

The Main Aspects of the Introduction of ERP-Systems at the Machine-Building Enterprises

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Abstract. Research goals and objectives: to carry out the analysis of the market of ERP-systems and to make scientific and practical recommendations for their choice for successful introduction at domestic machine-building enterprises.

Subject of research: design, implementation and use of ERP-systems at the machine-building enterprises of Ukraine.

Research methods: statistical, systematic and comparative analysis, modular design, analytical and expert methods.

Results of the research: The advantages of implementing ERP-systems at the machine-building enterprises have been evaluated, the most significant impact on individual indicators of enterprises has been determined and the advantages and disadvantages of automation of business processes at machine-building enterprises, depending on their separate types, are described. Examples of integration of subsystems on the basis of information flows and interaction of automated systems with external entities are given. It is proved that the success of the implementation of ERP-systems depends on the correct choice of the system class, the type of production, set priorities for the automation of business functions, taking into account the factors of criticality, readiness, speed and value. As a result, the maximum effect from the implementation of the ERP system potentially depends on: the completeness of its compliance with national legislation, the user interface's convenience and clarity, the ability to adapt to the industry-specific features and the specifics of the operation of a particular enterprise, the possibilities of integration into the system of external and internal modules, etc. It is important to involve the consulting companies, industry specialists and employees of the enterprise in the process of implementation.

Keywords: Enterprise Resource Planning (ERP), Enterprise Resource & Relationship Processing (ERP II), criteria for selecting, designing and implementation.

1 Introduction

Currently, the Ukrainian market has a large selection of high-class systems for automation of enterprises' functioning. The worldwide leaders in this field, represented in Ukraine, are products of SAP, Baan, Oracle and Microsoft companies. They are correctly localized and implemented, or are successfully implemented at the Ukrainian

enterprises. The products of such Ukrainian companies as "Information Technologies", Sirius System, IFS Ukraine and others are also common [8, 9, 12, 19]. And here, the main thing is not the creation of a large number of interesting information systems from the point of view of their developer. Design of ERP-systems should be aimed at the consumer, to offer managers and marketers more opportunities for understanding the views of consumers, to respond to their needs.

The current global trend towards building integrated enterprise management automation systems is the creation of the Enterprise Application Suite (EAS). This approach allows the most efficient use of the capabilities of accounting systems (ERP-systems, systems of financial and economic management, accounting programs) and OLAP-systems (planning and budgeting, knowledge management systems, data warehouses) and others.

However, most Ukrainian enterprises have different automated enterprise management systems that have been introduced long ago, they are inefficient and do not fully meet modern business management concepts and therefore can be classified by software capabilities. Among these systems are the following [9, 12, 19]: Material Requirements Planning System (MRP), Manufacturing Resource Planning System (MRP II), Manufacturing Execution System (MES), Customer Demand Planning System (CDP), Customer Relationship Management System (CRM).

Current demands for the operation of such systems require the use of advanced tools, a strong technological base, mobility, accessibility, reasonable price for the acquisition and service, taking into account relevant national standards [11, 15].

The aim of the article is to describe scientific and methodological foundations and practical recommendations on key selection criteria for the modern ERP-systems of a machine-building enterprise.

2 The Main Requirements for Modern ERP Systems

The analysis shows that for the Ukrainian enterprises the most relevant concepts of enterprise management systems are MRPII and ERP, which actually became world standards. They represent a set of general rules set out in 1980-1990 years [7]. Taking into consideration the fact, that ERP-systems are focused on fulfilling more tasks than MRPII, which focuses on managing production resources, in the article we focus on ERP, in particular, their modern version - ERP II.

It is difficult to calculate exactly what the ERP-system gives to the company, taking into account the diversity of systems, different conditions of enterprises before introduction, and the complexity and uniqueness of each project. An expert survey of specialists of machine-building enterprises of Khmelnytskyi region was conducted by us at the beginning of 2019. We asked about the effectiveness of the ERP-systems, introduced by them and the results of the survey showed positive results (Table 1).

Since the authors did not aim at assessing the effectiveness of embedded IT technology ERP-systems, then the calculation of the values of changes in table indicators did not apply common methods such as Return on Investment (ROI), Total Cost Ownership (TCO), Cost-Benefits Analysis (CBA) etc. Instead, the comparison of the

values of the indicators of economic characteristics before the implementation of the ERP-system and after the startup of the system at the enterprises was made. The assessment of qualitative and quantitative indicators was carried out on the basis of the points put forward in the questionnaires by experts of the enterprises, and also on the basis of statistical data of their financial reports.

