COMPUTER-AIDED WAREHOUSE MANAGEMENT AS AN ELEMENT OF LOGISTICS SYSTEM IN ENTERPRISES

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Abstract: Nowadays, increasing market share and gaining competitive edge plays an important role. This fact forces enterprises to choose adequate strategies of operation and make investments in development activities, including warehouse management, which is an intrinsic element of enterprise activities.
It should be emphasized that the existence of any system of warehousing, equipment in warehouses and their structure in any enterprise does not bring the expected and positive effects unless it is rationally and skilfully used and adapted to the specification of activities performed in the analysed organization.

Keywords: warehouse, warehouse management, WMS (Warehouse Management System) systems

1. Introduction

Logistics is a field of science which is a basic element of operation in enterprises. A precondition for financial accomplishments in enterprises is adequate control of flow of goods and services. Nowadays, the basic element in the domain of development is information technology and informatization. Good management of enterprises is based on the flow of current data and largely depends on different solutions in the domain of information technology. Apart from efficient flow of data, properly structured IT systems guarantee suitable register of resources in locations of production, sales points and logistics units. An important aspect of operation of information systems is their integration in the area of the whole enterprise. Quick exchange of data, concerning all the elements of enterprise's functioning, is the basis for suitable operation of systems. Suitable effect is guaranteed by IT techniques which in the area of enterprise are never limited to a single solution. Only suitably selected elements of IT system in the enterprise will guarantee its stable operation and meeting all the needs, necessary for comprehensive logistics in the enterprise. The goal of integrated IT systems is to solve the problems which occur during assignment of individual logistics functions to different organizational units. The goal of their operation is to integrate all the logistics tasks concerning operation of the whole enterprise. In a complete manner, integrated IT systems allow for supporting operation of enterprises in a very broad range, performing an essential role in such domains as sales, production, material requirements, consumption of materials or resource management. The most advanced integrated IT systems also support the process of decision-making in terms of transport and warehousing.

2. Warehouse Operations in Logistics Process

Similarly to any other organization, a warehouse is the place where a number of different activities and actions with key importance to the whole logistics process in the enterprise are performed. Due to huge role and importance of warehouse operations, it is essential to perform these activities with proper chronological order, according to the adopted warehousing technology. The whole process of warehousing is composed of the flow of materials and information. Therefore, one can distinguish between the four basic phases of this process, which is presented in fig. 1., i.e. [5.]:

- acceptance,
- storage,
- picking,
- release.

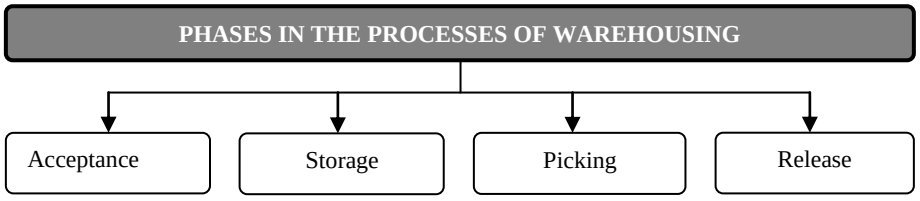

Figure 1. Basic phases of warehousing process [4.]

The first phase of warehousing, i.e. acceptance of goods, is connected with confirmation of receipt of goods and taking responsibility for these goods by the warehouse. This can be achieved in a twofold manner [4.]:

- external acceptance from the supplier from the outside of the enterprise, always connected with unloading of the external means of transport
- internal acceptance from internal supplier or other organizational unit within the enterprise. The goods are delivered using either internal or external means of transport.
- The main operations and tasks connected with acceptance of goods consist in [8.]:
- unloading deliveries, performed using available means of internal transport and re-loading equipment
- identification, which consists in determination of identity or unequivocal recognition of the goods, where recognized items are only name of the goods or, additionally, other data e.g. data of production and product life, serial number, quantity, which can be supported by use of barcodes or logistics labels
- sorting, i.e. dividing goods into suitable groups e.g. according to similar physical characteristics, range of products, supplier and recipient and also the form of transport unit,
- quantity control, which consists in calculation, weighing or measurement of the delivered material and comparison of the material with the records in the delivery documents, and quality control which is typically limited to visual control, but in the case of some raw materials used for production, only the samples for the investigations are taken in order to find whether they can be accepted to the warehouse or they have to be placed on deposit,
- preparation of goods for storage, which might consist in creation of unit load, changes in their height and mass, reloading to suitable containers or marking the goods,

- transfer of the delivery to the storage zone, which might be performed by the employees who accept the delivery or employees whose responsibility is to store the goods.

