ANNALS of Faculty Engineering Hunedoara
– International Journal of Engineering
Tome XV [2017] – Fascicule 2 [May]

ISSN: 1584-2665 [print; online]
ISSN: 1584-2673 [CD-Rom; online]
a free-access multidisciplinary publication
of the Faculty of Engineering Hunedoara

[1.]Marianna JACYNA, [2.]Piotr GOŁĘBIOWSKI, [3.]Konrad LEWCZUK

FUNCTIONS, RELATIONS AND BASIC ELEMENTS OF DATABASE FOR THE DESIGNING OF STORAGE FACILITIES

[1-3.] Warsaw University of Technology, Faculty of Transport, Koszykowa 75, Warsaw, POLAND

Abstract: During designing of warehouse facilities it is necessary to adopt series of input data. Each of the elements has a number of characteristics and parameters. In order to complex designing of warehouse facilities, it is necessary to develop an integrated database. The article discusses the concept of an integrated database, which will be prepared as part of the project SIMMAG 3D – System for modelling and visualization in the 3D warehouse facilities. Database allows for filtering of objects, depending on the function of the warehouse and the industry. It will contain also data connected with significant elements of the logistics network.
Keywords: designing of warehouse facilities, conditions of warehouse process, potential of warehouse facilities, integrated database, SIMMAG 3D

1. INTRODUCTION

Nowadays, logistic plays an increasingly greater role. In each companies are created logistics divisions, which are responsible for the supply of materials or the distribution of manufactured products. Proper flow of cargo and associated with them flow of information in space and time allows companies to achieve the desired profit levels because intermediates, which are necessary to produce the items are delivered on time and then the customer receives the product ordered on time.

In order to effectively fulfil the logistics processes logistics facilities are built, which are point elements of the transport and warehouse chain. They include, among others [1], [2]: warehouses, storage facilities, logistics centres, transhipment facilities, wholesale markets, container terminals, cross-docking objects or consolidation centres. One of the important types of logistics facilities are warehouse facilities, because they represent the largest group among all logistics facilities.

Warehouse facilities [2] are dedicated space where it is possible to store of goods. This space can be closed or not. In order to warehouse properly fulfil its function, i.e. storage, it must be designed properly. On the beginning of designing warehouse, it is necessary to perform study work [3], which can be divided into three aspects [4], [5]:

- strategic aspect, which essence is the analysis of the demand for services [6], as well as evaluation of the location of suppliers and receivers and their production capabilities and demand, which contributes to determine the size of the capital investment,
- the functional aspect, which essence is to establish transport connections between suppliers and receivers and the cost of their realization, as well as the specification of materials that will be stored and prepare their characteristics [7]: rules for admission and issue to/from the warehouse, the physical properties (mechanical, thermal, electrical, magnetic, optical, acoustic etc.), chemical and biological, transport form of cargo (form and parameters of unit packages, packaging and transport units) and the expected volume of stocks,
- operational aspect, which essence is the choice of the equipment and its coordination with other elements of the warehouse system [8], [9], [10].

Designing of warehouse facilities is a complex decision-making process. On each stage of designing it is necessary to adopt a series of input data beginning with type of used flooring, finishing on the type of forklift truck that supports warehouse. Each element has a number of characteristics and performances, as well as the recommendations and limitations associated with its use. A multitude of data makes it

necessary to look for tools which make movement between parameters easier. In order to possibility of comprehensively designing of warehouse facilities, it is necessary to develop a tool for collecting, storing and processing large amounts of data. The most convenient tool to perform these tasks are database.
During designing warehouse facilities it is necessary to use the data from different subject areas. There is a need to develop an integrated database, which will be allowed to operate various types of data. The article discusses the concept of an integrated database, which will be prepared as part of the project SIMMAG 3D – System for modelling and visualization in the 3D warehouse facilities, funded by The National Centre for Research and Development in the Programme for Applied Research 3 – Path B.
The paper presents the procedure to carry out studies on the designing of warehouse facility and the range of data necessary for this. We were discussed external and internal conditions of the warehouse process. We characterized the process of designing of logistics facilities together with an indication on set of parameters necessary for this. We indicated on the potential of warehouse, which must be mapped to be able to design a new facility. Based on the above data, we will develop an integrated database that will allow the filtering of objects, depending on the function of the warehouse and the industry. It will contain not only data on the warehouse facilities but also significant elements of the logistics network, with which the warehouse cooperate. We further characterized the functions of the proposed base and basic relations existing between the elements.