Table 1. Estimated advantages after the introduction of ERP¹

Indicator	Growth rate
Reducing the timing for closing the accounting period	95%
Improving general culture of management, reducing paper workflow, using the optimal scheme of business processes	90%
Increasing the number of deliveries right in time	80%
Reducing transport and procurement costs	60%
Improved after-sales	60%
Reducing delays in the shipment of finished products	45%
Increase in the turnover of the enterprise funds	35%
Reduced manufacturing defects	35%
Reducing business costs	35%
Reducing costs for administrative staff	30%
Improving the accuracy of cost accounting	30%
Reduced working capital requirements by improving the speed and quality of work	30%
Improvement of capital assets utilization	30%
Labor productivity growth	27%
Reduced warehouse space	25%
Reducing the time for the sale of goods	25%
Reduction of reserve stocks in warehouses, use of advanced methods of their planning and control	20%

As a result, as shown in table 1, the introduction of ERP systems in machine-building enterprises has had the most positive effect on the deadlines for closing the accounting period, the general culture of management, the use of optimal business process schemes, delivery in the exact terms, transport and procurement costs, after-sales service. For such a conclusion we have taken only those indicators, the growth rate of which exceeds 60%.

According to the statistical portal Statista, the entire world market of large and medium ERP was income from the sale of software \$ 82.1 billion in 2015 and the results of 2016 rose to \$ 82.3 billion [8]. The main problem when choosing the ERP modules and its implementation is the task of creating a unified system that meets the needs of employees at all departments [12, 13].

Modern enterprise management system that meets the ERP concept should have the following modules: Supply Chain Management (SCM), Advanced Planning and Scheduling (APS), Sales Force Automation (SFA), Stand Alone Configuration Engine

¹ Created by the authors based on the results of the expert survey of 28 machine-building enterprises of Khmelnytskyi region.

(SCE), Finite Resource Planning (FRP), Business Intelligence (BI), Online Analytic Processing (OLAP), E-Commerce (EC), Product Data Management (PDM) [6, 12].

Recently, one can observe the trend of intensive management technologies development aimed at improving the interaction with external entities: customers, suppliers, partners and others. These information systems are based on the management of a full cycle of production: from designing according to customer requirements to guarantee and service. These technologies in modern terms are: Customer Synchronized Resource Planning (CSR), Supply Chain Management (SCM), Customer Relationship Management (CRM).

3 ERP Selection Based on the Type of Production and Scale of Automation

In order to consider all the needs of a machine-building enterprise, the choice of ERP must begin with the analysis of production and, depending on its characteristics, focus on different management concepts and automated information systems. In the evaluation of existing trends in production planning, it can be noted that the individual production is the most difficult, which requires constant technological change, recruitment and changes in work processes and therefore, the use of ERP in this case is inappropriate. Here it is better to apply PERT (Program/Project Evaluation and Review Technique) methods and network planning methods, especially for analyzing the time for each individual task and minimizing the time spent on the whole project (Fig. 1).

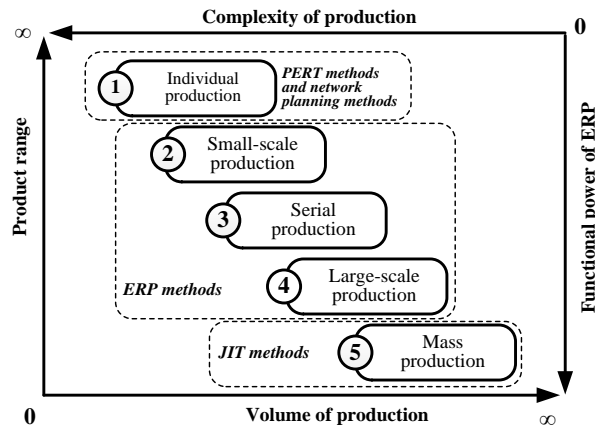


Fig. 1. Application of planning methods for different types of production depending on the volumes of production and its assortment²

The three following types are different versions of serial production, in which, when the seriality increases, the versatility of the equipment decreases and the spe-

² Suggested by the authors

cialization of workers shrinks, consequently, the number of types of finished products decreases, and the volume of output increases. The fifth type is characterized by mass production, the availability of specialized equipment, conveyors, technological complexes, the minimum number of types of products with maximum output volumes.