Acceptance of the delivery is followed by another phase in the warehousing process: storage of goods, which is the fundamental function of the warehouse. Storage is connected with storage of goods for a particular period of time, the most often based on application of unit load. Material goods are placed in a systematized manner in the space in the warehouse or on its surface area so that they effectively cover the cubic capacity of the warehouse. Moreover, storage of goods should take into consideration the parameters which characterize individual stock concerning the conditions of storage, such as temperature and humidity. This determines which part of the warehouse can be used for placing the goods in order to provide it with best conditions of storage [2.]. Therefore, storage consists in performance of several basic operations, which include [4.]:

- reception of goods from reception zone if the goods were not delivered to the storage zone by the employees who accept the delivery
- arranging goods in the storage zone according to several criteria, such as storage conditions, storage technology, type of unit load, method of description of storage places, parameters of turnover for particular groups of goods
- storage of goods which ensures suitable storage conditions
- periodical check of stock quality, typically carried out in the case of goods stored for a longer period of time
- transfer of material goods to picking zone if there is any in the warehouse

There are two methods of storage, which are closely related with the method of assignment of places of storage [8.]:

- method of fixed places of storage, with each element having a particular location assigned for them to be stored in,
- method of free places of storage, which allows for placing goods in any free place. This method releases ca. 30% of locations in the warehouse.

Another method for arrangement of goods in the warehouse is the method which takes into consideration the turnover of goods. This method uses the results of ABC analysis in terms of the two criteria [8.]:

- frequency of pickups: goods picked the most frequently are placed in the area closest to the reception zone
- size of pickups, which allows for definition of the capacity and type of location where picking of goods is carried out.

Picking is the third phase of the process of warehousing. It consists in picking up a particular quantity of goods indicated in an order from the stock and placing it in one or several unit loads. Basic operations in picking phase include [4.]:

- preparation of suitable load units necessary for picking of a particular order so that quick and direct access to a particular goods is ensured through e.g. opening of collective packaging, removing foil from a pallet
- order picking, which may occur both in the storage zone and picking zone
- checking the quantity of goods, carried out in order to confirm the compliance with the order in terms of the quantity
- packaging and arrangement in means of transport in a manner which protects from damaging, negative effect on the environment and further identification of goods

- transfer of the material after picking to the release zone.

Given the organizational and technological aspects, the phase of picking can be carried out:

- ‘in the storage zone or separated picking zone,
- according to orders or according to the types of goods,
- using the method of man-to-goods or goods-to-man,
- according to the picking orders, such as:
  - picking list,
  - labels,
  - radio terminal or batch terminal,
  - pick by light,
  - pick by voice [4.].

Picking in storage zone occurs when the inventory level of particular goods stored in the warehouse is not high or it is rarely picked. Picking in a separated picking zone allows for faster good reception due to shortening of the route to be covered by an employee. This zone contains only a part of stock. Picking of goods according to orders consists in picking individual goods items according to the order. This occurs in two stages. The first stage means collecting individual goods items with the quantity being a total of all the orders. During the second stage, the collected goods are divided into individual orders. The method of man-to-goods consists in collecting an order and the unit load e.g. pallet and moving to next locations, finding goods and placing them in the pallet. The method of goods-to-man consist in that an employee remains in the same place, whereas the goods, by means of e.g. picking carousel, are transferred to them, so that collection of goods and unit load with a particular quantity is possible. The picking list is a printed list containing goods items to be collected and their quantity. In the case of using of labels, picking should meet identical conditions as picking list. Each collected goods item contains the number of labels equal to the number of packagings to be collected. The label in the list determines the goods to be collected and, when glued on the packaging, identifies the goods. Radio terminals or batch terminals show orders displayed on the screen. Compliance of the collected goods is confirmed through scanning a barcode or location address. Pick-by-light technology uses light signals and screens in order to localize goods for picking. Pick-by-voice technology consists in that an employee hears selected picking orders generated by warehouse information system which are converted into voice signals. The picking employee confirms the performance of a task with voice, using a microphone [4.]. The last phase of the process of warehousing is release of goods. It consists in collection of all the goods previously completed in load units and other load which did not change its form from the moment of acceptance in the warehouse to the time of release. This occurs according to external or internal orders. The release, similarly to acceptance, can be divided into [4.]:

