Zeszyty Naukowe
Akademii Górnośląskiej
Nr 33 (9/2025), s. 268 - 288
DOI: 10.53259/2025.09.25

ISSN 2956-6673
e-ISSN 2956-6681

Katarzyna Sułek
Uniwersytet Ekonomiczny w Krakowie
Kraków, Polska
e-mail: sulekk@uek.krakow.pl
ORCID 0000-0001-6603-3225

ANALYSIS OF THE WMS SYSTEM IMPLEMENTATION SUPPORTED BY AUTOMATIC DATA COLLECTION TECHNIQUES – CASE STUDY

ANALIZA PROCESU IMPLEMENTACJI SYSTEMU WMS WSPIERANEGO TECHNIKAMI AUTOMATYCZNEGO GROMADZENIA DANYCH – STUDIUM PRZYPADKU

Keywords: warehouse, warehouse logistics, WMS, Warehouse Management System, barcodes, case study
Słowa kluczowe: *magazynowanie, logistyka magazynowa, WMS, kody kreskowe, studium przypadku*

Abstract

Purpose. The aim of this article is to analyze the process of implementing a Warehouse Management System (WMS) supported by automatic data identification techniques in a steel distribution company. The study seeks to identify changes introduced in warehouse processes, evaluate their impact on operational efficiency, and highlight practical benefits gained by the company.
Design/methodology/approach. The research was conducted basing on available literature in the field of warehousing logistics. Internal documents and data collected through an open, partially structured direct interview were also used as research material. The employed method facilitated obtaining answers to the pre-established questions, while allowing respondents the freedom to express their views based on associations related to warehouse management organization and the implementation of a WMS system.

Findings. The implementation of the WMS has significantly enhanced logistics processes. The system has improved the accuracy of warehouse records, expedited inbound, picking, and outbound operations, and reduced errors associated with manual data processing, strengthening control over material flows.

Practical implications. The adoption of the WMS has yielded tangible benefits, such as the elimination of paper-based documentation, increased operational efficiency, cost reduction, and enhanced customer service quality. The automation of warehouse processes has facilitated better space utilization and internal transportation management, positively impacting the overall performance of the enterprise.

Originality/value. This study contributes to the field of warehouse management by presenting an in-depth case study of WMS implementation in the specific context of steel product distribution.

The study explores the practical considerations involved in system deployment, identifies potential challenges, and emphasizes the advantages of integrating IT solutions with logistics processes.

Streszczenie

Cel badań. *Cel niniejszego artykułu stanowi analiza procesu implementacji systemu zarządzania magazynem (WMS), wspieranego przez techniki automatycznej identyfikacji danych, w przedsiębiorstwie zajmującym się dystrybucją stali. Badanie ma na celu wskazanie zmian wprowadzonych w procesach magazynowych, ocenę ich wpływu na efektywność operacyjną oraz podkreślenie praktycznych korzyści osiągniętych przez przedsiębiorstwo.*

Metodyka badań. *Badania przeprowadzono w oparciu o dostępną analizę literatury z zakresu logistyki magazynowej. Materiał badawczy stanowiły również dokumenty wewnętrzne oraz dane uzyskane na podstawie częściowo ustrukturyzowanego wywiadu bezpośredniego o charakterze otwartym. Zastosowana metoda umożliwiła uzyskanie odpowiedzi na wcześniej zdefiniowane pytania, jednocześnie dając respondentom swobodę wyrażania opinii w oparciu o własne skojarzenia związane z organizacją zarządzania magazynem oraz implementacją systemu WMS.*

Wyniki badań. *Wdrożenie systemu WMS w istotny sposób usprawniło procesy logistyczne, przyczyniając się do poprawy dokładności ewidencji magazynowej, przyspieszenia procesów przyjęć, kompletacji i wydań, a także do redukcji błędów wynikających z ręcznego przetwarzania danych, wzmacniając tym samym kontrolę nad przepływami materiałowymi.*

Implikacje praktyczne. *Zastosowanie systemu WMS przyniosło wymierne korzyści, takie jak eliminacja dokumentacji papierowej, wzrost efektywności operacyjnej, obniżenie kosztów oraz poprawa jakości obsługi klienta. Automatyzacja procesów magazynowych umożliwiła lepsze wykorzystanie przestrzeni i usprawnienie transportu wewnętrznego, co wpłynęło pozytywnie na ogólną efektywność funkcjonowania przedsiębiorstwa.*

Oryginalność i wartość badań. *Niniejsze opracowanie wnosi istotny wkład do badań nad zarządzaniem magazynem, prezentując pogłębione studium przypadku wdrożenia systemu WMS w specyficznym kontekście dystrybucji wyrobów stalowych. Badanie ukazuje praktyczne aspekty związane z implementacją systemu, identyfikuje potencjalne wyzwania oraz podkreśla zalety integracji rozwiązań informatycznych z procesami logistycznymi.*

INTRODUCTION

Effective supply chain management, which integrates a coordinated network of logistics and operational connections across organizational units involved in procurement, manufacturing, and distribution to end customers, is heavily dependent on the efficiency of material flows. Within this context, warehouses play a critical role as one of the key factors directly influencing the overall efficiency of the supply chain. Traditionally perceived as cost centers, warehouses have undergone a profound transformation and are now recognized as strategic assets capable of generating added value and enhancing organizational responsiveness [Minashkina, Happonen, 2020] particularly in the era of rapidly expanding e-commerce and heightened consumer expectations.

However, the constantly evolving market environment necessitates continuous exploration of solutions aimed at enhancing warehouse processes. This reorganization is increasingly facilitated by information systems, among which the Warehouse Management System (WMS) and plays a pivotal role in warehouse operations [Odeyinka, Omoegun, 2024].

This system, often supported by automated data collection technologies such as barcode, QR systems or RFID, enables the acceleration of numerical control over inbound and outbound products, enhances the efficiency of order-picking processes, reduces reliance on paper-based documentation, and simplifies inventory procedures.

This article is intended to provide an in-depth examination of WMS implementation in a steel distribution enterprise. Its primary aim is to identify and evaluate the procedural modifications introduced in warehouse operations, assess their impact on performance, and explore the application of automated identification technologies in routine processes. Special attention is devoted to deployment challenges and to the practical outcomes achieved, such as enhanced inventory accuracy, accelerated order processing, and improved traceability across the supply chain.

WAREHOUSE OPERATIONS AND THEIR IMPACT ON LOGISTICS EFFICIENCY

Logistics represents an integrated system of activities spanning various domains, with the most prominent being transportation and forwarding, production and distribution, and warehouse management. The latter, when subject to appropriate optimization processes, forms a crucial component of the logistics chain [Mohamed, 2024], enabling enterprises to achieve satisfactory operational outcomes relatively quickly and with minimal capital investment. Warehouse logistics significantly influences the efficiency and effectiveness of material flows while simultaneously shaping the associated cost structures [Januła et al., 2020]

A warehouse functions as a critical logistics facility that facilitates the seamless connection between key stages of material flow. It plays an essential role in bridging the gaps between the receipt of raw materials, their storage, and their eventual distribution to manufacturing or end customers [Januła, 2020; Samsudin et al., 2023]. By ensuring the efficient management of inventory and coordinating the movement of goods, warehouses optimize supply chain operations and contribute significantly to the overall efficiency of logistics systems. In a commercial enterprise, these stages involve procurement and sales, whereas, in a manufacturing enterprise, they comprise procurement and distribution [Nguyen et al, 2019]. According to A. Niemczyk's definition, a warehouse is a "functional and organizational unit designated for storing material goods (inventory) within a defined space in a storage facility, following an established technology, equipped with appropriate technical resources, and managed and operated by a dedicated workforce" [Niemczyk, 2008]. Consequently, a warehouse is a purposefully designed space that facilitates the efficient storage of goods and the execution of complex handling operations, thereby fulfilling several essential functions within a company's logistics structure, such as [Januła et al., 2020]:

1. Coordination of supply and demand,
2. Reduction of transportation costs,
3. Support for production processes,
4. Enhancement of marketing operations.

The implementation of proper warehouse management practices requires an in-depth understanding of the characteristics of stored inventory, which consists of accumulated and temporarily stored goods essential for business operations. These goods constitute part of a company's current assets and exist in various forms, including raw materials, work-in-progress inventory, and finished products [Vrat, 2014].

