6. INFORMATION SYSTEMS IN LOGISTICS

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The integration of technology and management systems plays an important role in improving efficiency, accuracy and strategic decision making. Three essential systems for streamlining business operations in logistics are Enterprise Resource Planning (ERP) systems, Warehouse Management Systems (WMS) and Transportation Management Systems (TMS).

ERP systems form the backbone of a company, integrating various departments (such as accounting, procurement, sales, production etc.) and processes into a unified system. WMS, on the other hand, focuses on optimizing warehouse operations, ensuring effective inventory management and storage optimization. Lastly, TMS is dedicated to the planning, execution and optimization of the transport of goods. This system is critical in reducing transportation costs and improving logistics efficiency.

This chapter not only provides an overview of each system but also explores how integration can lead to a more cohesive and intelligent business environment.

6.1. Enterprise Resource Planning (ERP) Systems

In the beginning companies were divided into different departments, depending on the functions they performed. Thus, there was a department of production, procurement, sales, finance, etc. Each department operated in isolation in such a way that it had its own data collection and analysis system. Those systems were not connected to each other. Today, organizations are considered as one system, and all the departments are its sub-systems (Leon, 2014). They all share the same, centralized database.

The existence of independent information systems for each department led to inefficiencies, data inconsistencies and redundancy and challenges in decision-making. The shift towards an integrated system was an important approach to organizational management since organizations are seen as a single, unified system. The critical component of this integration

is the centralized database which serves as a core part of the organization, ensuring that all departments have access to consistent, **real-time data**. This leads to better communication, coordination and collaboration between departments.

Figure 6.1 shows the difference between the traditional approach where departments are independent and each department has its own database and the modern approach where departments share one central database.

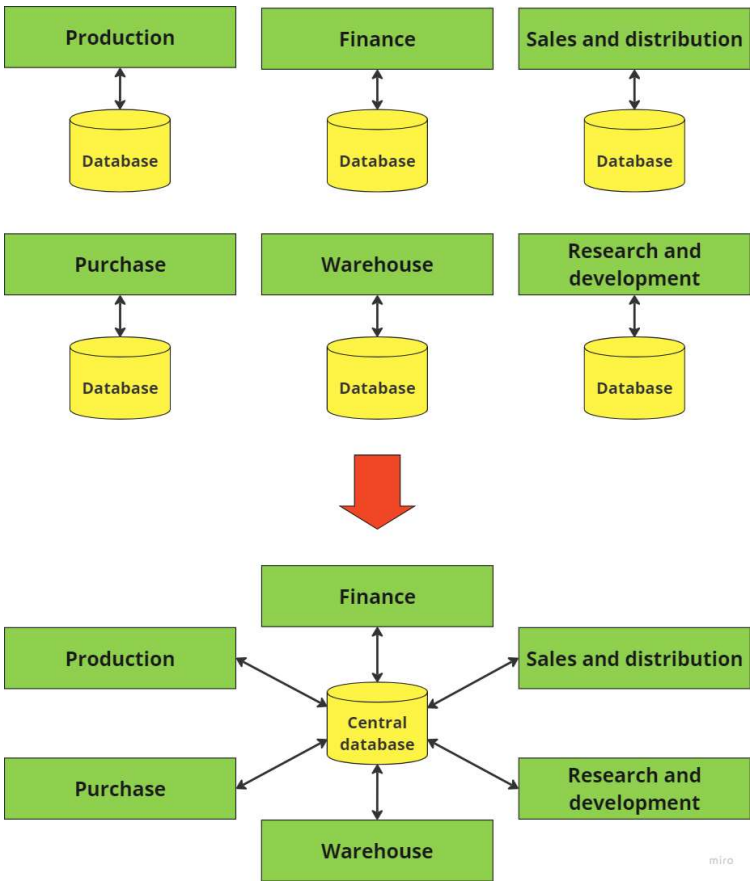

Figure 6.1 Difference between independent departments and departments which share the same central database

Source: Author, according to Leon (2014).

According to Bradford (2015), **enterprise resource planning (ERP)** systems are business systems that combine and organize data from various departments within the organization to create a single, comprehensive system that serves the needs of the whole enterprise. ERP systems integrate and coordinate processes and functions that were previously fragmented and supported by different legacy systems, or older, standalone business systems,

in a seamless manner, improving all aspects of critical operations, including purchasing, accounting, manufacturing, and sales.

In other words, the ERP system is a complex, modular software solution that integrates all of the company's business functions, helps in business process management and shares a single database for the whole system.