- external: to external recipient,
- internal: to internal recipient, within one organizational unit.

In the case of external release, the goods, if necessary, can also be packaged and arranged in unit loads and then controlled. The control consists in checking the compliance of the prepared material with the release documents, their completeness and marking according to the requirements of the recipient. After positive result of the control, the goods are loaded into the suitable means of transport and the documents which confirm transfer of goods are obtained. The process of internal release is much more simplified since packaging, forming transport units and loading usually do not occur [4.].

The activities and actions described above within the four phases of warehouses do not include all the operations which are performed in the warehouse. One can also mention inventory level stocktaking, registering inventory, maintenance of the stored goods or creation of promotional sets [2.].
As a result of division of the process of warehousing into the four phases (acceptance, storage, picking and release), warehouse space can be also divided into the four zones corresponding to each stage of this process, i.e. [1.]:

- acceptance zone,
- storage zone,
- picking zone,
- release zone.

The number of zones which exist in the warehouse and the scope of activities in each of them will determine the level of technological complexity of the warehousing process, i.e. the wholeness of the activities which are performed during the flow of stock through the warehouse.

3. WMS Systems

Warehouse operations are frequently supported by the information system implemented in the enterprise, which allows for the performance of activities in an effective manner and allows for rational management of the area and space in the warehouse. Using a suitable warehousing technology contributes to the efficient performance of warehousing processes and their accuracy. The tool which provides IT support for management of warehouse is provided by the warehouse management systems. These systems are 'computer software which supports management of the processes which occur in a warehouse from the moment when the goods are delivered to the warehouse to the moment of their release' [7.]. The WMS systems are the specialized tools for controlling operation in the warehouse and they are frequently compatible with integrated information systems for the whole enterprise (most frequently being ERP class system). WMS systems register in detail all the parameters which result from the processes which occur in the warehouse, which is not performed by ERP system since its operation is limited to recording inventory levels in quantitative and qualitative manner. 'WMS systems in practice are separate modules which contain a variety of specialized functions, connected with the specific activities in warehouses. They are oriented systems, which offer high functionality, easiness of integration with other IT systems and the effectiveness in data updating' [3.]. WMS systems ensure full control over automated processes, connected with acceptance and release of cargo. They guarantee continuous control of the warehouse and inventory levels and eliminate the opportunities of generating errors which are typical of non-computerized warehouse managements. A suitable designed and configured WMS system should, during its operation, perform the following functions [3.]:

- management of warehouse structure,
- division of areas and warehouse locations,
- classification of the content of the warehouse,
- support for performance of warehousing processes,
- creation and processing of logistics documents,
- generating the cargo sizes and their allocation,
- planning transport and shipment,
- packaging return services.

Management of warehouse structure is the functionality available in one of the applications of WMS system and guarantees services for the warehousing processes. In WMS systems, the warehouses are divided according to the following hierarchies [6.]:

1. Warehouse area
2. Raw
3. Column
4. Level
5. warehouse place.

Division of warehouse areas consists in separation of the areas in the warehouse and assigning them to particular warehousing operations. Division of these areas can also distinguish between the types of shelves for storage or the area of storage of a particular type of goods. One warehouse area does not have to be assigned to a uniform area, but it might cover the areas separated in a number of warehouses. In order to ensure higher transparency and easiness of use, the system might divide individual areas into classes. The same division can be also used during definition of the warehouse places. Warehouse places are typically divided according to their load capacity and size, which provides opportunities of making immediate decisions on selection of the place of storage of the accepted goods. The system, showing a particular place, allows for avoiding the situations where the shelves are overloaded or the material size does not match the size of the warehouse place. Furthermore, the system is capable of recording other characteristics of the warehouse place and using them for indicating optimal opportunities.