Regardless of the type of inventory stored, nearly every warehouse consists of four fundamental zones [Pisz et al., 2013]:

1. Receiving zone, where operational and technical activities are carried out to facilitate the proper acceptance of goods into the warehouse,
2. Storage zone, where goods are systematically stored,
3. Picking zone, designated for assembling items for specific orders (this zone is not always mandatory in warehouse layouts),
4. Shipping zone, where the final processes related to order dispatch and transportation take place.

Warehouse management is primarily centered on optimization efforts aimed at enhancing both accuracy and efficiency. These initiatives not only streamline operational processes but also facilitate the integration of advanced technological solutions, such as automation, data analytics, and real-time tracking systems. By incorporating these innovations, warehouse management systems can improve inventory control, reduce operational costs, and enhance overall service delivery, contributing to a more agile and responsive supply chain [Adeniran et al., 2024]. However, effective optimization requires a detailed understanding of the interdependent processes that collectively influence warehouse efficiency.

The first step in warehouse management is pre-advice (advance notification), which occurs before the physical receipt of goods. This process involves notifying the recipient of an upcoming delivery, specifying the exact time of arrival [Richards, 2014]. Additionally, the procurement department must inform suppliers of the storage capacity, ensuring modifications in packaging and labeling to facilitate smooth warehouse operations.

A fundamental operation that guarantees the accurate receipt of delivered goods, both in terms of quantity and condition, is the goods acceptance process. This process involves a series of essential steps, starting with the unloading phase. The unloading of goods marks the initial stage, setting the foundation for subsequent inspections and verifications to ensure that the items received match the specified order and are free from damage [Bartholdi, Hackman, 2017]. This procedure is vital for maintaining inventory accuracy, preventing discrepancies, and ensuring that only products meeting quality standards are accepted into the warehouse. During unloading, the reference number of the delivery vehicle is verified to assign it to the appropriate loading dock or storage area. In cases where transported goods require sealed delivery, an additional step involves verifying the security seals' integrity with the transport documentation [Hulstijn, 2012].

The quality and quantity control process can range from random sampling to a detailed comparison of item specifications against delivery documents. This is particularly important for high-value goods, hazardous materials [Sun et. al., 2025], or temperature-sensitive products [Palčnik, Podbregar, 2021]. The inspection is performed either directly during unloading or in a designated inspection area near the receiving dock. Defective items are marked accordingly and moved to a transitional storage area or directly into the warehouse, pending further processing decisions [Richards, 2016].

Goods that successfully pass the control process are transported to the storage area. The physical relocation of items within the warehouse marks the beginning of the storage process, defined by I. Pisz, T. Sęk, and W. Zielecki as a sequence of activities involving the systematic organization of inventory placement based on product characteristics and storage conditions. This phase involves several key activities [Pisz et al., 2013]:

1. Receiving goods from the inbound area,
2. Verifying and adjusting unit loads as necessary,
3. Placing inventory in designated storage locations based on warehouse topology,
4. Transferring inventory between different storage zones,
5. Conducting regular inventory maintenance,
6. Performing periodic quality control of stored goods,
7. Moving inventory to the order-picking or dispatch area.

Inventory remains in storage until a demand is initiated through internal requisitions or external customer orders, triggering the order-picking process. This process involves a series of logistical operations aimed at assembling goods according to customer requirements [Vaka, 2024]. It begins with the retrieval of units from the storage zone, which are then transferred to picking stations for final order compilation. The items are subsequently packed and secured before being forwarded to the shipping zone.

Order picking is characterized by a high number of manual [Henn, 2010] or fully automated [Vanheusden, 2023] handling activities, an increased flow of information due to order variability, and a heightened risk of errors, making it one of the most cost-intensive warehouse operations. Cost optimization in order picking can be achieved by selecting the most appropriate picking strategy based on product characteristics, order volume, and inventory diversity. Richards G. [2016] identifies two primary picking strategies:

1. Person-to-goods (where workers travel to retrieve items),
2. Goods-to-person (where automated systems deliver items to workers).

Warehouse operations allow for the implementation of various picking strategies, depending on inventory type, warehouse throughput, and budget constraints. While most companies still rely on the person-to-goods approach, growing automation has increased interest in goods-to-person strategies. Additionally, hybrid picking methods tailored to omnichannel distribution are gaining popularity.

The final stage in warehouse operations, following goods receipt, storage, and order picking, is order dispatch. The dispatch process involves preparing shipments for outbound transportation and includes [Pisz et al., 2013]:

1. Retrieving picked items from the storage or picking area,
2. Conducting final quantity and quality checks,
3. Sorting, packing, and labeling shipments,
4. Assembling shipments based on delivery routes and customers,
5. Forming transport units,
6. Transferring shipments to carriers as per logistics directives,
7. Loading goods onto external transport vehicles,
8. Generating documentation confirming the physical dispatch of goods.

The loading process plays a crucial role in ensuring the safe and efficient transportation of goods. Proper pre-packaging is essential, as it ensures that the cargo's dimensions and packaging formats are compatible with the capacity of the vehicle transport. This alignment not only minimizes the risk of damage during transit but also optimizes the utilization of available cargo space. By carefully selecting the appropriate packaging materials and configurations, the loading process helps reduce the likelihood of shifting or compression, which can compromise the integrity of the goods. Additionally, efficient space utilization contributes to cost-effectiveness, as it allows for the transportation of more goods within a single shipment, reducing the number of trips required and improving overall logistical efficiency. Once the loading process is complete and documented, warehouse operations transition into outbound logistics, where goods are transported to their final destinations [Richards, 2014].

Warehousing is therefore a structured sequence of operations encompassing goods receipt, storage, order picking, and dispatch, along with additional logistical tasks such as unloading trucks and conducting quality control. As technology advances, these processes are increasingly automated, enhancing warehouse efficiency while adding value to stored goods. This transformation is largely driven by the adoption of Warehouse Management Systems (WMS), enabling barcode-based inventory tracking and RFID technology, which facilitates contactless item identification through radio frequency communication [Custodio, Machado, 2020].

WMS SUPPORTING WAREHOUSE MANAGEMENT

Dynamically evolving market environment compels enterprises to implement information systems tailored to the specific nature of their operations. Software solutions are becoming an essential backbone for organizations, seamlessly integrating a wide range of internal processes and operations. These systems play a pivotal role in optimizing efficiency and coordination across various departments, with a particularly profound impact on warehouse management. By streamlining workflows, enhancing data visibility, and enabling real-time decision-making, software solutions are significantly transforming how warehouses operate, driving improvements in inventory control, order fulfillment, and overall logistical performance [Samsudin et al., 2023].

Among the various information systems that support warehouse operations, Warehouse Management Systems (WMS) play a pivotal role. These systems consist of a suite of specialized tools and algorithms tailored to monitor and manage the precise locations of unit loads. In addition to tracking inventory, WMS oversee a wide range of related operations, such as optimizing storage space, managing order picking and packing, coordinating inbound and outbound shipments, and ensuring accurate inventory control [Persson, 2024; Ortiz, Paredes-Rodríguez, 2021]. By integrating these functions, WMS enhance operational efficiency, reduce errors, and improve overall warehouse performance [Pisz et. al., 2013]:

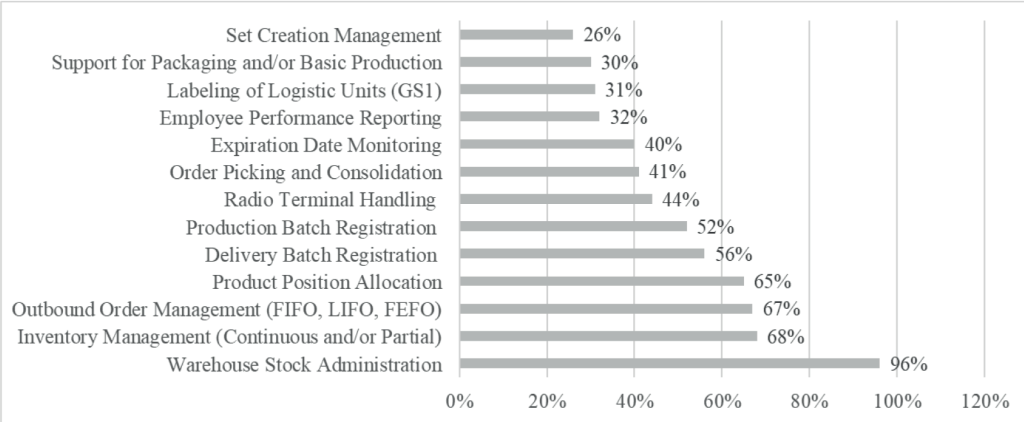
1. Managing multiple warehouses,
2. Classifying storage areas and warehouse zones,
3. Collecting data on storage locations, including type, quantity, and distribution,
4. Recording detailed product information, such as expiration dates, packaging structure, storage conditions, and serial numbers,
5. Enabling automated identification techniques such as barcodes,
6. Generating picking lists,
7. Wireless control of internal material handling equipment.