Research has shown that the use of modern flexible and powerful algorithms for the distribution of production processes has led to the development of Advanced Planning and Scheduling (APS). Therefore, the enterprises of the second, third and fourth types of production need to apply the concept of ERP, and for the fifth type - JIT-methods (Just-In-Time), because ERP-techniques for such production are too powerful. The scale of automation introduction at the machine-building enterprises of Khmelnytsky region can be divided into partial automation, by individual areas, by the chosen sphere of activity and full automation (Table 2).

Table 2. Features of automation of business processes at the enterprise³

Type of automation	Goal	Advantages and Disadvantages
Partial	Automation of certain local business processes	<i>Advantages:</i> individual subsystems are much cheaper than a complete solution. <i>Disadvantages:</i> lack of strategy; task locality; probability of getting pieces of unfinished infrastructure; additional costs due to functions duplication and servicing of unfinished modules; inefficiency of investment.
By individual areas	Automation of individual production areas or administrative units on functional grounds.	<i>Advantages:</i> automation systems in certain areas provide significant economic benefit; saving investment resources. <i>Disadvantages:</i> automation is carried out strictly under a certain type of manufacturing and its standards; frequent viewing of strategic and operational plans of automation
By sphere of activity areas	Automation of the chosen sphere of activity.	<i>Advantages:</i> implementing ERP & MRP II before full automation; all subdivisions of the chosen sphere of activity are involved; emerging information and communication structure of the company; a re-engineering of business processes and creating a business model. <i>Disadvantages:</i> requires frequent review of strategic and operational plans of automation; requires significant investments in hardware, software, hiring developers.
Full	Creation of an integrated enterprise management system.	<i>Advantages:</i> full integration of all modules and control units, procedures, functions and operations to a single system based on database; integration of the mathematical software on the basis of models and methods for providing planning and forecasting. <i>Disadvantages:</i> the need for adjustment of the strategic plan to reflect changes in the market; additional costs for service support and maintenance of hardware, software, hiring developers.

We have proved that in today's competitive processes ERP application helps optimize operations, reduces errors, improves forecasting and planning, and aims to significantly reduce costs and improve production processes. However, analyzing the advantages and disadvantages of automating business processes at an enterprise, it

³ Systematized according to the advantages and disadvantages based on our own research

must be emphasized that everything depends on the needs and financial capabilities of each particular enterprise.

4 ERP-Systems Selection Based on Their Capabilities

Since the beginning of the 21st century, new functional capabilities of the ERP system have begun to evolve in the world, which went beyond the traditional features of automation and optimization of business processes of the ERP methodology. The traditional concept of ERP envisaged primarily work with internal enterprise resources, resource planning, careful inventory management and insurance of transparency of manufacturing processes. The functional of modern systems has been supplemented by modules such as SCM and CRM, responsible for optimizing external communications of the enterprise. There was a separation of concepts: the traditional ERP management was called back-office, and external applications that appear in the system - front-office. Thus, a new standard has appeared - ERP II (Enterprise Resource and Relationship Processing) [3].

Our analysis confirms that new ERP really provides comprehensive management of key business processes, often in real time. Typically, these systems are represented by a set of integrated applications that the enterprise can use to collect, store, manage and view data about many types of their own activities. These systems monitor business resources (cash, raw materials, manufacturing facilities and the status of business liabilities (demand for products and materials) [2].

The analysis showed that the new ERP was complemented by the following modules [1, 6, 13, 19]:

- Supplier Relationship Management (SRM), which is designed to improve management, optimize purchasing power, improve customer service by selecting and properly working with suppliers, establishing and improving business processes with further analysis of results.
- Product Lifecycle Management (PLM), which helps in planning and optimizing production capacity and material resources.
- Supply Chain Management (SCM), which allows controlling processes in the warehouse and quickly respond to changes in supply and demand.
- Customer Relationship Management (CRM), which is used to manage relationships with consumers, including the collection, storage and analysis of information about customers, suppliers, partners, and information about relationships with them.
- Enterprise Asset Management (EAM), which can effectively manage all lifecycle, improve resource utilization and reduce costs by using powerful analytics tools.
- Business Intelligence (BI) & Online Analytical Processing (OLAP), which allows converting streaming business information into human-readable form.
- E-Commerce System, which manages activity of all electronic financial and trading transactions, as well as related business processes.