Classification of the warehouse content consists in providing opportunities of insight in warehouse inventory levels and searching for individual stock items based on a variety of criteria. The system uses the data concerning the previously set criteria and, based on these data, defines the zones which match a particular strategy of warehousing. The classification allows for quick finding the areas where a particular batch of goods is located. The same method is used for the carriers which are the equipment in the warehouse.

The support for performance of warehouse processes is the function which covers a number of activities, with its elements including [6.]:

Acceptance of Goods and their Registration. This element involves qualitative and quantitative control of the process of unloading. The system facilitates physical performance of goods acceptance through coordination of the flow of goods and pointing t o the best location of storage. The system can automatically create marking of individual batches of goods in the form of labels (e.g. GS1 system [9.]), or accept the labels which are the markings used by the supplier. Once the goods are accepted, they are registered in the system, which causes an increase in warehouse levels. The data are transferred to the integrated system providing a particular WMS system is compatible with it.

Performance of Picking. This process consists in assignment of carriers for picking by the system and presentation of the list of necessary items in comparison with the location of storage where a particular item should be collected. If an employee collects the whole content in a particular carrier, the compliance of the content of the carrier with the list of items is checked.

Release of Goods from the Warehouse. This means physical release of goods included in a customer's order. The number of goods to be released are input or transferred to the system through an integrated IT system. Depending on the demand of a customer, the order can be executed in batches or individually, through release of the whole quantity of goods contained in the order. This process is performed through creation of the printout with the list of goods and detailed information about where it should be placed or through transfer of data to the electronic device (depending on the technology utilized in a particular

warehouse). Release of goods occurs after the picking process described above and, after it is finished, the system records the operations and removes the released goods from inventory levels.

Creation and Processing of Logistics Documents. This is a function performed based on the data collected from the integrated system or those input manually directly to warehouse system. These data allow for continuous updating the inventory levels and the system generates documents used for execution of the order. The documents are generated in cooperation of the function responsible for making them available with other functional modules in the system, responsible for planning the activities connected with transport and warehouse works. In the case of the acceptance and release documents, they are generated, based on the compliance of the data collected directly from the system which compares the order with the quantity of the obtained goods. The compliance of the quantity of the accepted or dispatched goods with the order is checked, which is followed by updating the inventory levels. Only after this activity, one of the systems (planning or warehouse system) generates the invoices.

Another functionality is ***Generating the Size of Cargo and their Allocation.*** In this function 'a list of all materials for a particular dispatch is created. The materials can be sorted in the list, e.g. according to the postcode. This means that the cargo allocated to be dispatched to the locations which are in the same region will be placed next to each other. Based on the system information about available means of transport and their capacity, one can assign the same route to individual cargos' [6.].

Assignment of the route involves another function: ***Planning of Transport and Shipment.*** This means a set of functions in the system, with the main task being planning the most beneficial route of transport for the prepared dispatch of goods. The system generates optimal routes for individual vehicles, thus minimizing the costs. The system is sometimes capable of making the settlements for the particular transport. The process of optimization occurs through determination of the means of transport which allows for using the smallest possible number of vehicles, creation of the route so that the total of routes covered by all the vehicles is the shortest, and the shortest possible lead time is achieved. The system creates the tree of routes and provides access to the sketch of loading and waybill. 'The waybill contains all the items which have not been delivered to the recipients yet. It is sorted according to the dates of delivery input with the order position' [6.].

The last of the functions listed above is ***Packaging Return Services.*** It involves registration of all the logistics units (i.e. pallets, containers, forklift trucks etc.) which leave the warehouses or return to the warehouse. After the return of the previously released packaging, the system records its location in the warehouse area. The system contains the detailed data about the carriers in the warehouse and the amount and location of the carriers the warehouse expects to return [7.].