An enterprise resource planning (ERP) system is considered as a cross-functional system that automates and integrates the essential business operations of an organization in order to maximize effectiveness and efficiency (Mahmood et al., 2019).

Bradford (2015) states that companies can implement a module or modules of ERP software without having to buy and implement the complete package because most of it is flexible enough.

According to Bradford (2015), ERP systems are often thought of as "back-office" systems since they integrate "back office" functions like order fulfilment, purchasing, accounting, and finance. ERP systems are now more than just back-office systems; they include front office, customer-facing, and supply chain-facilitating modules.

ERP systems have many **advantages**, such as (Bradford, 2015; Paredes Hernandez, 2023):

- Improved transparency and insights – data from every department can be accessed by executive-level employees,
- Real-time access to information – data is available in real-time to all users in all departments,
- Reduction of operational costs – through lower inventory costs, production costs or purchasing costs,
- Single interface through all modules – modules in ERP system look the same and provide the same way of functioning,
- Scalability – cloud-based ERP systems enable the use of additional computing resources in case of company and data growth,
- Improved customer service - a new system such as ERP software can enable more personalized and expedited customer service because it centralizes all customer data.

Some of the **disadvantages** of ERP systems are (Bradford, 2015; Paredes Hernandez, 2023; Oracle, n.d.a):

- Complex and time-consuming implementation – the implementation of an ERP system can take between a few months and several years, depending on the size of the company,
- Price – ERP systems are often very expensive, especially the popular ones: SAP and Microsoft Dynamics NAV,
- Change management - it will take a lot of time and effort to make sure that every important employee is adequately trained on how to use the new system.

The main reason why companies implement ERP systems is to support their company's growth. Also, the implementation of an ERP is the goal of a considerable number of businesses in order to enhance their productivity and processes (Software Path, 2022).

Implementation of ERP systems is very complex and the most ERP projects fail. According to Saunders (2022), about 80% of ERP projects fail. 25% of ERP projects were cancelled or delayed, and another 55% have missed the stakeholders' expectations for the project.

Mahmood et al. (2019) conducted research in which they identified the most critical issues/challenges faced by organizations when implementing the ERP:

1. **Top management support** – the support, strategic direction and active involvement of top management are essential for the successful implementation and management of ERP systems,
2. **Change management** - resistance, particularly from middle managers accustomed to traditional methods, poses significant challenges to adopting new ERP systems,
3. **Training and development** - the complexity of ERP systems requires extensive and ongoing employee training, with insufficient training leading to potential ERP failures and often representing hidden costs for organizations.
4. **Effective communication** - clear and continuous communication and coordination among various departmental users is vital for successful ERP implementation and organizational change management,
5. **System integration** - involves the complex task of integrating various ERP modules with existing business applications and legacy systems within the organization,

a process essential for optimizing business processes and improving efficiency, yet often costly and complex.

Another equally crucial aspect of the ERP system implementation is the financial investment required for the implementation and maintenance of ERP systems. This forthcoming sub-chapter will explore the various components of ERP system costs, encompassing both the initial investment and the ongoing operational expenses.

6.1.1. Costs of ERP systems

Enterprise Resource Planning (ERP) systems have become an integral part of modern business operations, offering a range of benefits from improved efficiency to enhanced data integration. However, the implementation of such systems comes with significant costs that organizations need to consider carefully.

ERP systems have traditionally been used by companies that sell tangible goods. These comprehensive software solutions were designed to serve large multinational organizations. As a result, their implementation was exceedingly costly and complex. ERP modules like purchasing, sales, and logistics are the foundation for the financial reporting processes, and automating these across a global organization could create significant returns on investment (Berry, 2021).

The total cost of implementing an ERP system includes expenses related to software licensing, hardware requirements, implementation, maintenance, consulting, formal and informal training and customization. These costs are usually referred to as **total cost of ownership (TCO)**. It can vary significantly depending on the scope of implementation, the complexity of the software, and the chosen ERP vendor. For mid-sized organizations, the investment in packaged ERP software alone can amount to a few million dollars (Leon, 2014; Tilley, 2020).

In addition to software costs, the implementation of ERP systems often requires substantial investments in IT infrastructure. This includes servers, storage systems, network components, and possibly upgrading existing components that are nearing the end of their life cycle (Bradford, 2015). While cloud computing can reduce some of these hardware costs as the ERP software runs on the vendor's servers, the initial investment in infrastructure remains a significant component of the overall cost.

