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AFFORDABLE DIGITAL MANUFACTURING PLATFORMS FOR SMALL WOODWORKING BUSINESSES: THE ROLE OF DIY CNC IN THE DEVELOPMENT OF ARTISANAL DESIGN

Summary. *Information systems play a key role in modern business, providing process automation, data collection and analysis, and management decision-making. The integration of information systems in woodworking enterprises will help optimize production processes, speed up decision-making, and increase business efficiency. Integration with machine tools has made it possible to monitor machine performance and, based on this data, build a new type of incentive model with fair and balanced pay rates and significantly increase machine productivity by eliminating downtime. Thus, monitoring machine productivity plays a key role in the digital transformation of production, ensuring effective management of production processes. Therefore, the application of the recommended integration methods can significantly improve the industry's performance. Analysis of the topic shows the demand and relevance of this research, and a review of the literature indicates the need to develop new integration methods to optimize the work of woodworking enterprises. The purpose of this work is to study existing information systems and the role of DIY CNC woodworking enterprises and to further develop and analyze methods for integrating these information systems to optimize business processes at woodworking enterprises. This will significantly increase efficiency and productivity.*

Key words: *CNC, milling machine, woodworking, design, automation, hybrid processing, manufacturing platforms.*

Introduction. The development of a methodology for integrating information systems specifically for the woodworking industry will allow for its specific characteristics, business processes, and the needs of enterprises to be taken into account. The results of the study will be of practical use to enterprises in this industry, helping to improve their activities and increase their competitiveness in the market. For successful data integration, it is necessary to consider not only technological aspects but also functional requirements that will ensure the efficiency and reliability of the process. Support for different data formats is becoming an important aspect, as data can be presented in various formats, such as CSV, JSON, XML, SQL, and others. Data mapping plays a key role in establishing correspondence between data fields from different sources for successful transformation and loading.

Distributed data processing provides the ability to process large amounts of data in distributed systems, which increases the performance and scalability of the integration process. Support for data transfer protocols such as HTTP, FTP, SOAP, and REST allows for the efficient transfer of information between systems [1]. Researchers have different opinions and views when choosing digital manufacturing platforms. Most researchers mainly consider and compare the following systems:

1C: Enterprise is a national ERP system widely used by Ukrainian companies in various industries.

2. SAP ERP is an international ERP system that is also widespread in Ukraine, especially among large enterprises.

3. Microsoft Dynamics 365 is an enterprise management platform actively used by companies in Ukraine and beyond.

4. Oracle ERP Cloud is a cloud-based ERP solution that offers a wide range of business management features.

The topic of automation of woodworking business processes has been studied both in Ukrainian and foreign science, but remains insufficiently studied in terms of applied solutions based on the integration of various information systems. The object of the study is the information systems of woodworking enterprises, and the subject of the study is the methodology for integrating these systems to optimize business processes.

Literature Review. The modern concept of "Do It Yourself" (DIY) provides new opportunities for woodworking businesses to participate in the structural transformation of the economy on an innovative basis. Similar to how E. Toffler [2] described three waves of economy (agricultural, industrial, and information), three waves of DIY are defined: natural (First Wave), industrial (Second Wave), and digital (Third Wave) [3]. In the First Wave, people grow what they eat and produce what they need without making regular purchases at the market. For example, they build their own houses from local natural materials. In industrial DIY, people buy ready-made kits, such as pre-designed boat and furniture kits, and use standardized instructions to assemble them themselves. The third wave of DIY relies on the functional capabilities of the interactive and social Web 2.0 and digital design/manufacturing, which allows ordinary citizens to invent, design, manufacture, and/or sell products that they themselves have conceived [4].

So we are talking about the digital transformation of the DIY sector through the integration of Industry 4.0 technologies and the widespread use of Web 2.0 information technologies in providing opportunities for learning and knowledge sharing in the creative process, i.e., DIY 4.0. DIY 4.0 products range from small and simple to large and complex, created using additive manufacturing (AM) technologies. This is possible thanks to the use of platforms,

the most well-known of which are Cubify, Kraftwurx, Sculpteo, and Shapeways [5].

In the article "Developing recommendations for process automation using Elma Bpm in enterprises" [6], the authors note the flexibility and simplicity of Elma: "The ELMA BPM software product provides ease of modeling and speed of making changes to processes and helps track how these changes are reflected in the work of business processes. The system helps to identify bottlenecks, which allows for significant optimization of the organization's business processes."