A WMS facilitates efficient warehouse management by offering a wide range of functionalities, from inventory administration and order grouping to warehouse layout optimization [Persson, 2024].

According to the 2014 report "Information Systems in Polish Warehouses" by Logisys Sp. z o.o., based on responses from 346 participants of whom slightly over one-third reported using a WMS the most frequently utilized functions included inventory management (96%), conducting stock-taking (68%), managing outbound order sequencing using FIFO, LIFO, or FEFO principles (67%), and assigning specific storage locations to products (65%). Detailed statistics on the use of various WMS functionalities are illustrated in Figure 1.

However, the presented functionalities, do not fully reflect the comprehensive capabilities of a Warehouse Management System (WMS), whose scope is considerably broader. Therefore, the first step in implementing this software involves a detailed analysis of the strategy and needs of a given business entity. This analysis results in defining the key requirements for the implemented solution, ensuring the achievement of the intended objectives [Andiyappillai, 2019]. This approach stems from the fact that implementing an IT solution for an inefficient or redundant process will not enhance the enterprise's productivity. As a result, automation is primarily applied to business areas where the implementation of a WMS will significantly improve operational efficiency, as well as to bottlenecks processes that have traditionally been time-consuming and inefficient. The introduction of a WMS can greatly enhance the efficiency of various operations within an enterprise, while also enabling optimal utilization of warehouse space and material handling equipment [Richards, 2016].

Figure 1. Most Frequently Used Functions of Warehouse Management Systems (WMS)



Source: Own description based on Logisys Sp. z o.o., 2014.

The implementation of a WMS is a key factor in maintaining a competitive market position, as optimizing warehouse processes without automation can be highly challenging. Deploying an IT-based inventory management system has a direct impact on increasing the speed and accuracy of warehouse operations. Furthermore, warehouse efficiency is considered a crucial element in effective supply chain management. However, achieving full warehouse process optimization, which directly affects the overall productivity of the enterprise, requires the integration of supporting technological solutions. These include automated data collection techniques, among which barcodes play a particularly significant role [Deepali et. al., 2024; Samsudin et al., 2023]. Barcodes are defined as a specific combination of light and dark elements (bars) arranged linearly in varying widths, representing a strictly defined sequence of machine-readable characters [Gołembska, 2013]. Currently, approximately 250 different barcode solutions exist in economic practice. Despite the availability of various options, one-dimensional (1D) and two-dimensional (2D) barcodes remain the most widely used [Burke, Ewing, 2014]. Due to the international standardization of barcode symbology and application, their use is feasible at all stages of the supply chain without requiring additional investment expenditures. Implementing an automatic product identification system using labels with combinations of dark and light elements has a significantly positive impact on all aspects of enterprise operations, enabling [Baj-Rogowska, 2014]:

1. Detailed verification of operational accuracy,
2. Reduction in the need for paper-based documentation,
3. Significant reduction in inventory audit time,
4. Increased operational speed and elimination of errors in process execution.

Technologies for automatic identification of data and objects, such as barcode systems, greatly enhance organizational efficiency, allowing businesses to achieve multiple benefits, including cost reduction, improved warehouse operations, enhanced transportation efficiency, and increased customer service levels.

From the perspective of warehouse management, the most important areas of application for labels containing barcodes, encompassing elements such as [Deepali et al., 2024]:

1. **Product** Barcodes/QR codes enable the encryption of a wide range of information about a given product, such as name, manufacturer or distributor details, weight, capacity, color, size, composition, etc.
2. **Documentation** The implementation of barcode labels allows for the automation of financial, warehouse, and production document registration. In this case, the barcode is placed on sheets used by various warehouse departments and on production documents.

3. **Warehouse Organization** Specific storage areas, and often individual shelving units or staging zones, are marked with barcodes printed on labels.

Warehouse management also includes various phases of material flow, enabling the use of linear arrangements of light and dark elements, including receiving and issuing goods, placement and storage, order picking, and inventory tracking and movement [Istiqomah et. al., 2020].

The first step in physically updating warehouse stock levels involves scanning the barcode assigned to transport documents, displaying on the scanner screen the type and quantity of goods, followed by laser scanning of barcodes placed on individual unit loads. The WMS system then automatically updates warehouse inventory. However, the status of received goods differs from actual warehouse stock levels, as the unit loads have not yet been placed in the designated storage area and are therefore not ready for order fulfillment.

The physical receipt of goods into the warehouse initiates the process of placing received unit loads into appropriate staging locations. After entering data regarding specific inventory items, the system automatically analyzes their characteristics, allowing for the determination of an appropriate storage location. At this stage, the barcode assigned to the designated location and the label corresponding to the specific unit load are scanned, enabling the placement of the correct goods in the correct location [Istiqomah et. al., 2020]. Completion of the placement process changes the status of the received goods, making them available for order fulfillment.

Order picking using barcodes begins with scanning the label on the picking list, which contains the order number, item type and quantity, and storage location. The next step involves laser scanning the barcode corresponding to the designated storage area, and if the location is correct, the barcodes assigned to the specific items are scanned [Yao, Carlson, 1999]. Upon completion of order picking, the WMS system is updated – warehouse stock levels are adjusted, and the order is marked as "fulfilled."

Before the assembled unit loads leave the warehouse, order completeness is verified. The barcode of the picking list is scanned, displaying the order number and the types and quantities of items included, which are then compared with the actual stock. Inventory items that pass the verification stage are packed in a manner that ensures proper preparation for further handling [Istiqomah et. al., 2020]. If the prepared unit loads match the order, the WMS system assigns them the status "ready for shipment" and prints the final packing lists.

Verification is the process directly preceding the loading of goods, initiated by laser scanning of the barcode placed on the shipping manifest. The loading list, containing a detailed breakdown of item types and quantities subject to further transportation processes, is also scanned. Loading can only proceed if the unit loads are properly prepared, individual inventory items have no visible defects or damages, the quantity and type of goods match the shipping manifest, and the vehicle and driver details match those provided in the shipment notification. Completion of the loading process causes the system to automatically update the order status, marking it as "shipped."

However, the shipment of goods is not the final area where barcode solutions can be applied. Their implementation also brings numerous benefits in inventory control processes [Tien et. al., 2019] aimed at comparing the actual quantity of warehouse stock with the inventory recorded in the WMS system, improving the accuracy of material flow processes. The barcode placed on the relevant inventory document is scanned, containing the item name, the quantity recorded in the Warehouse Management System, and the storage location. The employee responsible for inventory tracking then scans the label corresponding to the specific storage location and item. Upon completion of the process, the system automatically generates a warehouse report with updated inventory levels.

The multifunctionality and versatility of barcodes allow their application in internal and inter-warehouse transfers. Reaching the minimum stock level in a given warehouse triggers the generation of instructions for relocating specific goods between different areas. The warehouse employee responsible for executing inter-warehouse transfers then scans the barcode on the inventory items subject to movement, followed by scanning the labels marking the new storage locations assigned by the system.

The application of barcodes in warehouses is extensive. Regardless of the phase of material flow they pertain to, their implementation brings numerous benefits. In the receiving process, the implementation of barcode solutions significantly improves the quantitative control of received and dispatched goods while increasing the speed of order picking processes. The application of barcode labeling in storage areas facilitates the localization of specific product categories according to the FIFO principle. Furthermore, barcodes have a positive impact on inventory processes by reducing the time required to determine stock levels and expiration dates. In terms of inventory tracking and movement, the implementation of barcode labels eliminates paper-based documentation, accelerates the generation of documents confirming goods receipt and dispatch [Deepali et al., 2024], determines inventory turnover rates, and simplifies the procedures for preparing reports and statements for accounting purposes.

IMPLEMENTATION OF A WMS SYSTEM – CASE STUDY

Analysis of the warehouse management and suggestions for improvement

The pursuit of a high level of customer service compels business entities to engage in continuous monitoring and real-time analysis of the needs of a broad group of stakeholders. With the advancement of civilization, consumer expectations regarding the offerings of individual enterprises have evolved, now exhibiting an increasingly diversified nature. In response to customer demands, organizations are constantly expanding the range of products and services they offer [Andiyappillai, 2020].