The hidden costs associated with ERP implementations, such as consultancy fees, also play a significant role in the total expenditure. These costs include the fees for external consultants who are familiar with the ERP system but may not have in-depth knowledge of the organization's specific business processes (Leon, 2014).

Nearly 80% of total costs occur after the purchase of the hardware and software (Tilley, 2020).

The cost of ERP software is influenced by various factors. For example (Hale, 2019; Wood, 2023):

- **Deployment method** – ERP systems can be deployed on a cloud, on premise or as a combination of the two.
- **Number of users** – ERP systems with a lower number of users could cost less.
- **Applications required** – a number of modules can range from core modules to some specific modules.
- **Customization level** – any additional upgrades of the initial software increase the price of the ERP system.
- **User training and support** – usually, but not always, implementation fees include a year of customer support. Real-time, consistent support may come at an additional expense.
- **Hardware upgrades** – companies may need to buy extra hardware (e.g. servers, storage, network infrastructure) during implementation in order to support their new ERP.

The average budget per user for an ERP project, according to a Software Path (2022) report, is $9,000. However, this cost varies based on the size of the business and the number of users. According to Hale (2019), maintenance costs may amount to 10% to 20% of the initial license fee.

6.1.2. ERP systems trends

In recent decades organizations have spent millions of dollars in implementing ERP systems (Ruivo et al., 2020). The ERP software revenue is growing 8% year over year to a market

value of $44 billion in 2023 (Haranas, 2023) and it is projected to reach $62 billion by 2028 (Statista, 2023).

Nowadays, there is a large number of ERP software vendors. According to Davidson (2023) top ERP software vendors are Microsoft, SAP, Oracle, Sage, Epicor and Infor.

When it comes to purchasing ERP software, manufacturing is the industry with the highest representation (27%). At 20%, construction is in the second place. Together, distribution and transportation, which are included in the supply chain industry's broader definition, account for 16% (Wood, 2023).

According to Statista (2023), the **requirement for customization** is one of the primary customer preferences in the ERP software market. Software that can be customized to meet the unique demands and specifications of businesses is essential. The need for flexible and scalable cloud-based ERP solutions has increased as a result. Customers also want software that is simple to use and seamlessly integrates with other systems.

The future and trends of Enterprise Resource Planning (ERP) systems are shaped by evolving business needs and technological advancements. As of 2023, several key trends are prominent in the field of ERP (Luther, 2023):

- **Cloud ERP** - Cloud-based ERP solutions are becoming increasingly popular due to their simpler deployment, lower costs, elasticity, and the ability to accommodate business growth. The pandemic has accelerated the shift from on-premises software to cloud ERP, as these systems allow employees to work remotely with ease. According to Wood (2023), 42% of companies used Cloud-based ERP in 2022 (compared to 2013, when this percentage was only 4%). Typically, cloud ERP is provided as software as a service (SaaS), which means users must pay a monthly, quarterly, or annual fee for ongoing access.
- **Two-Tier ERP** - The two-tier ERP approach is gaining traction. This strategy uses a primary ERP system at the corporate level, while subsidiaries and divisions operate using a different, often cloud-based, ERP solution. Larger companies might keep using their main ERP system for financials and other core processes, while smaller business units would look for solutions tailored to their specific requirements.

- **Digital transformation** - ERP systems are playing a crucial role in the digital transformation of businesses. By integrating digital technology into all business functions, ERP systems are boosting revenue, competitiveness, and improving customer service and communication.
- **Integration with other technologies** - Modern ERP systems are increasingly integrated with other technologies, such as IoT and social media, to enhance core processes and provide greater visibility and a better customer experience.
- **Personalization** - ERP systems are evolving to offer more personalized experiences to customers, supported by AI-based assistive and conversational user interfaces like chatbots. This trend is facilitated by cloud ERP platforms designed for easier configuration and industry-specific solutions.
- **AI-Powered insights and improvements** - AI and machine learning are being embedded into ERP systems, providing valuable business insights by analysing operational and customer data. This integration helps in optimizing a range of business processes and improving personalisation.
- **Predictive analytics** - The use of predictive analytics in ERP systems is on the rise, focusing on analysing data to predict future trends and outcomes, which aids in better decision-making and strategic planning.
- **Mobile ERP** - Mobile ERP is becoming more common, offering on-the-go access to critical business data and facilitating remote work. Mobile ERP apps with user-friendly interfaces help employees to complete tasks efficiently, irrespective of their location.

These trends indicate a significant shift in ERP systems towards more adaptable, personalized, and integrated solutions that align with modern business practices and technological advancements.