Researchers have different opinions and views when choosing digital manufacturing platforms (ERP). Combining all previous studies on the topic of choosing an ERP system, we can conclude:

The functionality of 1C is not significantly inferior to foreign systems. On this topic, in the article "Choosing an ERP system: 1C or SAP," the author makes the following conclusion: "In general, it is impossible to say which of the systems is better; each has its own advantages and disadvantages. Ukrainian users should also consider factors that, at first glance, seem insignificant but can tip the scales when choosing a system:

− 1C solutions require much lower payments than SAP;

− working in SAP is complicated by the use of special terminology and an inconvenient information search system; for example, to find the right document, you need to know its exact number;

− most highly specialized SAP industry solutions are not localized;

− In SAP, it is not possible to delete the original document.

− In 1C, it is possible to modify software modules to adapt the system to specific user requirements.

Above, when reviewing the information systems of woodworking enterprises, we examined and compared 1C: KA and 1C: ERP. The summary can be found in the table from the article "Business process automation in large enterprises: a comparative analysis of 1C: ERP and 1C: KA" [7]:

1 C : ERP	1 C : Comprehensive automation
Budgeting with consideration budget process	Simplified budgeting (Financial plans , cost limiting)
Production, planning resources, repairs	Simplified production (without planning and repairs)
Cost management , calculation cost price (including production orders)	Calculation of cost per order buyer

Source : [8]

As can be seen from the table above, the functionality of 1C:KA allows you to automate most of the processes of companies whose main activity is any type of trade, services, and production of goods. All the main blocks that enable successful trading activities are present in both databases. Thus, when choosing a management system for woodworking enterprises, it is worth considering the results of existing studies, as well as the cost of solutions.

Results of Experimental Studies

Functionality 1C: Comprehensive automation, provided it is properly integrated with other systems, may be sufficient for automating processes at such enterprises. These information systems help manage production processes, increase efficiency, and control product quality at woodworking enterprises. Taking into account existing business processes (reviewed above) and tasks, the typical architecture of woodworking enterprises can be represented as follows (Fig. 1).

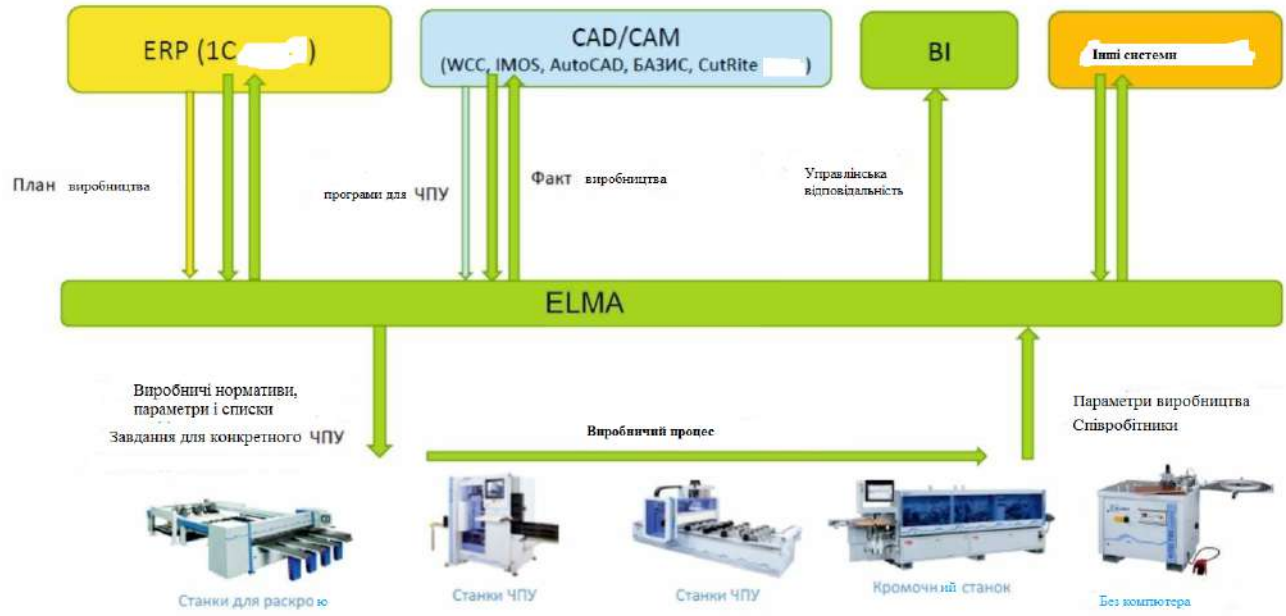

Fig. 1. IT architecture of the company

Source: [9]