Among the companies striving to ensure customer satisfaction there is a firm specializing in the supply of highly processed, certified steel products, including structural pipes and profiles, precision tubes (manufactured from cold-rolled, pickled, and hot-rolled strips), drawn bars, sheets, and acid-resistant metallurgical products, across the entire territory of Poland.

The company is committed to maintaining optimized inventory levels, often tailored to specific customers, offering services in order fulfillment and the organization of material transportation directly to recipients while emphasizing reliable and comprehensive logistics and advisory support.

These activities necessitate the efficient execution of warehouse operations, ranging from unloading and storage to the shipment of properly prepared loads. However, the techniques used in handling steel products differ from those applied in traditional warehouses, requiring specialized approaches to inventory management and logistics processes.

The warehouse, comprising Hall 01 (Figure 2), where precision products (EN 10305), bars, and flat bars (EN 10278) are stored, and Hall 02 (Figure 2), designated for black, structural materials (EN 10219) and galvanized products, enables the storage of goods in the form of bundles. These bundles are defined as organized individual items arranged parallel to each other, allowing for the formation of compact unit loads using binding materials such as straps, belts, or wires [Lisińska-Kuśnierz, Cholewa, 2006]. A common phenomenon observed in the metallurgical industry is the interchangeable use of the terms "package" and "full-package load" when referring to bundled goods stored in warehouses.

The receipt of goods takes place in the areas marked in Figure 2 with the letters X and Y. The first step in this process is to designate the appropriate unloading area, which is selected based on material parameters. Since individual warehouse halls are intended for the storage of specific types of products, trucks carrying black, structural, and galvanized materials are directed to Zone X, while precision products, bars, and flat bars are directed to Zone Y. Zone X also enables handling operations using an overhead crane operating intermittently, whereas loading and unloading in Zone Y are carried out exclusively with a forklift.

Weather conditions also play a key role in the receipt process. Since steel products are susceptible to corrosion, on rainy days all handling operations are carried out in Zone X, which allows unloading inside the facility, while the outdoor Zone Y remains out of use.

The physical receipt of the delivery is preceded by the submission of transport documents, which accompany a given batch of materials, directly to the person responsible for generating the Goods Received Note (GRN) based on the relevant purchase order and the received documentation.

At the same time, the trailer directed to the appropriate area is uncovered,

enabling warehouse personnel to perform an initial inspection provides an opportunity to assess the actual condition of the load, ensuring that any potential issues, such as damages or discrepancies, are identified early. This process helps maintain inventory accuracy and safeguards the quality of goods before they are further processed, stored, or dispatched.

If the material was damaged during transport, photographs are taken as evidence in the complaint process. Items with scratches or deformations are removed from the trailer, and all damaged goods are transported to an area referred to as the “complaint warehouse”, while loads without visible defects are transported to the appropriate staging area. If this area is occupied, individual bundles are placed directly onto storage racks.

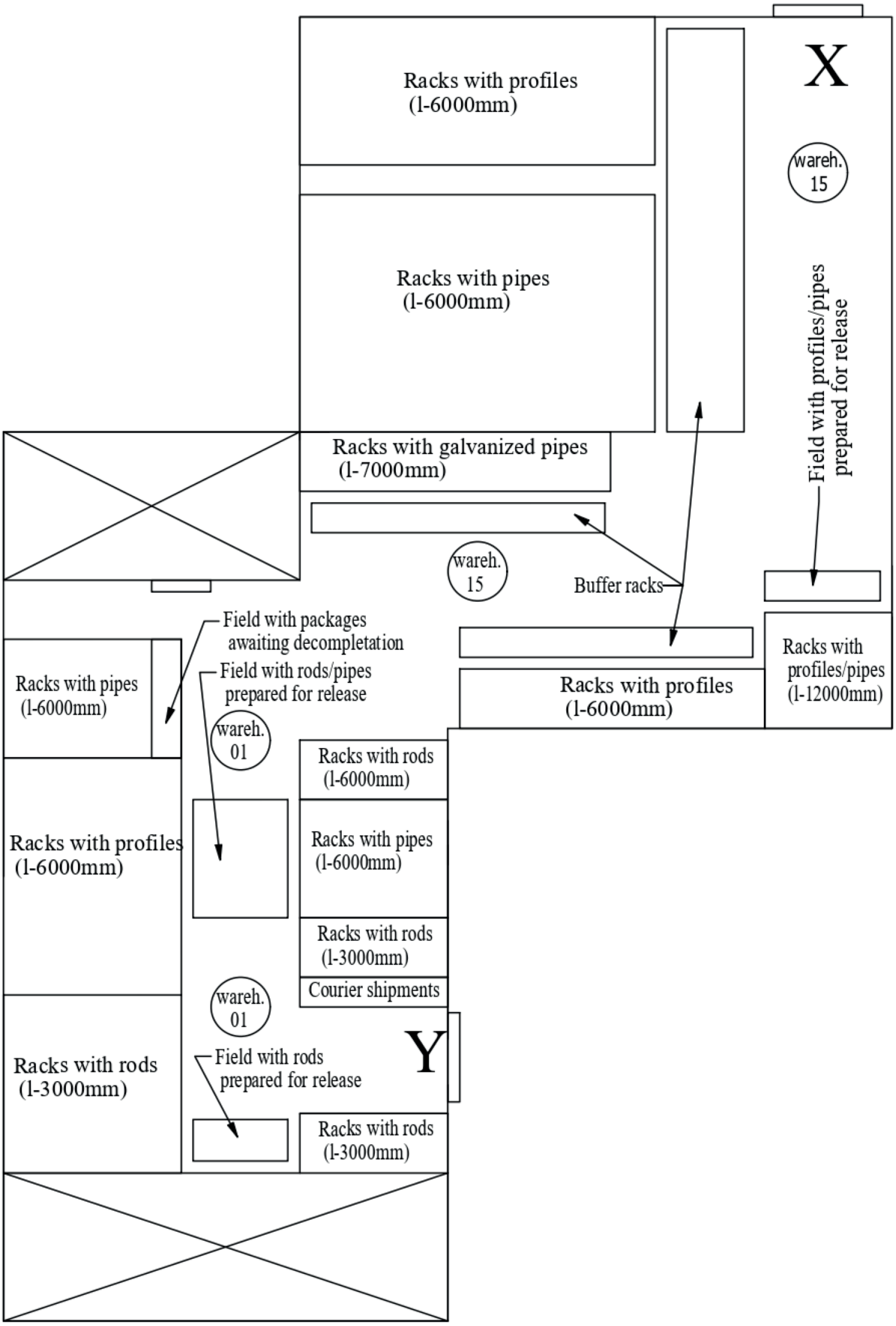
During unloading, quantity and quality control is carried out on an ongoing basis. If this process is carried out by a two-person team, one employee is responsible for unloading the trailer, while the other selectively verifies the compliance of individual product parameters with the dimensions listed in the shipping documents. If a single worker is responsible for unloading, the inspection of the material properties takes place only after the entire trailer has been unloaded.

Goods that successfully pass the inspection process are transported to warehouse racks. The steel warehouse follows the random-location storage method, meaning that materials with specific parameters do not have fixed storage locations but are instead placed based on the current arrangement of space in individual storage racks. An exception applies when the received delivery consists of homogeneous inventory items, in which case the storage area is arranged so that goods with similar parameters are stored in a specific location. A detailed diagram of the goods receipt process in BPMN format is presented on the Figure 3.

The occurrence of customer demand, expressed through a purchase inquiry, confirmation of a prepared offer, and the generation of a sales order by the sales department, which, after prior approval by the Sales Director, is issued as a Goods Dispatched Note (GDN), marks the beginning of the order fulfillment process.