ERP systems manage basic supply chain functions like inventory control and order fulfilment, but they are typically very basic. Their main objective was to assist with financial processes. The inventory management module of an ERP was not very good at managing the labour in the warehouse, but it might be pretty good at tracking inventory valuation for the enterprise balance sheet. As a result, the market saw the emergence of best-of-breed logistics applications that could complement the ERP and close gaps. Warehouse management systems

(WMS) and transportation management systems (TMS) emerged as the two main categories of logistics applications (Berry, 2021).

6.2. Warehouse Management Systems

From the moment materials or goods enter a distribution or fulfilment centre until they leave, a **warehouse management system (WMS)** enables companies to monitor and manage warehouse operations. The primary objective of a WMS is to facilitate the efficient and economical movement of materials and goods through warehouses. Picking, receiving, put away, and inventory tracking are just a few of the many tasks that a WMS performs to facilitate these movements. WMS software systems provide real-time visibility into a company's entire inventory, both in transit and warehouses, and are a crucial part of supply chain management (O'Donnell, 2020).

According to SAP (n.d.a), a warehouse management system optimizes various warehouse activities. It streamlines the receiving and put-away process using RFID technology and integrates with other software for efficient item handling. In inventory management, WMS provides real-time visibility and supports advanced analytics for better stock control. For order picking, packing, and fulfilment, it guides efficient storage, retrieval, and packing, employing technologies like RF scanning and robotics to optimize order processing. Shipping processes are enhanced by integrating with logistics software, ensuring timely and accurate deliveries. WMS also aids in labour management, offering insights into labour costs and productivity, and supports efficient task management. Additionally, it facilitates yard and dock management, improving loading efficiency, and supports cross-docking for perishable goods. Finally, WMS provides valuable warehouse metrics and analytics, enabling better decision-making and process optimisation.

SAP (n.d.a) lists 5 benefits of a WMS:

1. **Improved operational efficiency** - WMS systems enhance efficiency and handling volumes by automating and streamlining warehouse processes from inbound receipts to outbound deliveries.
2. **Reduced waste and costs** - WMS helps in minimizing waste, especially for date-restricted or perishable stock, and optimizes warehouse space utilisation.

3. **Real-time inventory visibility** - It offers real-time insight into inventory movement, aiding in accurate demand forecasts and improved traceability.
4. **Improved labour management** - WMS aids in forecasting labour needs and optimising task assignments based on various factors, thereby enhancing employee morale.
5. **Better customer and supplier relationships** - WMS leads to improved order fulfilment and faster deliveries, increasing customer satisfaction and enhancing supplier relations.

Warehouse management system development is still being influenced by technological advancements. For example, those are (Scullin, 2023):

- **Automated picking tools** - technologies like voice automated order picking, robotic order picking, and pick-to-light systems, coupled with sophisticated barcoding,
- **Automatic Guided Vehicles (AGVs)** - enhance storage and retrieval processes, crucial for tasks like pallet and rack storage, container management, and automating the receiving process,
- **Internet of Things (IoT)** - By integrating IoT, various automated and manual elements are controlled within a unified network, enhancing inventory control, labour planning, and customer experience through faster fulfilment rates,
- **Augmented (AR) and virtual reality (VR)** - AR technology, through devices like smart glasses, provides real-time overlays of instructions or information in a warehouse environment, aiding in tasks like route navigation and bin location without the use of hands. VR is utilized for training and safety purposes, such as training lift truck operators and improving delivery routes.

Berry (2021) states that the WMS market is very mature, and there are many well-known software companies that offer a wide range of features to help with even the most complicated warehouse tasks. A lot of the top WMS providers now offer delivery models in the cloud. 40-50% of new WMS customers now choose cloud delivery over on-premises deployments. Some of the popular WMS vendors are (Gartner, n.d.): SAP Extended Warehouse Management (EVM), Oracle Warehouse Management (WMS Cloud), Microsoft Dynamics 365 Supply Chain, Manhattan WMS and Infor WMS.

6.3. Transportation Management Systems

A Transportation Management System (TMS) is a crucial software in logistics that optimizes the movement of goods across various modes of transport. As part of a broader Supply Chain Management system, TMS optimizes load and delivery routes, tracks freight, and automates tasks like trade compliance and freight billing. This system not only ensures timely delivery but also reduces costs, thereby benefiting both businesses and customers. It offers comprehensive visibility into transportation operations, aids in compliance, and simplifies the shipping process across land, air, or sea (SAP, n.d.b; Oracle, n.d.b).