The diagram shows that Elma provides communication between different systems and infrastructures within the enterprise. As part of this study, Elma was integrated with edge banding machines. To integrate the Elma system with edge banding machines that do not have a data collection interface, a search was conducted for a suitable programmable logic controller. This controller was connected to the machine units in the control cabinet.

Fig. 2. PLC (programmable logic controller)

Machine monitoring data can be used to analyze equipment performance, identify downtime and its causes, plan preventive maintenance, improve production processes, optimize equipment load, reduce costs, and increase productivity.

Integration with CAD/CAM

The integration of ERP (enterprise resource planning) with CAD (computer-aided design) is of great importance for companies involved in the development and manufacture of products.

Integrating ERP with CAD allows you to increase production efficiency and quality, improve data and resource management, and reduce the time and cost of production processes. Let's consider the CAD-ERP integration methodology using a typical diagram, where the CAD system is a program commonly used in furniture manufacturing in Ukraine. It is recommended to configure the CRM module in Elma and start the production process with technical specifications,

ensuring end-to-end processes. The design is developed according to technical specifications, and the finished CAD model looks like this:

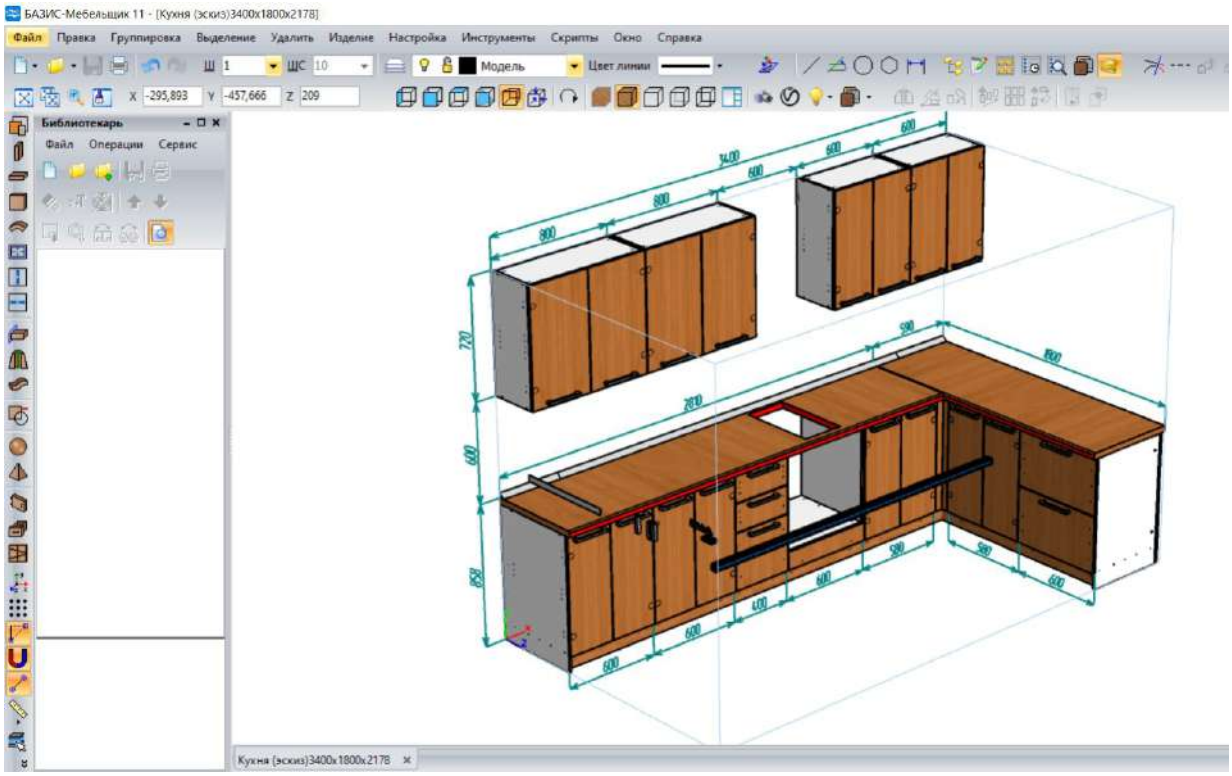

Fig. 3. Model in CAD

Source: [10]