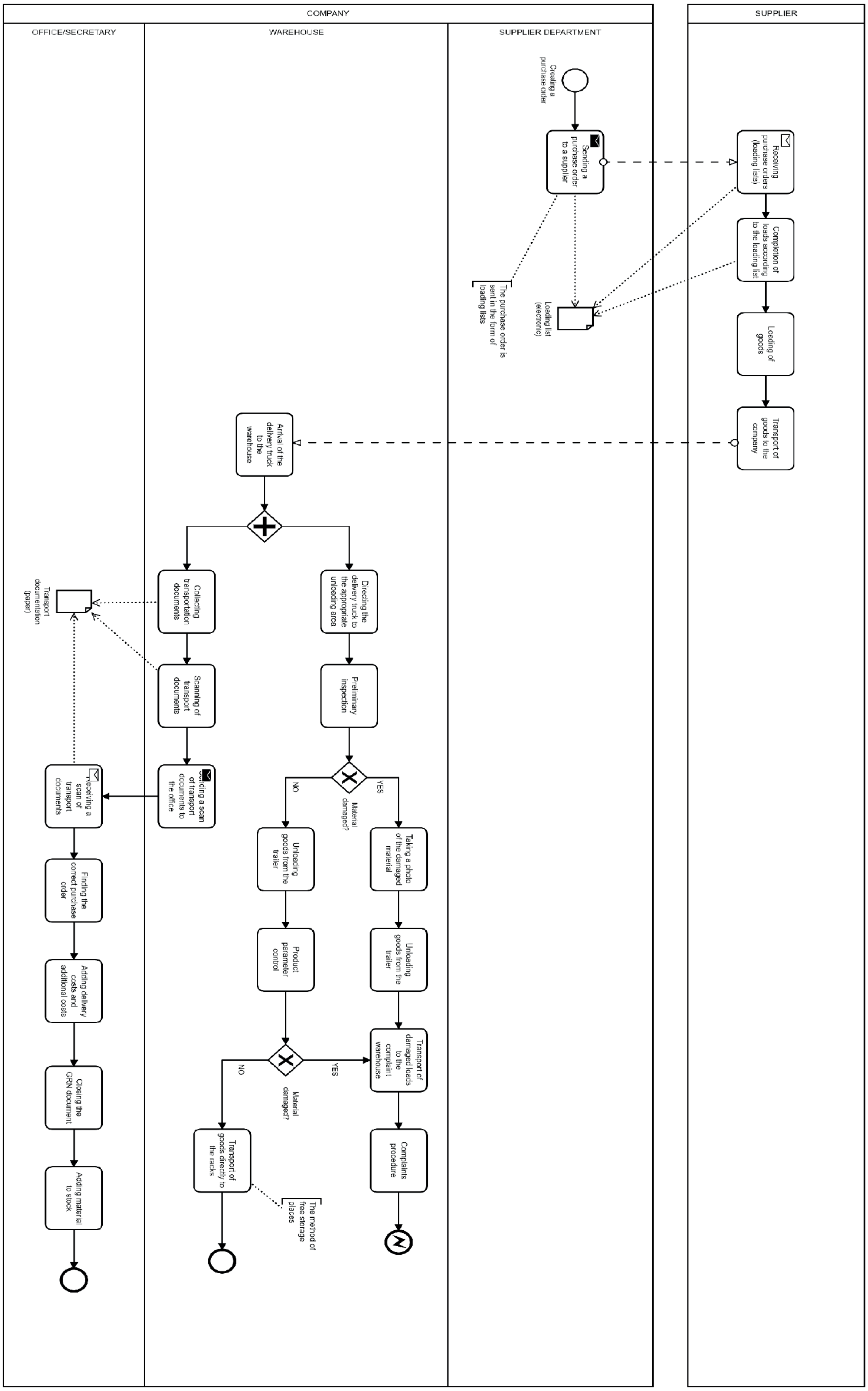
At this stage, transport documents are prepared, grouping orders from customers whose locations are in close proximity, and serving as picking lists. Each order receives a unique numerical identifier, which is also assigned to bundles containing the ordered inventory items.

Figure 2. Warehouse Layout Diagram



Source: Own description based on an internal company documentation.

Figure 3. The goods receipt process before the implementation of the WMS system



Source: Own description based on an internal company documentation.

If the quantity of material in a given bundle fully meets customer demand without requiring additional separation, the target company's name is recorded on the label alongside the identifier. The extracted bundles are then transported either to the staging area for shipment preparation or to a zone designated for separating specific quantities of inventory items.

Due to the nature of the products, the bundle separation process is conducted using a specialized warehouse cart, where the required number of pipes or bars is separated. The items making up a given order are then transported to the assigned staging area, while the remaining portion of the bundle is re-banded and returned to storage racks.

The completion of these processes requires verification of the compliance of the load parameters with the items listed on the picking lists, along with the execution of any necessary corrective actions. The time required for order picking depends on the number of inventory items included in the loading documents, ranging from one hour (for bundled unit loads transported by a truck with a load capacity of up to 6 tons) to two days (for 24 tons of non-homogeneous inventory items).

Once the Chief Logistics Officer has prepared the final loading documents, a transport request is sent to partner freight companies, which, after verifying fleet availability, either confirm or decline the transport proposal. If the proposal is accepted, the next step is to determine the precise transport specifications, which are strictly defined in the freight order.

The goods dispatch process begins with data verification, where the information recorded during transport scheduling is checked against the details provided by the driver before loading. These details include driver's full name, registration numbers of the tractor and trailer, name of the forwarding company responsible for the transport and number of delivery points.

Next, based on the load parameters and weather conditions, the most appropriate handling area is selected. The fundamental loading principles dictate that sheets, bars, and 12-meter profiles should be placed at the bottom of the trailer, as they exhibit higher resistance to mechanical damage (compared to thin-walled products), making them less susceptible to deformation when compressed by other items.

Additionally, it is critical to account for the unloading sequence at the customer's location. Items designated for the first delivery point should be loaded last, ensuring efficient unloading.

Similar to the order picking process, the duration of the goods dispatch operation varies significantly, ranging from 30 minutes to three hours, with additional delays in the case of non-standard inventory items, which require special preparation and securing.

The dispatch process concludes when the driver signs the documents confirming their presence during loading, after which the trailer is secured, and the vehicle leaves the company premises. A comprehensive diagram of the above processes is presented on the Figure 4.

The described activities reflect the warehouse management practices. Although the current inventory management methods are relatively effective, the company's executive board has decided to implement a WMS system, supported by automated data collection technologies such as barcodes. This decision was made due to the need for improvements in various processes across all material flow phases.

The goods receipt process, despite being well-organized and refined, is one of many areas requiring reorganization. In particular, procedures for handling non-standard situations, such as the receipt of non-compliant or damaged goods, need improvement, as they currently often lack consistency, leading to discrepancies between system data and actual stock levels and quality.

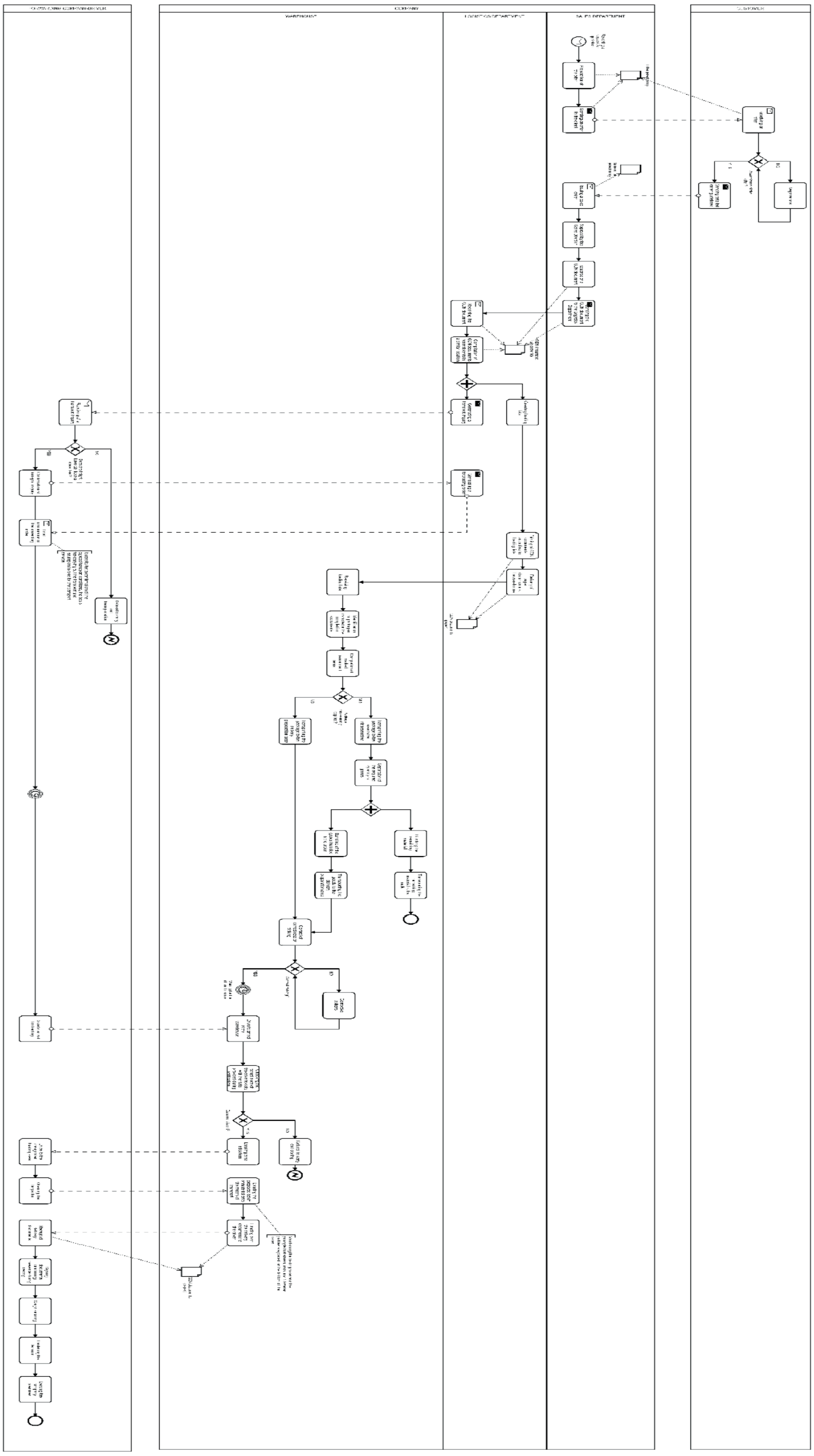
Another cause of inventory discrepancies is that warehouse employees sometimes authorize the loading of materials in bundle quantities, even when their weight slightly deviates from order specifications. These adjustments, recorded in paper documentation, are not reflected in the computerized system, leading to inventory mismatches.