In general, there are three main areas that determine the development of the class ERP II: deepening the functionality of ERP; the emergence of technologies that simplify the creation of specialized industry solutions; creation of new and improvement of existing management modules between corporate business processes.

Our system analysis revealed that the main differences between ERP and ERP II arose from the rapid development of e-commerce and increased interaction between all subjects of financial and business processes via the Internet, so the modern system received a Web-based architecture (Fig. 2).

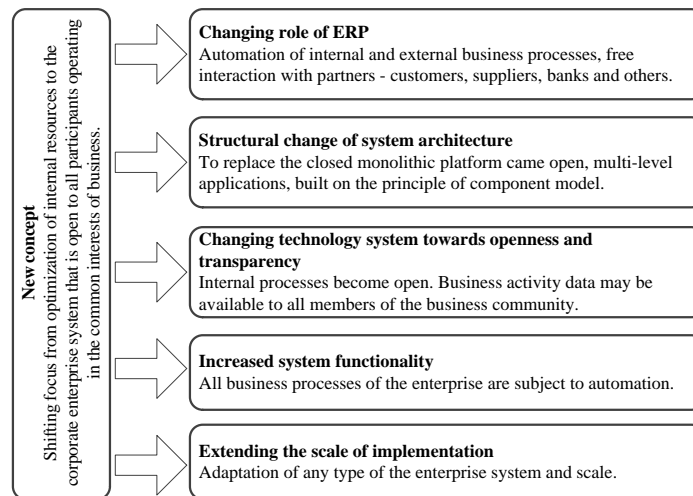


Fig. 2. Differences between ERP and ERP II⁴

In our opinion and in the opinion of many scientists enterprise resource management requires a comprehensive review of all business processes within a single information system [4, 6, 9, 11, 19]. The absence of functions important to the enterprise in the system and the impossibility of their additions for a certain period of time - indicate the inexpediency of its implementation at this enterprise. And because of this, in the face of increased competition, it is necessary to find out the real needs of the enterprise from the function of modern ERP and to develop and describe the sequence of such a system, to determine the need for individual blocks of automation of business processes.

We have proved that an important aspect of implementing the chosen ERP is the level of integration between its subsystems. As an example, consider a scheme of integration of subsystems based on information flows (Fig. 3).

⁴ Systematized by the authors based on [1, 5, 13]

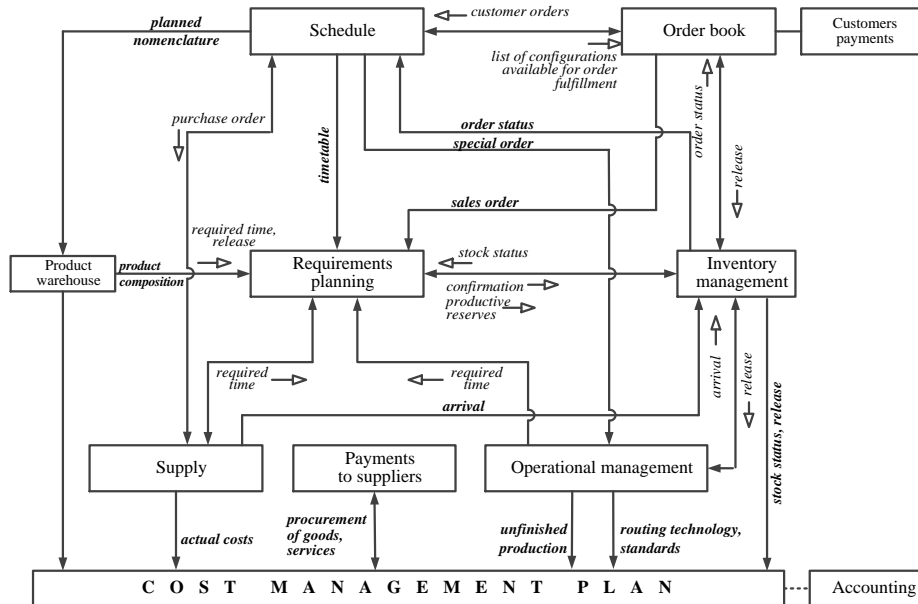


Fig. 3. An example of the integration of subsystems based on information flow⁵

At the same time, we believe, it is necessary to be aware how the chosen enterprise management system integrates with external objects and systems (Fig. 4).