The scope of functionality of WMS systems depends on their configuration for the purposes of the warehouse they are used for. As mentioned previously in the present study, the WMS systems are frequently compatible with ERP system and, in large companies, this compatibility is necessary for ensuring IT support at the highest level. ERP system is a planner system, whereas WMS encompasses the whole area of functioning of the warehouse in terms of support of physical performance of acceptance, storage and release of goods. Full functionality of the WMS system in cooperation with ERP system is presented in fig. 2. The figure also shows the areas of mutual effect of the system.

Information concerning WMS systems allow for drawing the conclusion that they are an essential IT element in the logistics structure in the enterprise. WMS systems support the processes concerning physical realization of the flow of goods. Therefore, they are the tool which guarantees appropriate performance of all the assumptions which were generated as a result of the operation of the systems of planning.

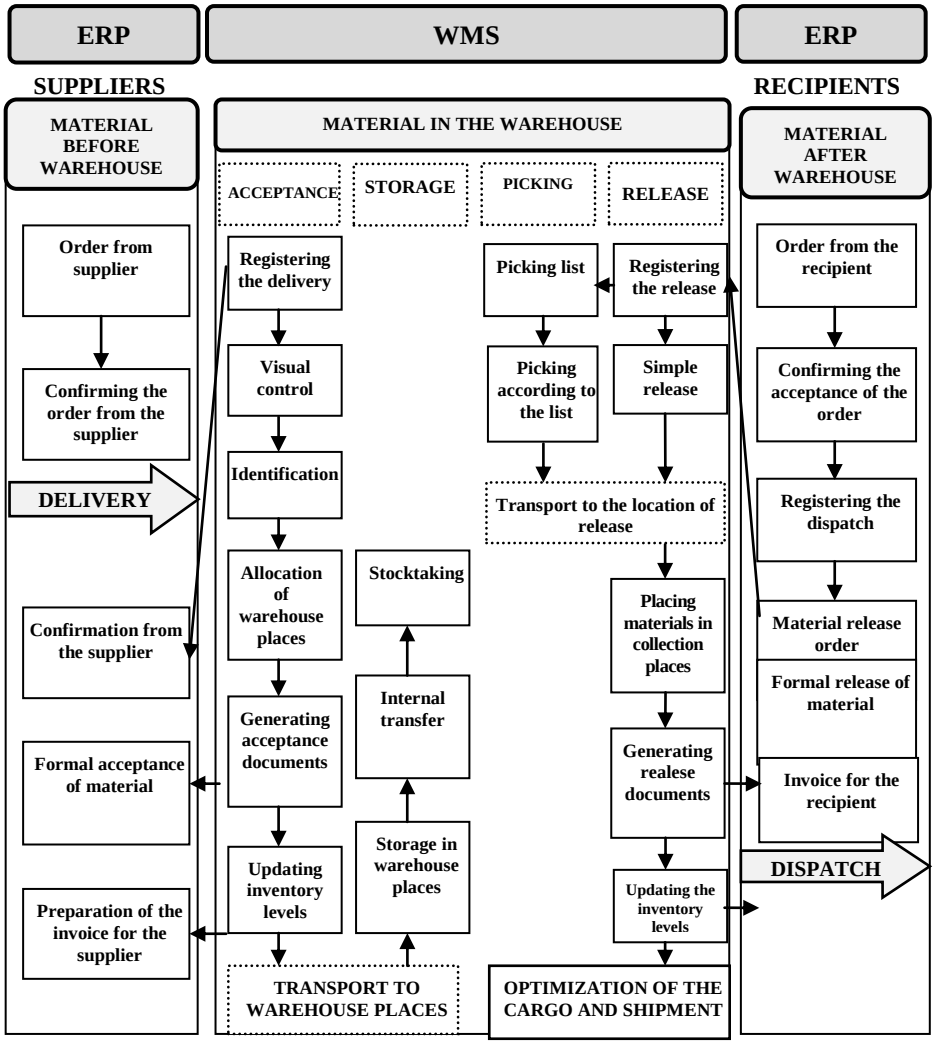

Figure 2. Functions of the system in ERP+WMS variant [6.]