Additionally, there is a clear need to improve document circulation. Currently, not only loading operations but all warehouse processes rely on paper documentation, limiting data accessibility, while any changes or discrepancies are communicated via manual emails, which are not automatically generated, requiring manual entry and recipient selection.

The need for reorganization is also evident in the order picking process. Since warehouse staff receive a single printed copy of the loading list, picking can only be performed for items located in one warehouse hall at a time. Implementing electronic documentation would allow simultaneous order fulfillment across multiple halls, significantly accelerating picking and order processing.

The analysis of warehouse management system and the identified areas for improvement indicate that the implementation of a barcode-based WMS system is a challenge worth undertaking to support the company's growth. However, this process will require investments in new software, specialized equipment, and employee training.

Figure 4. The process of picking and issuing goods before the implementation of the WMS system



Source: Own description based on an internal company documentation.

The course and analysis of the implementation process of the WMS system

The implementation of a solution enabling the reorganization of individual warehouse processes necessitated the delegation of an employee responsible for modernizing the warehouse management system. The appointment of a Project Manager was therefore the first step in the implementation of the WMS system.

The next stage focused on a tender process. A necessary condition for cooperation was familiarity with the industry's specifics, while price played only a secondary role. Ultimately, the work on the WMS system implementation was entrusted to a long-term business partner and the supplier of the currently used software.

The implementation of the WMS system necessitated the purchase of devices enabling automatic data collection processes. The number of scanning devices was directly linked to the number of loading and unloading stations, as one scanner was assigned to each two-person warehouse team. Thus, two scanning devices were purchased to enable ongoing execution of warehouse processes, along with one backup device to be used in case of a malfunction of the main scanners.

The modern equipment, tailored to the needs of the company, enabled the initiation of activities aimed at optimizing warehouse operations, starting with the receipt of deliveries, followed by the determination of storage locations, picking and retrieval processes, and finally, the shipment of appropriately assembled inventory items.

From an organizational perspective, the modernization of each process followed a similar pattern. The implementation of individual modules was preceded by consultations aimed at comprehensively defining the requirements for each aspect of the implemented software. The modules developed on this basis were subjected to testing processes to practically verify the effectiveness of the WMS system (Wicki, 2020). The completion of control activities resulted in the preparation of a detailed report, which included comments and observations to enable the software provider to correct potential errors. The testing processes were repeated until full operational effectiveness of each procedure within a given module was achieved.

The most challenging aspect was the selection of the technology to improve the delivery receipt process. Ultimately, however, a solution was developed that constituted a modernized version of the current procedure, incorporating enhancements resulting from the implementation of the WMS system.

According to the procedure presented on the figure 5, the delivery receipt process will begin with the procurement department preparing a temporary Goods Received Note (GRN) document, listing the items included in the expected shipment. The unloading of the truck, preceded by control activities and the designation of the appropriate handling area, will then require the scanning of transport documents, which will be sent directly to the email inbox of the person responsible for verifying the type and quantity of ordered items against the transport documentation. On this basis, a batch printing of barcode labels will be carried out.

The unloading process, performed simultaneously with the verification of item parameters, will allow the distribution of appropriate labels among individual bundles. These labels will be scanned to verify the quantity of materials, which the warehouse worker will confirm or modify, reconciling the actual state with the values displayed on the scanner.

The completion of the validation process, which triggers the official generation of the GRN document, will initiate transport operations, focusing on moving individual inventory items to their designated locations, as indicated on the scanner. This step will be the basis for closing the GRN document and officially adding the received goods to inventory.

Since the delivery receipt process is particularly complex from the perspective of the implemented software, a decision was made to introduce additional functionalities, allowing the development of procedures for handling discrepancies between the ordered goods and the materials physically delivered to the warehouse. These functions will allow the WMS system to generate the following reports:

1. Cumulative Variance Report – analyzes quantity discrepancies related to specific inventory items, considering acceptable value deviations (approximately 3% of the order value).
2. Unresolved Items Report – verifies the consistency of materials listed on the purchase invoice with the grade and quantity of items physically delivered to the company. The presence of "unresolved" items indicates discrepancies between the expected and actual structure of the delivery.
3. Packaging Report – provides a summary of barcode labels assigned to specific inventory indexes, along with their corresponding purchase document numbers (GRN), enabling the precise identification of items included in a given shipment.

The completion of programming work, resulting in the implementation of the "Delivery Receipt" module, enabled the subsequent stages of the WMS system implementation, which focused on order picking and goods dispatch, as outlined in the Figure 6.

The activation of these processes, triggered by the receipt of an inquiry, will lead to the generation of an offer, which will serve as the basis for preparing a sales order. Once approved by the Sales Director, this order will be transformed into an official GDN document.

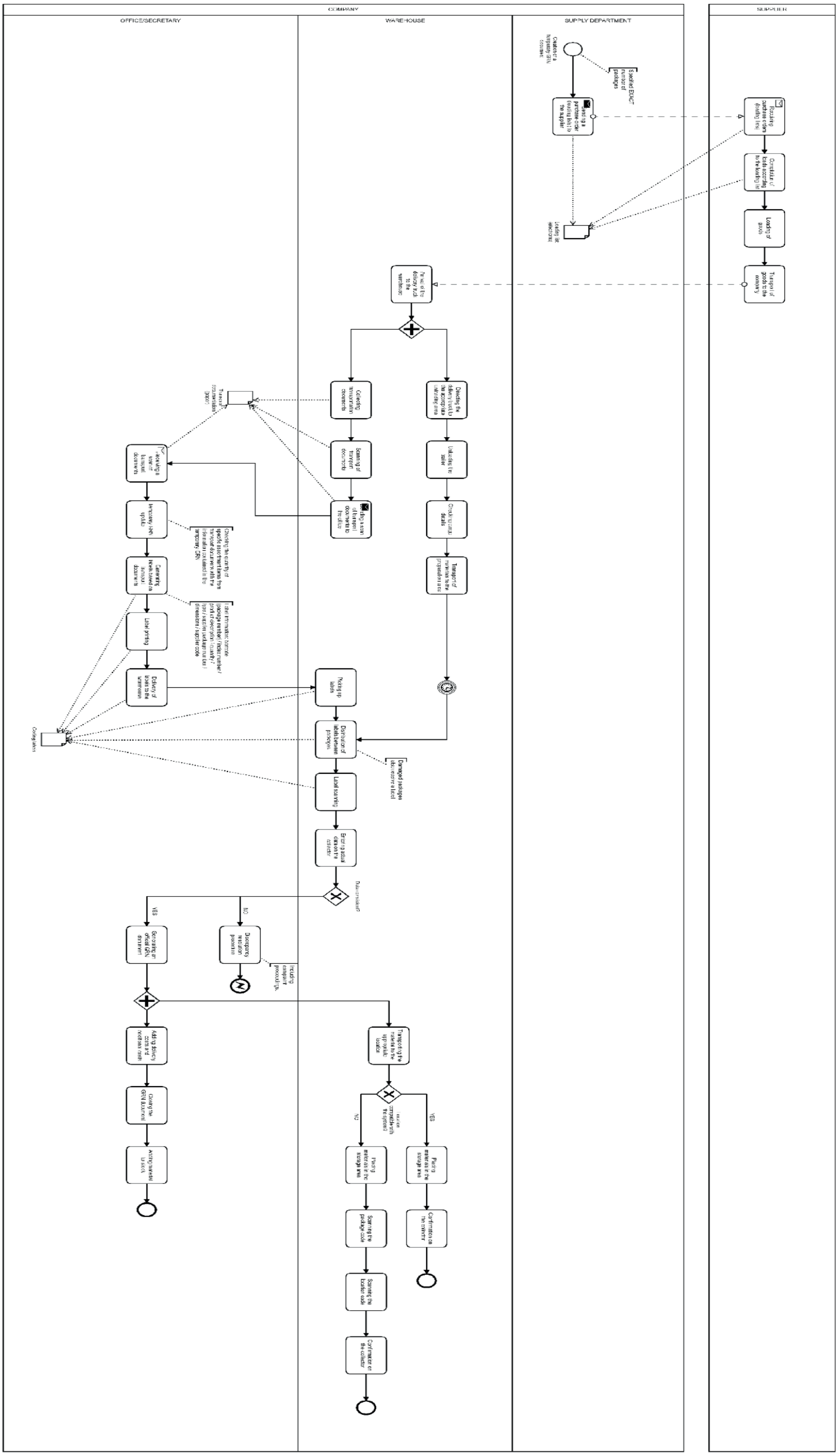
To meet individual customer requirements, the sales department may designate a specific batch of material, consisting of items from a specific manufacturer. In the absence of additional guidelines, the system will automatically select a batch of goods for dispatch in accordance with the FIFO principle.