According to Berry (2021), there are several ways that a TMS can lower the cost of transportation. The shipping department can save a lot of time and effort by automating the process of booking and tracking shipments. Routing guide capabilities ensure that shipping clerks choose the method of transport that costs the least for each shipment. A lot of TMS products can optimise less-than-truckload shipments into full-truckload shipments, which are much cheaper.

Some of the benefits of TMS are (SAP, n.d.b; Inbound Logistics, 2023):

- **cost savings** – TMS significantly reduces both administrative and shipping costs, optimizing load and freight management,
- **real-time visibility** – provides critical insights into the transportation process, enhancing route efficiency and tracking,
- **greater customer satisfaction** – ensures on-time delivery and improves customer experience through better tracking and billing processes,
- **improved efficiency** – TMS enhances the overall efficiency of transportation operations,
- **enhanced decision making** – offers valuable data for informed decision-making, improving strategic planning in transportation management.

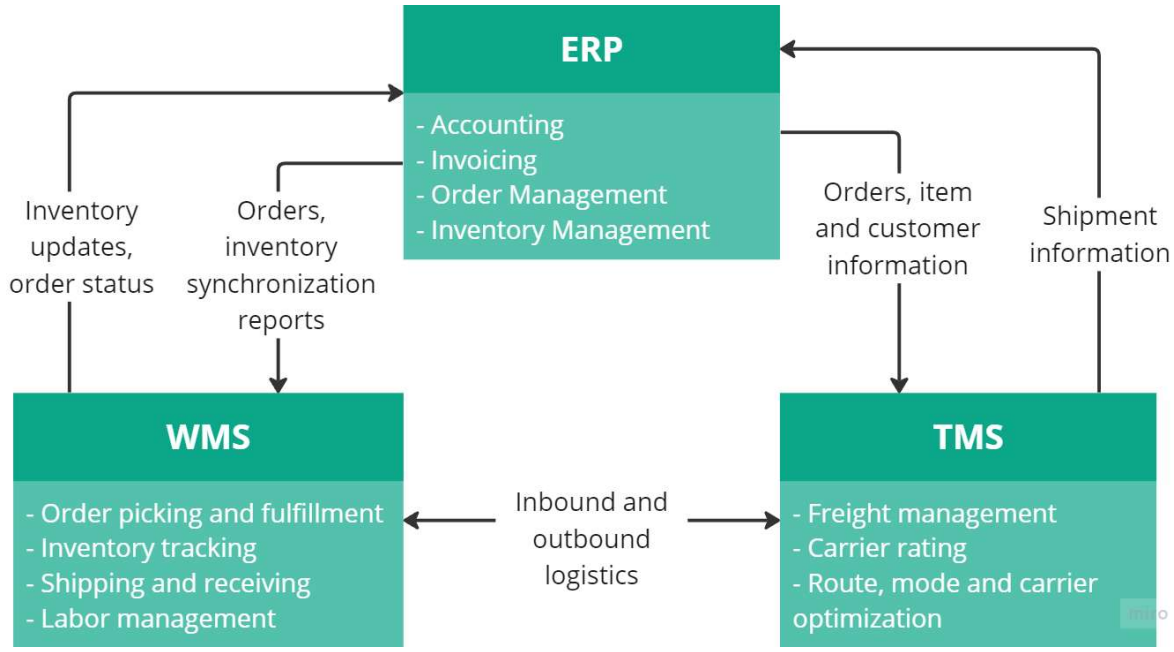

Figure 6.2 The connection between ERP, WMS and TMS

Source: Essex (2020).

Figure 6.2 shows the connection between ERP, WMS and TMS systems. According to Essex (2020), an ERP system manages accounting, invoicing, order, and inventory management. The WMS assists with fulfilment, shipping, and receiving tasks in a warehouse, such as picking and storing goods, and updates the ERP system's inventory module with real-time data from barcode and RFID scans. The ERP system provides order details to the TMS for shipment preparation and execution. The TMS returns shipment details to the ERP for accounting and order management, and potentially updates customer relationship management (CRM) modules for customer updates on order status.

In this chapter, the important role of ERP, WMS and TMS systems for logistics was described. These systems, critical in modern logistics, collectively enhance efficiency, ensure precise inventory management, and optimize transportation processes. The integration of ERP, WMS, and TMS is not just a technological advancement but a strategic necessity, driving businesses towards greater efficiency, accuracy, and customer satisfaction in the field of logistics and supply chain management.