4. Analysis of Function of Warehouse Software RDM in the Enterprise X

The analysis of IT tools which support logistics in the enterprise X is a warehouse system RDM v.10.2.1. The system's name is an abbreviated form of Retek Distribution Management, developed by an American enterprise Retek. A direct provider of this software to the enterprise X is Oracle, which has been the owner of Retek since 2005. RDM is a part of the project of Retek software. Full Retek software is supposed to comprehensively meet the demand of entrepreneurs for IT logistics systems and, within the implementation of the full Retec software, the enterprise is equipped in ERP, SCM, WMS and CRM systems. The first phase of the analysis and assessment of the RDM warehouse software involves the analysis of the scope of its functionality. The modules, of the RDM software with the functions of each module are presented in table 1.

Analysis of all the modules and the functions of RDM software indicates that the scope of functionalities in the software allows for a comprehensive services for all the aspects

concerning warehouse operation. The software deals with recording of all the processes which occur in the warehouse and generates the instructions which present the most effective method of performance of these processes.

Table 1. Structure and Functions of RDM v.10.2.1 [10.]

Module	Module Functions
Warehouse operations	– Acceptance of goods: record of the accepted goods, allocation of warehouse places and preparation of warehouse sketch for the sector of the warehouse where the material will be placed – Internal material transfer: creation of the detailed instructions and sketches for performing goods transfer inside the warehouse – Picking: creation of the detailed picking list for execution of the order with consideration of the type, quantity and place of storage of goods allocated to the particular carrier – Goods release: registration of the material released from the warehouse – Acceptance of the carriers: registration and preparation of the sketch of locations of the carriers returned to the warehouse.
Contractors	– Preview of contractors: opportunities of the insight into information about contractors and their resources.
Reports	– Stocktaking: function which allows for stocktaking in a warehouse – Packaging: reports concerning the number of carriers in the warehouse, number of packages, which are expected to be returned to the warehouse and loss connected with the wear of carriers – Inventory levels: reports concerning the inventory level for the goods in the warehouse.
Transport	– Dispatch: allocation of loaded carriers to particular transport semitrailer, creation of the sketch of loading, determination of the optimal route for the carrier and generation of the waybill – Selection of the semitrailer: allocation of the transport semitrailer for a particular transport. The software takes into account the type of the transported goods and the infrastructure of the recipients.
Dispatcher: an application for recipients	– Notification: information for the recipient about the time of transport, route and amount of carriers with the goods – Data: the data about the driver, vehicle and carrier available to the recipient – Documents: transport documents available to the recipient (BL document, waybill, sketch of loading).
Documents	– Release and acceptance of goods: documents concerning the acceptance and release of goods. – Internal transfer: documents which register changes in the places of storage of goods in the warehouse – Warehouse sketch: the document which presents the distribution of goods in warehouse area – Picking list: the list of goods for dispatch with the guidelines concerning their collection and packaging – Sketch of loading: the document which presents the arrangement of carriers in transport semitrailer – Carrier markings: markings placed on the carriers in order to facilitate the process of checking the compliance of the delivery by the recipient. – BL document: list of goods with specification of the carrier they are in – Waybill: the document which is used by the recipients for recording the arrival of a carrier.

The advantage of the software is also provided by the full transport services, with the system automatically selecting transporting semitrailers, showing distribution of goods in the trailers

and determining the route of transport and recipients. The system is fully compatible and exchanges the data with GOLD eLight. All the operations concerning the changes in the inventory levels are confirmed after ensuring that the introduced changes have also been recorded in the database of GOLD eLight. Furthermore, each user of GOLD eLight has access to an RDM application named Dispatcher, which is dedicated to recipients and provides access to any information concerning the deliveries. The flow of information between the systems and their application occurs fast and without problems, which has essential effect on the effectiveness of work in all the divisions in the enterprise.
Further analysis consists in the assessment of the effectiveness of the activities performed by means of RDM warehouse software. The first element necessary for carrying out this assessment is analysis of the reliability of transport, performed by one of the distribution centres of the enterprise X. The data concerning transport reliability is presented in Table 2.
When defining transport reliability as a proportion of deliveries performed on time to all the deliveries, this value is estimated at the level of 91%. Given that the distribution centre of the enterprise X performed 1124 deliveries during the period of the study (10 days), the obtained result can be deemed as satisfactory.

Table 2. Transport reliability [11.]