The ready GDN documents will then be electronically transmitted to the Chief Logistics Officer, who, by grouping customer orders from specific geographic regions, will assign them a route number (e.g., GDN1 and GDN2 for customers located in the north will be transported via Route 2). Cooperation with the freight company will then proceed analogously to current practices.

The developed loading lists, available in the "Order Picking" module on the scanner, will allow warehouse employees to display the documents and inventory items included in a given shipment. The process of material retrieval involves scanning both the label assigned to the bundle and the barcode associated with the specific storage location. During the picking procedure, the quantity of items retrieved must be entered into the system. Additionally, information regarding the remaining contents of the bundle will be updated accordingly. Once this is completed, the remaining goods will be re-banded and transported to the designated storage area as instructed by the Warehouse Management System (WMS). The process concludes with scanning the barcode of the correct storage location to ensure accurate tracking and inventory updates.

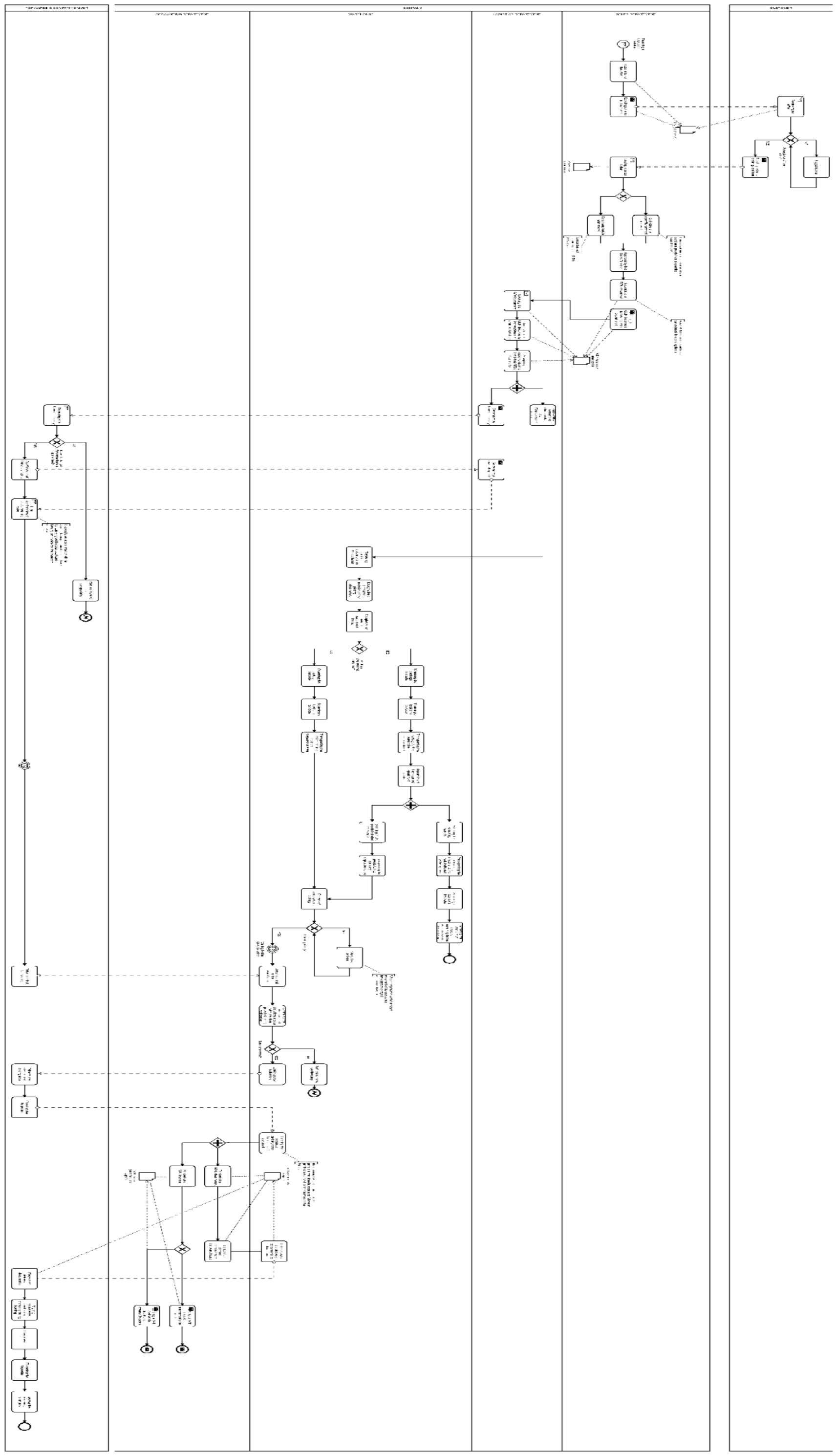
The completion of the order picking process, verification of load preparation accuracy, and other activities proceeding analogously to current loading procedures, will be finalized by printing the GDN documents for the customer and the automatic issuance of a VAT invoice, which, after prior approval by the accounting department, will be printed and sent to the buyer either in paper form or as an e-invoice.

Figure 5. The goods receipt process after the implementation of the WMS system



Source: Own description based on an internal company documentation.

Figure 6. The process of picking and issuing goods after the implementation of the WMS system



Source: Own description based on an internal company documentation.

The implementation of the WMS system, supported by automated data collection technologies, and will provide the company with numerous benefits, the most significant of which include:

1. Near-total elimination of paper documentation (all warehouse operations will be conducted via data collectors).
2. Ability to measure warehouse shift productivity.
3. Increased speed of order picking processes (WMS functionality enables the precise identification of storage locations for specific inventory items).

4. Optimization of storage processes (picking will conclude with the WMS system indicating the optimal storage location for remaining goods in a bundle).
5. More accurate record-keeping (faster detection of errors in received deliveries containing non-compliant materials).
6. Enhanced efficiency in handling complaints (real-time data collection enables the identification of precise parameters of damaged materials, along with the manufacturer's batch number).
7. Improved sales department efficiency (the ability to obtain real-time information on exact inventory quantities within bundles increases the likelihood of issuing GDN documents in full-bundle quantities, facilitating warehouse operations).
8. Improved corporate image (automation will enhance the receipt process for customers utilizing automated data collection systems).

In the omnichannel commerce environment, barcode solutions used for identification, collection, and sharing of product information have become an operational standard for most major enterprises. They provide near-total automation of customer service processes, allowing companies to reduce operational costs, increase sales, and build brand trust by providing complete and up-to-date product information [Andiyappillai, 2020]. The universal benefits of WMS implementation, strengthened by industry-specific innovations, will enable the company to gain a competitive advantage and achieve market leadership in the steel products sector.

