possible in the following incompatible cases:
- at time $t$, the information system and the control system (CS) are free. For the time interval $\Delta t$, no single
feature appeared in the area of operation of the control system. The probability of this event is equal to

\[ P^{00}(t) (1 - \lambda \Delta t) \]  

- at time \( t \), IMS was in the state \( A^{01} \). During the time \( \Delta t \), the data on the required attribute was transferred to forces and means of action. The probability of this event is equal to

\[ P^{01}(t) \nu_2 \Delta t; \]  

Then the ratio for state \( A^{00} \) is written in the following form:

\[ P^{00}(t+\Delta t)=P^{00}(t)(1-\lambda \Delta t)+ P^{01}(t) \nu_2 \Delta t \]  

After the appropriate transformations and the transition to the limit as \( \Delta t \to 0 \), we obtain:

\[ \frac{d}{dt} P^{00}(t) = - P^{00}(t) \lambda + P^{01}(t) \nu_2 \]  

Let us consider the state of IMS \( A^{01} \). It is possible in the following incompatible cases:

- IMS at time \( t \) is in the state \( A^{01} \). For the time interval \( \Delta t \), no single new fact appeared in the area of operation of IMS and not carried out the supply service relevant forces and means. The probability of this event is equal to

\[ P^{01}(t) (1 - \lambda \Delta t)(1- \nu_2 \Delta t); \]  

- at time \( t \), IMS was in the state \( A^{10} \). During the time \( \Delta t \), IS detected and issued data on the required CS factor

\[ P^{10}(t) (\nu_1 \Delta t); \]  

- at time \( t \), IMS was in the state \( A^{11} \). During the time \( \Delta t \), IS found and issued data on the required CS factor, but CS did not use them, as it was busy processing data on the previous fact. And therefore, the obtained data were irretrievably lost due to the short duration of the factor’s presence in the area of IMS activity. The probability of this event is equal to

\[ P^{11}(t) \nu_1 \Delta t. \]  

Then the ratio for the state \( A^{01} \) is written in the following form:

\[ \frac{d}{dt} P^{01}(t) = - P^{01}(t)(\lambda+ \nu_2) + P^{11}(t)\nu_1+ P^{10}(t)\nu_1. \]  

When compiling a differential equation, the state of IMS \( A^{10} \) should be based on the fact that it is possible in the following incompatible cases:

- at time \( t \), IMS was in the state \( A^{00} \). For the time interval \( \Delta t \), the required factor manifested itself in the area of operation of IMS and it was identified by IS. The probability of this event is equal to

\[ P^{00}(t) \lambda \Delta t \]
- at time $t$, IMS was in the state $A^{10}$. During the time $\Delta t$, the required factor manifested itself in the area of operation of IMS and it was not identified by IS and the data were not transferred to CS. The probability of this event is equal to

$P^{10}(t)(1 - v_1\Delta t); \quad (10)$

- at time $t$, IMS was in the state $A^{11}$. During the time $\Delta t$, CS issued data for the effect of the corresponding forces and means on the relevant factor. The probability of this event is equal to

$P^{11}(t) v_2\Delta t. \quad (11)$

Then the ratio for the state $A^{10}$ is written in the following form:

$$\frac{d}{dt} P^{10}(t) = P^{00}(t) \lambda - P^{10}(t) v_1 + P^{11}(t) v_2. \quad (12)$$

Finally, the last state of IMS $A^{11}$ is possible in the following incompatible cases:

- at time $t$, IMS was in the state $A^{01}$. During the time $\Delta t$, new data on the required features were obtained

$P^{01}(t) \lambda \Delta t; \quad (13)$

- at time $t$, IMS was in the state $A^{11}$. For the time interval $\Delta t$, the data on the required features of IS and CS were not processed in the scope of new deliveries. The probability of this event is equal to

$P^{11}(t)(1 - (v_1 + v_2)\Delta t); \quad (14)$

Then the ratio for the state $A^{11}$ is written in the following form

$$\frac{d}{dt} P^{11}(t) = P^{01}(t) \lambda - P^{11}(t)(v_1 + v_2). \quad (15)$$

The general system of equations describing all possible states of IMS is represented in the following form from four differential equations (DE):

$$\frac{d}{dt} P^{00}(t) = - P^{00}(t) \lambda + P^{01}(t)v_2$$

$$\frac{d}{dt} P^{01}(t) = - P^{01}(t)(\lambda + v_2) + P^{11}(t)v_1 + P^{10}(t)v_2$$

$$\frac{d}{dt} P^{10}(t) = P^{00}(t) \lambda - P^{10}(t)v_1 + P^{11}(t)v_2$$

For stationary processes, we assume that there are no transients in the system. This allows the following conclusions to be drawn for the transition probabilities:

$t \to \infty, \quad \frac{d}{dt} P^{ij}(t) \to 0, \quad P^{ij}(t) = P^{ij} = \text{const.}$

Then differential equations are transformed into algebraic equations:
\[ P^{00}(t) \lambda = P^{01}(t) v_2 \]
\[ P^{01}(t)(\lambda + v_2) = P^{11}(t) v_1 + P^{10}(t) v_1 \]
\[ P^{10}(t) v_1 = P^{00}(t) \lambda + P^{11}(t) v_2 \]
\[ P^{11}(t)(v_1 + v_2) = P^{01}(t) \lambda \] (17)

Solving a system of algebraic equations, we can determine the probabilities of different states of the information management system:

\[
P^{00} = \frac{v_1 v_2}{\lambda v_2 (\lambda + v_1 + v_2)}
\]
\[*\]
\[
P^{01} = \frac{1}{v_1}[\hat{\lambda}(\lambda + v_1 + v_2) + v_1 v_2]
\]
\[
P^{10} = \frac{1}{v_1}\hat{\lambda} + v_2[\hat{\lambda}(\lambda + v_1 + v_2) + v_1 v_2]
\]
\[
P^{11} = \frac{1}{v_1}[\hat{\lambda}(\lambda + v_1 + v_2) + v_1 v_2]
\] (18)

Where \( \lambda \) is the intensity of the flow of labor resources in the area of responsibility of personnel services of the enterprise.

The probability that the candidate remains unidentified and are not serviced by personnel service, is

\[
P^{01}_{\text{OTK}} = \frac{v_1 \hat{\lambda}(\lambda + v_1 + v_2)}{(v_1 + v_2)[\hat{\lambda}(\lambda + v_1 + v_2) + v_1 v_2]}
\] (19)

3. The discussion of the results

Let us take the maximum intensity of the flow of candidates \( \lambda = 170 \) people/year. As noted earlier, the flow of unemployed can be considered as a Poisson flow with intensity \( \lambda(t) \).

Let us suppose that \( v_1 = 170 \) people/year. The data of the information system comes to the data processing and management system (MS), which has a limited capacity to process the received information per unit of time.

We denote the capacity of control system through \( v_2 \).

Figure 2 shows the dependence of the states of the information management system on the intensity of the activity of the management system \( v_2 \), which organizes a set of measures for the “maintenance” of identified candidates (inclusion in the personnel reserve, etc.).
Figure 2. Dependencies of the states of the information control system on the intensity of the activity of the management system $v_2$.

The probability value was obtained that the candidate would not be enrolled in the personnel reserve

$$P_{0\nu_2} = \frac{\lambda_1 (\lambda + v_1 + v_2)}{(v_1 + v_2) [\lambda (\lambda + v_1 + v_2) + v_1 v_2]}$$

Figure 3 shows the dependence of the probability that a newly discovered candidate will be "serviced" by MS, i.e., included in the personnel reserve, from $v_2$.

Figure 3. The dependence of the probability that a newly discovered candidate will be "serviced" by MS, i.e., included in the personnel reserve, from $v_2$. 
Figure 4 shows the dependence of the probability that the required candidate will be identified by IS and "serviced" by MS from the intensity $\nu_2$.

![Figure 4](image)

**Figure 4.** The dependence of the probability that the required candidate will be identified by IS and "serviced" by MS from the intensity $\nu_2$.

Figure 5 shows the dependence of the service probability on the number of candidates $\nu_1$ and intensity $\nu_2$.

![Figure 5](image)

**Figure 5.** The dependence of the service probability on the number of candidates $\nu_1$ and intensity $\nu_2$. 
4. Conclusions

The information system was introduced in one of Moscow medical clinics in 2017: the time of patient service in the registry was tested by the administrator. After analyzing and collecting all the characteristics of the production process, the information was structured into a Gantt chart. After the audit, it was revealed that the candidate selected with the help of the enterprise’s labor potential management system copes with its duties faster by 5-7 minutes. Taking into account the clinic serves several districts of Moscow, this saved time leads to a decrease in queues and an increase in the quality of service, since patients have increased satisfaction from visiting the clinic.

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