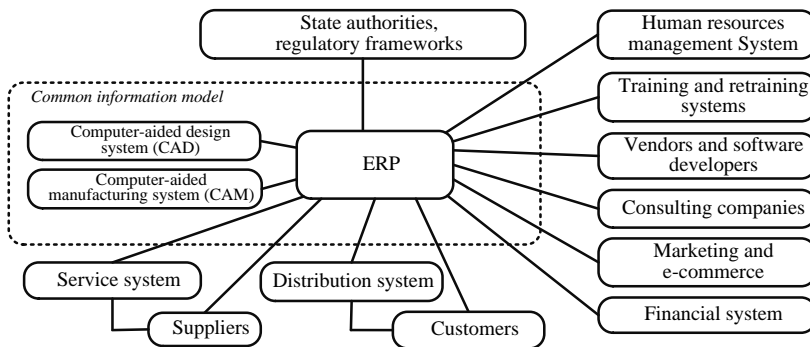


Fig. 4. An example of interaction of ERP system with external entities and their systems⁶

With schemes given above and on the basis of functional features one can create an implementation plan of all subsystems, which eventually will become a powerful tool for managing financial and economic activity of the enterprise.

⁵ Built by the authors, based on the analysis of the functional structures of industrial enterprises of Khmelnytskyi region

⁶ Built using [1, 6, 13]

5 Criteria of Criticality, Readiness, Speed and Costs in the Enterprise Management System

The analysis shows that most companies are choosing ERP for help with specialized consulting companies, but even with the involvement of external consultants, the company should also attract its own experts who can influence the final decision.

Among the wide range of criteria to select the ERP system should be the following: functionality of the system; total cost of ownership (acquisition costs, implementation and support); guarantees of successful implementation; reliability, performance, system perspective; efficiency and payback period of the project; support level by integrator after implementation; level of service and the possibility of further development of the system by our own specialists. The maximum effect after implementing ERP is potentially dependent on selected priorities in automation of business processes at the enterprise. In our opinion, analysis of possible automation steps should be carried out according to the criteria of criticality, readiness, speed and cost.

With the criticality criteria one can identify "problem areas" in the company, usually subsystem of sales, marketing and advertising are analyzed to attract new customers and retain existing ones. To enhance the efficiency of controlling over financial resources you must first carry out automation of financial management and cost of production. First and foremost, priority should be given to automation "problem areas" in view of the relationship of their business processes with other enterprise activities (Fig. 5).

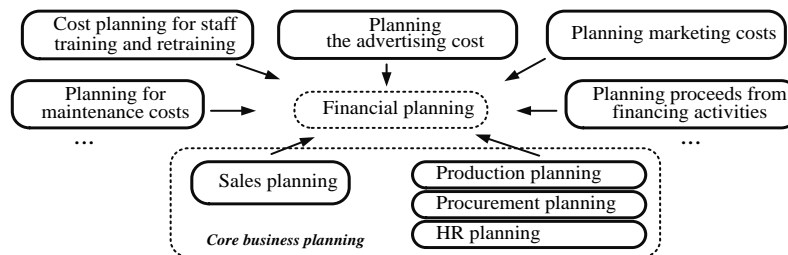


Fig. 5. Automation of the functioning of the financial and economic management⁷

Research [10, 16, 17, 18] shows that automation of financial and business enterprises can improve not only the effectiveness of operational control over the use of funds, but also increase the effectiveness of sales and management subsystem, procurement personnel management subsystem, marketing activities management subsystem, etc. It may not be promising to develop your own automation block, but to integrate an already existing module.

Here, in our opinion an important evaluation criterion is the readiness of enterprises to introduce an integrated information system, which consists of professional and psychological readiness of employees and managers. Lack of professional readiness could lead to the rejection of the project or hiring third-party developers that will increase the cost of implementation. Psychological readiness may be due to a signifi-

⁷ Suggested by the authors

cant increase in the functional responsibilities of staff and promote responsibility, especially at the stage of development and implementation.

Another criterion that we have defined is speed implementation solution, when automating site is chosen because of the simplicity of the design and subsystems implementation.