2. EXTERNAL AND INTERNAL CONDITIONS OF WAREHOUSE PROCESS

Study works on the project of warehouse facility and processes in it are determined by many factors - both internal and external. It should be noted that the major impact on the type of developed conception of the object has a type of designed warehouse. This concept depends on the industry for which warehouse is designed. The choice of the industry forces the right way of material units forming. We can identify the following types of warehouse facilities and appropriate for the types supported units [3], [7]:

- warehouses of unit materials – formed and stored in the form of loading units (pallets, containers, packages, bundles etc.),
- warehouses of bulk materials – stored in bulk,
- warehouses of liquids – stored in tanks.

Materials stored in the warehouse should be stored according to their physical, chemical and biological properties. It should be in the warehouse distinguish appropriate areas for storage of hazardous materials and materials that require special storage conditions - e.g. the appropriate temperature, humidity etc.
Designing of warehouse facility should contain the following processes [3], [11]-[16]:

- material supply,
- acceptance of material and optionally sorting, repackaging, conservation, etc. and if it is possible buffering,
- storage,
- order picking and/or commission,
- issuing and possibly packaging and marking,
- material sending.

Process of material supply to warehouse is carried out in the supply zone. In this zone is followed contact of external transport with the designed object. In this zone contact of external transport with the designed object is followed. Here is carried out unloading of external transport (rail or car). Delivery can be carried out in individual packages, packages or in form of pallet. Delivered cargo is transported to the zone of admission to the warehouse. Depending from the form of transport cargo can be here palletised or repacked, sorted and preserves. Depending from operational capabilities in this area analysed and in the next one can be its temporary storage in the input buffer. The next process, which is implemented in the warehouse, is a storage in storage area, to which the cargo from the receptions zone is transported. In the storage area it is possible to storage units, and if in the object there is no separate order picking area, also is order picking and/or completions. If in warehouse facility is separate order picking area, the material is transported from the storage area there and processed. After order picking cargo is moved to the zone sending. In this zone, the cargo is sorted, packaged, labelled and stored temporarily (if necessary) in the output buffer. The last element realized in the issues zone is palletizing of cargo. After that, it is transported to a shipping zone. Depending from the formation cargo is shipped in unit packages, packages or in form of pallet using means of external transport (rail or road).
For each of the above-mentioned processes are developed a number of concepts which could differ [3]:

- adopted type of devices for storage of materials and means of transport (external: railway wagons, motor vehicles, intermodal transport units, internal means of transport and loading, unloading and handling means),
- technology system of warehouse,
- control systems and warehouse management (including in the area of information flow),
- type of structures and various types of installations,
- linear infrastructure (access roads to the warehouse, roads designated in area adjacent to the warehouse, rail roads, road of internal transport) and point (arrangement of buildings, gates, ramps).

3. THE POTENTIAL OF WAREHOUSE FACILITIES

For developed concept of warehouse facility, which has been selected using the indicators to assess the quality of solutions (parameters and quantitative and qualitative indicators) [17], [18], [19] is preparing technological project of warehouse [3], [5]. Its preparation consists of four stages: formulation of logistics tasks, object shaping, object dimensioning and comparisons and evaluation of options. Designing of warehouse facility can be presented as follows (figure 1).