Scripts in Elma are written in C# and TypeScript. For general understanding, below are several methods of a working script that decodes xml:

```
public virtual void ParsingXml(Context context)
    {
        if (context.XMLFileBM != null && context.XMLFileBM.File != null)
        {
            ErrorLog = string.Empty;
```

Integrating ELMA and 1C allows you to combine business management and business process automation. Here are a few ways to integrate these systems:

1. Using API: ELMA provides an API that allows you to interact with other systems, including 1C. With the API, you can exchange data between ELMA and 1C, which will automate processes and reduce manual labor.

2. Integration via databases: You can configure data exchange between the ELMA database and the 1C database. This approach allows you to transfer information between systems and update data in both systems in real time.

3. Use of data exchange standards: You can synchronize data between ELMA and 1C using standard file formats (e.g., XML, CSV). This will allow you to transfer information about business processes, orders, employees, and other objects between the Elma and 1C systems.

In other words, all of the integration solutions explored earlier can be applied. However, the best integration option is API and web services. The methods listed above can be applied based on the competence of the company's developers and the desired degree of automation, taking into account the security requirements of the information system.

Integration with CAM systems and machine tools.

The integration of information systems (IS) with CAM systems and machine tools is a key aspect in the context of Industry 4.0, where digital technologies and automation are revolutionizing manufacturing methods. A proper IT infrastructure with deep integration with machine tools and CAM systems demonstrates significant productivity gains through process automation, reduced equipment setup time, increased manufacturing accuracy, and reduced production cycle times. Quick retooling of machines for different orders, reduced downtime, and machine performance analysis are impossible without the integration of CAM systems, machines, and IS. Integration enables the collection of data on manufacturing processes, which is the basis for analysis and optimization of production. Data analytics identifies bottlenecks in production, predicts equipment failures, and optimizes production processes. The overall integration of IS with CAM systems and machines within Industry 4.0 is becoming a

mandatory element for the successful operation of manufacturing enterprises, providing competitive advantages, increased productivity and product quality, as well as flexibility and adaptability to changing market conditions. The use of this integration opens up broad prospects for the development of modern industrial production. This task can be implemented using the proposed integration scheme (see Fig. 1).