Cost component is generally perceived by management as an investment, and taking into account the fact that ERP has a modular structure, it is recommended to start a project with low-cost modules, in order not to risk losing the invested funds if for some reason the project fails. Therefore, ERP introduction should be carried out on areas of the enterprise where the maximum economic effect is expected, the implementation process will take place quickly and with minimal cost, and the staff is ready to change and will be able to use benefits.

Selecting the type of ERP is difficult and responsible task, since these systems are usually implemented for quite a long time (the average lifetime is 9 years) [5], they should have expected functionality and reasonable price.

When purchasing ERP, you must consider the TCO, which in turn consists of the following costs [4, 7, 16, 17, 19]: preparations for the project (audit of the company, development of technical specifications, modeling etc.); installation, adjustment and adaptation of the system to the specifics of the enterprise; simulation, testing and experimental exploitation; purchase and installation of necessary equipment; training (users and support personnel for follow-up); hiring additional staff technical support of the system; transferring data from the previous system; ongoing maintenance and support (salaries, purchase or repair of equipment, etc.); maintenance services from a company-developer (hourly consultations, urgent revision etc.).

Since these types of costs can increase the cost of the system by times, compared with the cost of the software itself, therefore, it is necessary to make a full pre-calculation of costs.

6 Use of Advanced Development Tools and Support of Economic Security

The analysis of information technology used in ERP is equally important. If the system is based primarily on its own development, then there may be a strong dependence on the supplier company [1, 4, 19]. In our opinion, it is advisable to use proven technologies, especially those oriented at industry. Especially for large and medium enterprises we need to focus on the level of implementation of "client-server" architecture using powerful database management systems of Oracle, IBM and Microsoft companies.

Considering the current tendency to increase competition in the market, you should also take care of the security system to prevent unauthorized access and so on. It is necessary to examine mechanisms for data exchange between structural divisions, set a distributed data access, organize work in the sphere of identifying leaks or external threats and so on. Of course, the organization of information security is based not only on the use of software, but also on logistical organization, users' experience and their corporate culture.

Effective functioning of ERP depends on the quality of service, including: the ability to select the necessary and appropriate level of service for the customer; prompt response to requests and ordered system of control over them; providing advice in real time; completeness of orders execution; free and prompt elimination of errors by the developer; availability of favorable conditions for the supply of new versions, etc. [14, 16, 17, 18].

Research has shown that for automation systems of large and medium enterprises in Khmelnytskyi region, the quality of service and support comes to the fore in the long run, and so, when choosing ERP, you can sacrifice a certain functionality of the system, but not the quality and completeness of the service and support.

In our opinion, as practical recommendations to domestic enterprises, before choosing and implementing an ERP system, you need to use the following criteria and pre-verify: the completeness of reflection in the system of national legislation, the compliance with the procedure for the implementation of operations adopted in the enterprise, the clarity of the interface and documentation to users, the functionality of the system on similar enterprises, taking into account branch characteristics and specifics of own production, the possibility of branching out within affiliates, integration with other management systems.

7 Conclusions

Based on the research and analysis of existing scientific approaches, the article assesses the advantages of implementing the ERP system at the enterprises of mechanical engineering, expertly determines its most significant impact on individual indicators of the enterprises, determines the main criteria for modern management system requirements to compliance with the resource planning concept. The authors offered scientific and methodological approach to the application of planning methods for various types of production depending on the volume of output and assortment, and also described the advantages and disadvantages of automating business processes at the enterprises in Khmelnytskyi region depending on the individual types of automation. The article defines a list of modules that appeared in modern ERP II, singles out differences between ERP and ERP II, and also provides examples of integration of subsystems based on information flows and interactions with external business entities. The authors systematized the criteria for providing benefits of the development or acquisition of ERP and suggested the use of advanced tools for developing and maintaining the economic security of enterprises, and presented practical recommendations on the use of ERP at the enterprises.

The results of the conducted research confirm that the introduction of the modern ERP-system at the enterprise allows you to obtain competitive advantages and ensures compliance with modern world standards for improving the company's rating, leads to an increase in the market segment, sales growth, creates the ERP-system compliance with the expectations of the head of the company, because it is the head of the enterprise who is responsible for setting the task and goals. The introduction of the modern ERP-system also finds the factors of the false work of some departments of the enterprise; weakens internal audit, as the quality of external audit increases.

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