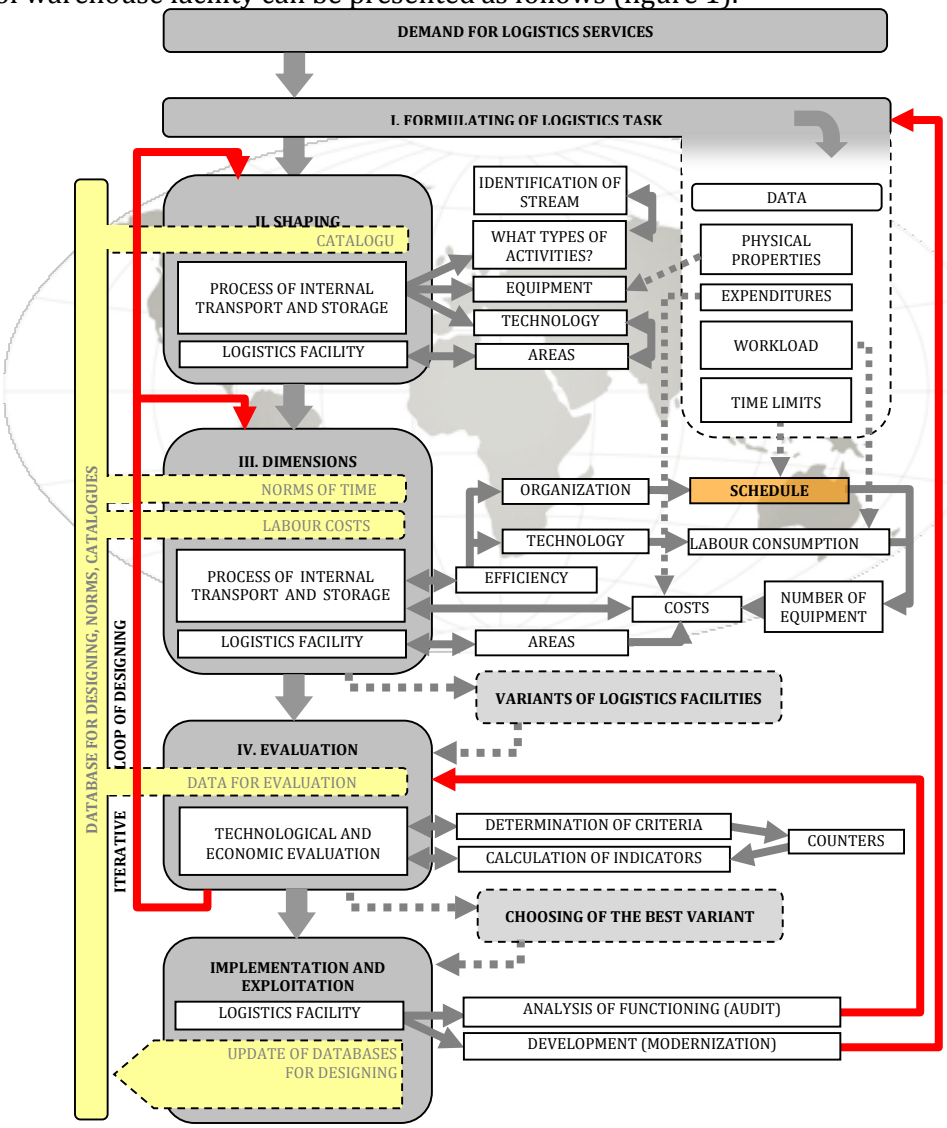

Figure 1 – The procedure for designing of logistics facilities (*Source*: own work)

To complete the technological project of warehouse, it is necessary to determine its potential. Through the potential is understand superstructure and linear and point infrastructure. As mentioned in point 1, as part of the initial concept it is assumed types of vehicles that is superstructure. They can be divided into external means of transport: rail and road, carrying out transport in relation supplier – ramp and ramp – recipient and means of internal transport realizing transport in relations: ramp – warehouse, warehouse – warehouse and warehouse – ramp. From the point of view of designing a warehouse the most important are means of internal transport.

Means of internal transport, related to the work of warehouse, can be divided as follows [3], [20]:

- pallet trucks:

- lifting carriages or lift trucks,
- fork-lift trucks with different types of drive,
- counterbalance trucks, trucks with support front and combined,
- front trucks, side-loading trucks and front-side-loading trucks,
- power industrial, manual, supported and Automated Guided Vehicle trucks,
- trucks with and without a place for the operator,
- order picking trucks to work in narrow aisles,
- means for horizontally transport powered industrial and manual,
- means for horizontal transport automatic with possibility of driven by human,

- transport equipment to support racks:
  - stacker cranes,
  - overhead type cranes,
  - cranes,
  - special equipment,
- conveyors for the continuous transport:
  - roller conveyors,
  - belt conveyors,
  - chain conveyors,
  - plate-bands conveyors,
  - floor conveyors,
  - circular conveyors,
  - overhead conveyors,
  - rotary tables,
  - sliding trucks,
  - constant lifting equipment (elevator).