CONCLUSIONS

Technological advancements that enhance the ability to process information and transport goods are driving the continuous evolution of systems and concepts that allow businesses to adapt to changing environmental conditions. The selection of appropriate IT software, tailored to the specific needs of an industry, plays a crucial role in ensuring the profitability and sustainability of business operations. As companies strive for higher levels of customer service and the need to meet industry standards, modifying existing operational frameworks becomes essential.

Warehouse management, a critical component of business operations, is often targeted for optimization. Many organizations choose to implement a Warehouse Management System (WMS) to streamline processes such as receiving, storage, picking, and dispatch. By integrating this software with automated data collection technologies like barcodes, businesses can significantly improve warehouse operations, reducing picking errors, enhancing inventory accuracy, and increasing the efficiency of stocktaking activities.

Effectively managing warehouse operations, ensuring the seamless coordination of receipts, storage, picking, and dispatch, is a complex challenge. It requires the synchronization of various activities to boost overall company efficiency. The case study presented in this dissertation highlights that a thorough understanding of the organization's strengths and weaknesses, reflected in the decision to implement a WMS system, plays a pivotal role in enhancing the company's image. This strategic move not only improves operational efficiency but also positions the company to achieve market leadership, particularly in the local steel product sector.

ACKNOWLEDGMENTS

The publication was co-financed/financed from the subsidy granted to the Cracow University of Economics – Project nr 77/ZZO/2023/PRO.

BIBLIOGRAPHY

Adeniran I.A., Efunniyi C.P., Osundare O.S., Abhulimen A.O., 2024: *Optimizing logistics and supply chain management through advanced analytics: Insights from industries*. International Journal of Scholarly Research in Engineering and Technology, 4(1), 52–61. https://doi.org/10.56781/ijsret.2024.4.1.0020

Andiyappillai N., 2019: *Implementing warehouse management systems (WMS) in logistics: A case study*. International Journal of Logistics Systems and Management, 2(1), 12–23. https://doi.org/10.5281/zenodo.2576011

Andiyappillai N., 2020: *Digital transformation in warehouse management systems (WMS) implementations*. International Journal of Computer Applications, 177 (45), 34–39. https://doi.org/10.5120/ijca2020919957

Baj-Rogowska A., 2014: *Technologie automatycznej identyfikacji wspomagające funkcjonowanie łańcucha logistycznego*. Prace Naukowe Wyższej Szkoły Bankowej w Gdańsku, 34, Wymiary logistyki – ujęcie holistyczne. Gdańsk.

Bartholdi J.J., III, Hackman S.T., 2017: *Warehouse & distribution science* (Release 0.98). The Supply Chain & Logistics Institute, H. Milton Stewart School of Industrial and Systems Engineering, Georgia Institute of Technology. Retrieved from http://www.warehouse-science.com

Burke E.M., Ewing D.L., Jr., 2014: *Improving warehouse inventory management through RFID, barcoding and robotics technologies* (MBA Professional Report). Naval Postgraduate School.

Custodio L., Machado R., 2020: *Flexible automated warehouse: A literature review and an innovative framework*. International Journal of Advanced Manufacturing Technology, 106, 533–558. https://doi.org/10.1007/s00170-019-04588-z

Deepali C., Monika P., Dharmendra S., 2024: *Integrating barcode technology into warehouse management systems for enhanced efficiency and inventory accuracy*. Journal of Computing and Systems Research, 2 (1), 8–14.

Gołembska E. (Ed.), 2013: *Kompendium wiedzy o logistyce*. Warszawa: Wydawnictwo Naukowe PWN.

Happonen A., Minashkina D., 2020: *Systematic literature review and research gap issues on third party logistics operators selecting WMS for efficient operations for customers*. International Journal of Supply Chain and Inventory Management, 3 (2), 142–166.

Henn S., Koch S., Doerner K.F., Strauss C., Wäscher G., 2010: *Metaheuristics for the order batching problem in manual order picking systems*. Business Research, 3 (1), 82–105

Hulstijn J., Overbeek S., Aldewereld H., Christiaanse R., 2012: *Integrity of supply chain visibility: Linking information to the physical world*. In M. Bajec & J. Eder (Eds.), CAiSE 2012 workshops (pp. 351–365). Springer.

Istiqomah N.A., Sansabilla P.F., Himawan D., Rifni M., 2020: *The implementation of barcode on warehouse management system for warehouse efficiency*. Journal of Physics: Conference Series, 1573. https://doi.org/10.1088/1742-6596/1573/1/012010

Januła E., Kasińska M., Kwiatkiewicz P., Laskowski M., 2020: *Zapasy i magazynowanie*. Poznań: Wydawnictwo AS.

Lisińska-Kuśnierz M., Cholewa A., 2006: *Przechowywanie i transport towarów: Wybrane zagadnienia*. Kraków: Wydawnictwo Akademii Ekonomicznej w Krakowie.

Logisys Sp. z o.o., 2014: *Systemy informatyczne w polskich magazynach: Raport 2014.* Logisys Sp. z o.o.

Mohamed A.E., 2024: *Inventory management*. In Operations management – Recent advances and new perspectives. IntechOpen. https://doi.org/10.5772/intechopen.113282

Nguyen H.T., Anh D.B.H., Thuc T.D., 2019: *Global supply chain and logistics management*. Academic Publications.

Niemczyk A., 2008: *Zapasy i magazynowanie (Vol. II): Magazynowanie*. Poznań.

Nisa S., Rahmawati I., 2023: *Enhancing inventory control through barcode-based warehouse management system: A qualitative analysis*. Indonesian Journal of Innovation Studies, 25.

Odeyinka F., Omoegun O.G., 2024: *Warehouse operations: An examination of traditional and automated approaches in supply chain management*. IntechOpen.

Ortiz S.J., Paredes-Rodríguez A.M., 2021: *Evaluación sistémica de la implementación de un sistema de gestión de almacenes (WMS).* Revista UIS Ingenierías, 20(4), 145–160.

Palčnik I., Podbregar I., 2021: *WMS implementation in distribution logistics: Case study of retail chain store*. Management and Information Technology – Science, 3(1/2), 9–19.

Persson N., 2024: *The effective integration and optimization of Warehouse Management Systems: A systematic literature review*. Chalmers University of Technology.

Pisz I., Sęk T., Zielecki W., 2013: *Logistyka w przedsiębiorstwie*. Warszawa: Polskie Wydawnictwo Ekonomiczne.

Richards G., 2014: *Warehouse management: a complete guide to improving efficiency and minimizing costs in the modern warehouse*. *Second edition,* London, Kogan Page.

Richards G., 2016: *Zarządzanie logistyką magazynową*. Warszawa: Wydawnictwo PWN.

Samsudin A.F., Darmawan B., Dwiyanti V., Mupita J., 2023: *Attributes and effect of implementation of Warehouse Management System (WMS) for company sustainability*. Jurnal Teknologi Transportasi dan Logistik, 4(2), 199–212.

Sun Y., Chen Q., Guo J., Adumene S., Goleiji E., Yazdi M., 2025: *A risk-based review of dangerous goods storage and handling at a manufacturing facility*. The International Journal of Advanced Manufacturing Technology, 130(5–6). https://doi.org/10.1007/s00170-025-15778-3

Tien N.H., Hung Anh D.B., Duy Thuc T., 2019: *Global supply chain and logistics management*. Academic Publications.

Vaka D.K., 2024: *Supply chain renaissance: Procurement 4.0 and the technology transformation*. Aqua Publications.

Vanheusden S., Van Gils T., Ramaekers K., Cornelissens T., Caris A., 2023: *Practical factors in order picking planning: State-of-the-art classification and review*. International Journal of Production Research, 61(6), 2032–2056. https://doi.org/10.1080/00207543.2022.2053223

Vrat P., 2014: *Basic concepts in inventory management*. In Materials management (pp. 21-36). Springer Texts in Business and Economics. Springer, New Delhi. https://doi.org/10.1007/978-81-322-1970-5_2

Wicki L., 2020: *The impact of WMS implementation on work productivity: The case of three distribution warehouses*. Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie. Ekonomika i Organizacja Logistyki, 5(3), 77–91.

Yao A.C., Carlson J.G., 1999: *Impact of real-time data communication on inventory management.* International Journal of Production Economics, 59(1), 213–219. https://doi.org/10.1016/S0925-5273(98)00234-5