Study period	Number of deliveries	Deliveries on time	Proportion of deliveries on time to all deliveries
1.	104	97	93%
2.	146	104	71%
3.	112	105	94%
4.	83	79	95%
5.	124	115	93%
6.	159	142	89%
7.	56	54	96%
8.	109	102	94%
9.	137	121	88%
10.	94	91	97%
Total	1124	1010	**Średnia = 91%**

The figure 3. below shows graphical representation of transport reliability during the period of the study.

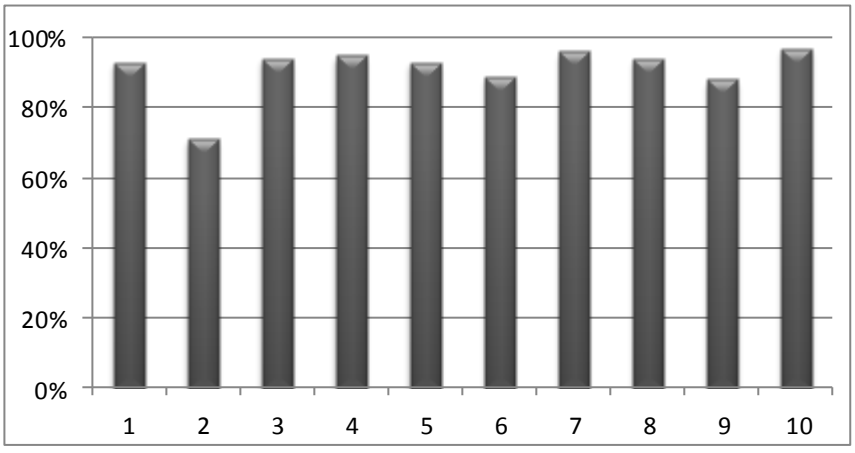

Figure 3. Transport reliability for the performance of deliveries [12.]

The value of proportion of deliveries performed on time to the total of deliveries ranges from 71% to 97%. In order to provide further details, the figure 4. presents the delay time for the deliveries which did not reach the recipient on time.

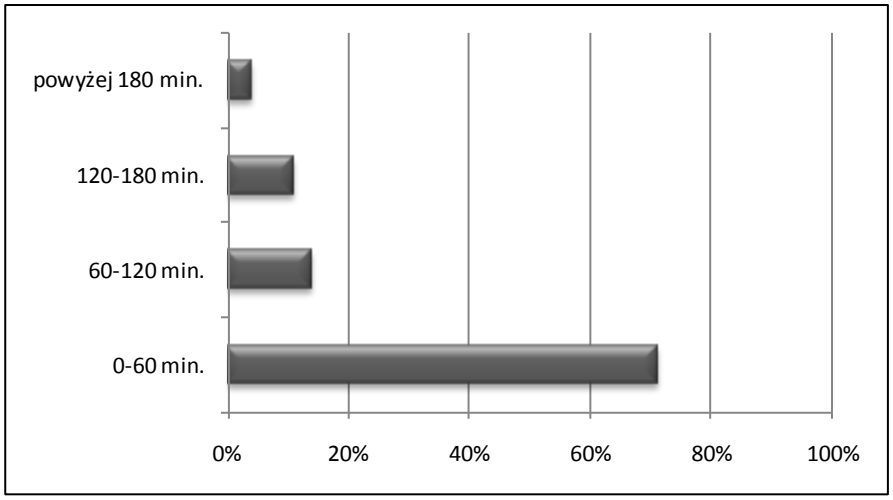

Figure 4. Delays in deliveries which were not performed on time [11.]

Among 9% of the deliveries which are performed on time, 71% include the deliveries whose delivery does not exceed 60 minutes. Only 4% among these deliveries are reported to reach the delay exceeding 180 min. Therefore, the analysis revealed that the area of RDM software responsible for planning transport is effective since it realizes the distribution assumptions of the enterprise X to a significant degree.
Further part of the analysis concerns the reliability of the system with respect to warehousing tasks. The figure 5. presents the reasons for the occurrence of failures in the executed deliveries.