For each of the selected means of internal transport it is necessary to obtain the values of number of parameters, which are important from the point of view of designing (such as drive type, method of operation, load capacity, lifting height, weight, width, length, height). The most convenient tool for their collection and storage is the database. Further it will be presented the concept of the database for the designing of warehouse facilities.

The second group of the potential of warehouse facility is point infrastructure. To this group we can include [3], [20], [21]:

- racks:
  - for small components,
  - for order picking (commission),
  - pallet to the height of 12 meters,
  - to high storage (over 12 mneters),
  - supported for roof and walls,
  - gravity floor,
  - drive-thru,
  - cantilever,
  - sliding,
  - roundabout,
  - with multilevel access,
  - multifunctional,
- equipment for handling of units:
  - palletizer,
  - depalletizer,
  - machines for securing of load units,
  - machines for stacking,
  - machines to control the dimensions,
- auxiliary equipment for storage and handling:
  - storage, picking and transport boxes,
  - fencing systems,
  - rack trucks and rack ladder,
  - storage and rack landings,

- stairs and railings,
- lighting,

- means to the flow, collecting and processing of information,
- others.

For each of selected elements of the point infrastructure it is necessary to obtain the values of number of parameters, which are important from the point of view of designing (including height, width, length, efficiency, lifting capacity, possibility of upgradeable). The most convenient tool for their collection and storage is the database. Further it will be presented the concept of the database for the designing of warehouse facilities.

Apart from the proper parameterization of point infrastructure it is important to present the necessary parameters for linear infrastructure of warehouse facility and its surroundings. By linear infrastructure it should be understood two groups of roads: roads in internal transport and roads for external transport. In terms of the first group of roads [22] there are communication and transportation roads and roads for pedestrians. These roads should be adapted to the size of their load and to the type of equipment used for transport [23]. Their surface should be done with the right kind of material. In addition, it should be separated evacuation routes. Apart from presenting of certain parameters of internal transport roads, it should be parameterised for roads external transport [24], [25], [26], [27], which will be marked on the area adjacent to warehouse facility, in order to be able to model and visualize them in 3D. For storing of parameter values of characteristic elements of point infrastructure it will be used the database.

4. INTEGRATED DATABASE

As mentioned above, the most convenient tool for storing of large numbers of values parameters are database. In general it can be said that the database used in tools for modelling and visualization are the foundation to conduct research on designing and 3D visualization of objects occurring in these processes. This principle applies not only for transport objects, but for each area in which modelling is the primary of research tool [28].

According to the definition, the database is a collection of digital data, accumulated according to strict rules, allowing for their storing and processing. An important variant of the database are integrated database. These are databases that contain many kinds and types of data. The integration is based on connecting of data obtained from various sources in a way that ensures their complementarities and allows their use from the point of view of facilities designing [29], [30]. With databases are related mechanisms of managing them, which specify the rules of organizing, searching, editing and modifying individual elements. Utilization of databases for data collection is extremely important from the point of view of data persistence (data are not fleeting), it is also possible to save a lot of data in it, which are dependent on each other.

For proper operation of the system SIMMAG 3D it is necessary to enter the data (figure 2) in the scope of the location of warehouse facility in the logistics network, data for the warehouse model and data necessary to carry out the simulation of warehouse process. Data for the operation of the above modules in large part correspond (there are relationships between the different groups of data). There is no point in preparing a set of input data required to work only at a certain stage, but it should be develop a single database, which will be fed into the individual modules with the necessary values. The data in the characterized database are interconnected relationship.

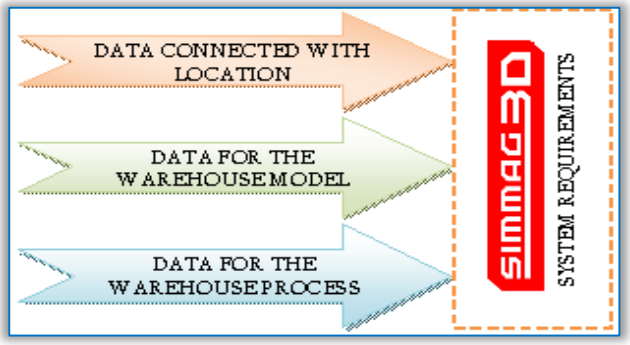

Figure 2 – Demand of the system SIMMAG 3D on data (*Source*: own work).