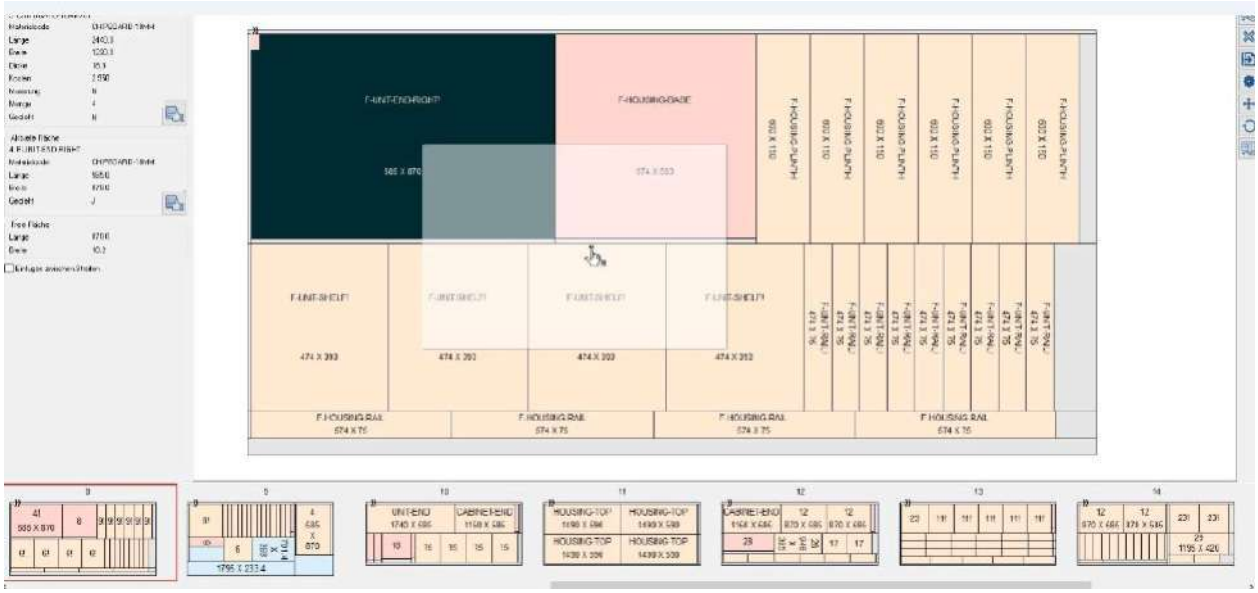

Fig. 4. Cutting diagram on CutRite

Source: [11]

CAM systems help convert three-dimensional models of parts into instructions that are understandable to machine tools in order to automate the process of material processing and workpiece manufacturing. Traditional CAM systems in woodworking enterprises include Basis-CNC, Cut-Rite, b-solid, and others. Let's consider the general integration methodology using CutRite as an example. CutRite is software designed to optimize the material cutting process. With this system, you can efficiently use raw materials, minimize cutting waste, increase the productivity of the production process, and transfer the cutting diagram in the form of instructions (control program) to the machine. The importance of integrating CutRite with the information system is to implement

automatic marking of parts. In modern production, each part is marked, and the marking contains important information for automatic processing.

In addition to marking, the most important element of modern production is the monitoring and analysis of machine operation. Monitoring machine productivity is an integral part of modern production. Monitoring and analytics systems allow you to continuously monitor and analyze equipment performance, ensuring a quick response to any changes. This improves the efficiency of production processes, increases productivity, and minimizes equipment downtime. Data analysis allows you to identify potential problems, optimize machine settings, and improve product quality.

The implementation of machine performance monitoring systems leads to cost reduction, increased production capacity, and improved competitiveness of the enterprise. Thus, machine performance monitoring plays a key role in the digital transformation of production, ensuring effective management of production processes. The task of machine monitoring can be solved by integrating the Elma database and machine operation. To do this, it is necessary to design and create a reference book of machines and parameters that need to be monitored. Next, it is necessary to study the operation of the machine, methods of integration, and determine the indicators.