REFERENCES

1. Berry, J. (2021). Logistics in the Cloud-Powered Workplace. In Sullivan, M. & Kern, J. (Eds.). The Digital Transformation of Logistics. Piscataway: IEEE Press.
2. Bradford, M. (2015). Modern ERP: Select, Implement, and Use Today's Advanced Business Systems, 3rd Edition. Lulu.com
3. Davidson, R. (2023). Top 6 ERP Software Vendors. SoftwareConnect [available at: https://softwareconnect.com/erp/top-vendors/, access January 15, 2024]
4. Esex, D. (2020). Transportation management system (TMS). TechTarget [available at: https://www.techtarget.com/searcherp/definition/transportation-management-system-TMS, access January 15, 2024]
5. Gartner (n.d.). Warehouse Management Systems Reviews and Ratings [available at: https://www.gartner.com/reviews/market/warehouse-management-systems, access January 17, 2024]
6. Hale, Z. (2019). What Factors Determine the Cost of ERP Software?. Software Advice [available at: https://www.softwareadvice.com/resources/erp-software-pricing/, access January 15, 2024]
7. Haranas, M. (2023). Oracle, Microsoft, SAP, Workday Lead Cloud ERP Market: Gartner. CRN [available at: https://www.crn.com/news/cloud/oracle-microsoft-sap-workday-lead-cloud-erp-market-gartner, access January 17, 2024]
8. Inbound Logistics (2023). Transportation Management System: Meaning, Importance, and Benefits [available at: https://www.inboundlogistics.com/articles/transportation-management-system/, access January 17, 2024]
9. Leon, A. (2014). ERP demystified, 3rd edition. McGraw Hill Education.
10. Luther, D. (2023). 8 ERP Trends for 2023 & The Future of ERP. Oracle Netsuite [available at: https://www.netsuite.com/portal/resource/articles/erp/erp-trends.shtml, access January 15, 2024]
11. Mahmood, F., Khan, A. Z. & Bokhari, R. H. (2019). ERP issues and challenges: a research synthesis. Kybernetes, 49(3), pp. 629–659.

12. O'Donnell, J. (2020). Warehouse management system (WMS). TechTarget [available at: https://www.techtarget.com/searcherp/definition/warehouse-management-system-WMS, access January 15, 2024]
13. Oracle (n.d.a). What are the benefits of an ERP system? [available at: https://www.oracle.com/hk/erp/what-is-erp/erp-benefits/, access January 20, 2024]
14. Oracle (n.d.b). What Is a Transportation Management System? [available at: https://www.oracle.com/scm/logistics/transportation-management/what-is-transportation-management-system/, access January 15, 2024]
15. Paredes Hernandez, J. (2023). The advantages and disadvantages of ERP systems. IBM [available at: https://ibm.com/blog/enterprise-resource-planning-advantages-disadvantages/, access January 16, 2024]
16. Ruivo, P., Johansson, B., Sarker, S. & Oliveira, T. (2020). The relationship between ERP capabilities, use, and value. Computers in Industry, 117, 103209.
17. SAP (n.d.a). What is a warehouse management system (WMS)? [available at: https://www.sap.com/products/scm/extended-warehouse-management/what-is-a-wms.html, access January 15, 2024]
18. SAP (n.d.b). What is a transportation management system (TMS)? [available at: https://www.sap.com/products/scm/transportation-logistics/what-is-a-tms.html, access January 15, 2024]
19. Saunders, P. (2022). Are ERP Projects Really The Stuff Of Nightmares?. Forbes [available at: https://www.forbes.com/sites/sap/2022/06/28/are-erp-projects-really-the-stuff-of-nightmares/, access January 20, 2024]
20. Scullin, Ch. (2023). 7 Smart Warehouse Technologies to Implement Today. Camcode [available at: https://www.camcode.com/blog/smart-warehouse-technologies/, access January 10, 2024]
21. Software Path (2022). What 1,384 ERP projects tell us about selecting ERP (2022 ERP report) [available at: https://softwarepath.com/guides/erp-report, access January 15, 2024]
22. Statista (2023). Enterprise Resource Planning Software – Worldwide [available at: https://www.statista.com/outlook/tmo/software/enterprise-software/enterprise-resource-planning-software/worldwide, access January 15, 2024]

23. Tilley, S. (2020). Systems Analysis and Design, 12th Edition. Boston: Cengage Learning.

24. Wood, L. (2023). How Much Does ERP Cost?. SoftwareConnect [available at: https://softwareconnect.com/erp/pricing/, access January 22, 2024]