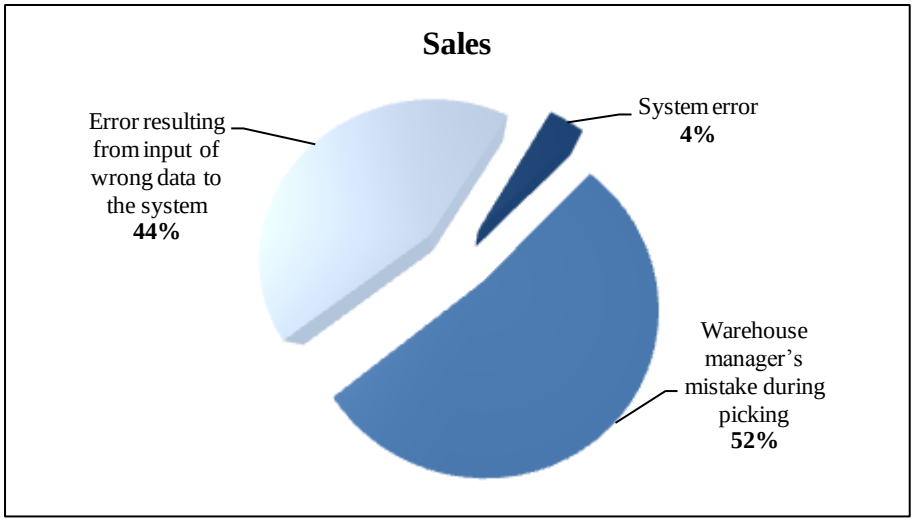

Figure 5. Reasons for failures in deliveries [10.].

The analysis also revealed the degree of proportion of the RDM warehouse system in the process of generation of failures in the deliveries. The failures which result from improper operation of the software account for only 4% of all the reasons. With the number of non-conformities during deliveries, which rarely exceeds 50 pieces in one delivery (with average number of goods in one delivery of dry goods being 20,000 pieces), the number of failures resulting from operation of the system is insignificant.
Based on the analyses, one can conclude that operation of RDM warehouse system leads to optimization and effective performance of distribution processes in the enterprise X. The analysis shows that RDM software guarantees a high level of effectiveness, both in the area of warehouse works and in the area of transport planning. The scope of its functionalities and full compatibility with other systems shows that it is a useful and essential element in the area of distribution in the enterprise X.

5. Summary

The effectiveness of management of logistics processes in enterprises largely depends on its IT support facilities. The level of development of information technology opens up the opportunities of intervention and optimization by means of computer software in all the logistics processes which occur in the enterprises. Technological advances affect the opportunities for development in the enterprises and their chances to maintain the position in the market. High level of competitiveness forces continuous changes in entrepreneurs, striving for making the product offer more attractive. However, in order to increase the attractiveness of offer without losing the financial balance, the costs of the processes which occur in the enterprise should be optimized. The most effective tool to achieve this is IT tools. IT systems allow for integration of the whole supply chain, providing its users with opportunities for immediate exchange of information and insight in all the resources. Operation of the systems leads to optimization of the processes in all the logistics aspects, which gives measurable benefits in the form of cost reduction and improvement in work organization. Reduction in the costs of activities results in reduction of prices and improves chances of increasing incomes in the market. An advantage of modern IT solutions for logistics is their comprehensiveness and mutual compatibility. Each area of operation in the enterprise can be adjusted a suitable functional system. These systems are built so that they can be integrated without problems with the systems operating in other areas. Furthermore, all the systems operate with one database of the biggest software, which controls business processes in the whole enterprise (ERP). Nowadays, development of information technology leads to integration of the elements of IT systems in individual categories in the area of one system. However, due to the limitations during the process of implementation, total integration into a single piece of software remains impossible. Nevertheless, IT tools support logistics management in all possible areas, whereas their reliability and effectiveness have substantial effect on the results obtained by the enterprise.

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[9.] System GS1 is a set of international standards which facilitate effective management of global supply chains. GS1 standards encompass barcodes, electronic communication, synchronization of basic data and electronic product code.
[10.] author's own elaboration based on the material from the enterprise X.
[11.] author's elaboration based on the data from the enterprise X in the period of 4th to 14th April 2011
[12.] author's own elaboration based on Table 2.