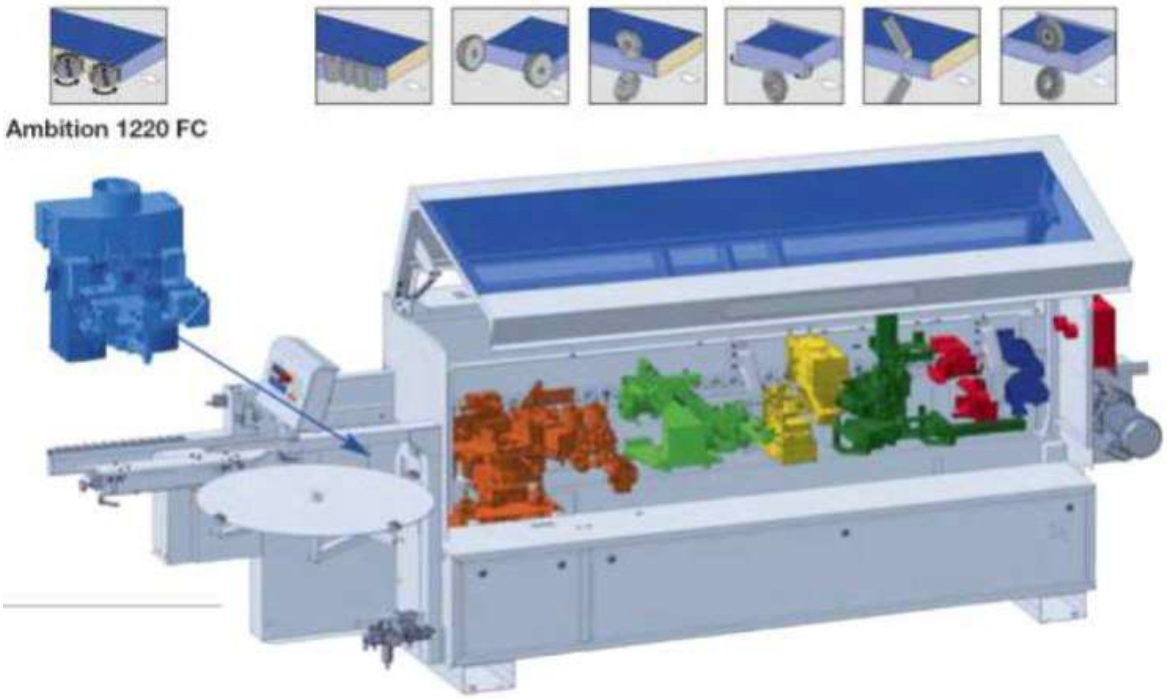

Fig. 5. Edge banding machine

Source: [12]

Woodworking enterprises have both modern machines with data collection and analytics modules and machines without such options in their balance sheets. If the machines do not have a data collection module, programmable sensors must be connected (depending on the specific machine). In such cases, the integration of the information system with the production machine can be implemented using specialized communication protocols such as OPC (Open Platform Communications) or MQTT (Message Queuing Telemetry Transport). To do this, it is necessary to connect sensors to the machine that collect data about its operation and configure the software to transfer this data to the information system. The data can then be processed, analyzed, and used to monitor machine performance, plan maintenance, optimize production processes, and perform other tasks [13].

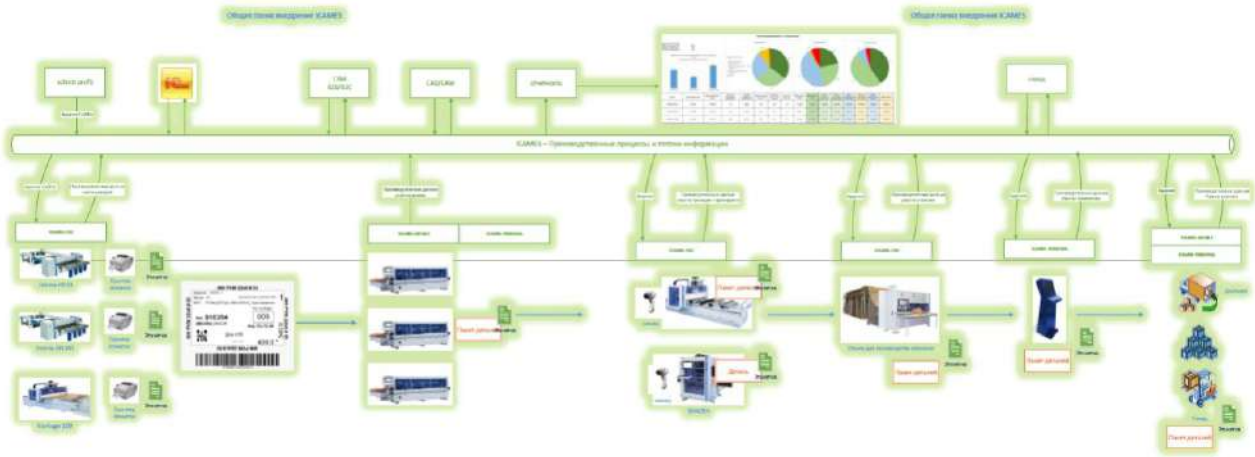

Fig. 6. 1C furniture production

Source: [14]

Based on the results of the study, it can be concluded that by applying existing integration methods and the typical information system integration schemes recommended in this study, business processes can be automated without resorting to expensive foreign ERP systems such as SAP ERP [15]. When using Elma as an additional software layer (middleware), the functionality of 1C: KA is sufficient for successful business process construction. In addition, this concept does not require the purchase of CRM and PLM modules. Such a system is much more flexible and easier to implement and develop.

Conclusions. This study examined the main methods of integrating information systems and studied the information systems of woodworking enterprises. The results of the study showed:

1. The information systems of woodworking enterprises in Ukraine are generally not optimal. Most companies continue to ignore the possibilities of creating IT infrastructure by integrating information systems.

2. Effective integration of information systems contributes to a significant improvement in productivity and enterprise management and will allow for the automation of many routine processes.

3. There is no need to purchase expensive special ERP systems for a successful information system model. Significant results can be achieved by integrating existing tools.

4. The developed methods and recommendations allow you to reduce costs, decrease task completion time, and improve product quality.

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