The database developed for the project SIMMAG 3D is an integrated database. It means that it is not only a collection of data, but complete tool which is an integral part of the system SIMMAG 3D for modelling and visualization in the 3D of warehouses. Development of a comprehensive database tool results from the need to designing of different variants of warehouse facilities and for visualization of warehouse processes. Through the development of an integrated database it is possible to quickly prepare a project of facility and optionally easy making of changes in designed structure. The concept of the database for designing and visualization in 3D of warehouse facilities is illustrated on figure 3.

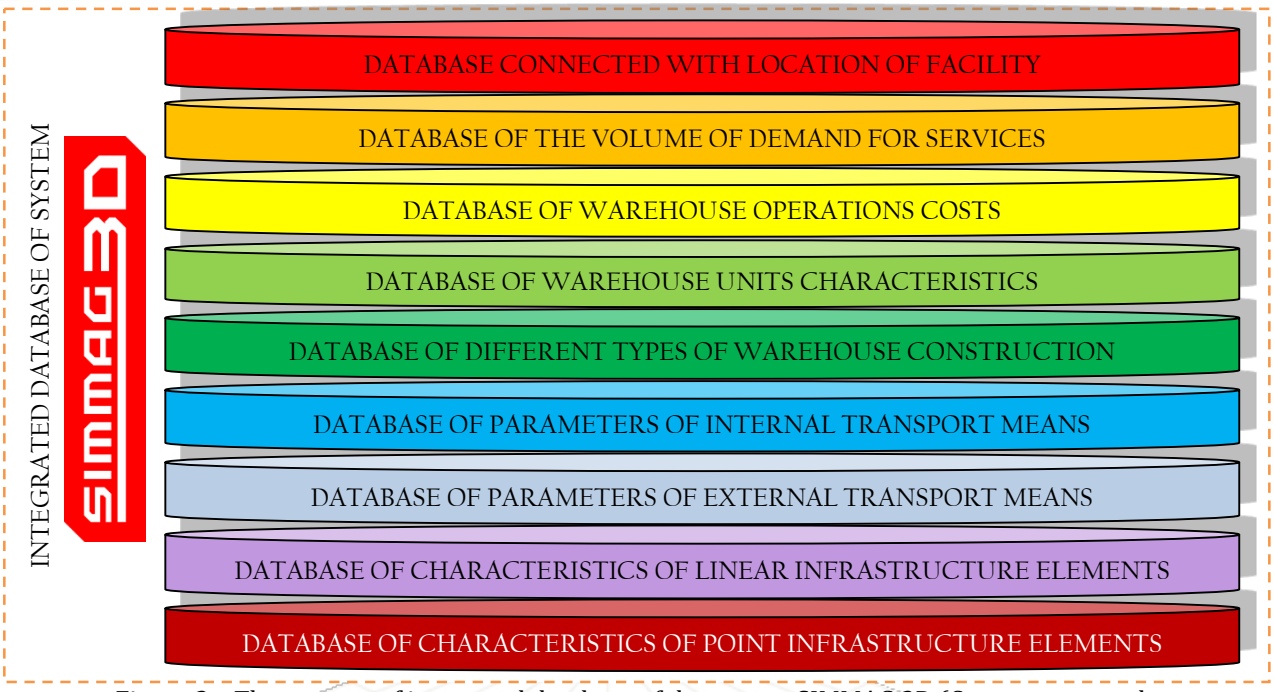

Figure 3 – The concept of integrated database of the system SIMMAG 3D (*Source*: own work.

Development of the database will be possible after identification of the data and considerations for designing of warehouses and organization of the process of material flow in these facilities. Execution of this work requires the identification of among others:

- structure of suppliers and recipients of materials supported by analyzed or designed warehouse,
- means of external transport used by suppliers and recipients and the requirements associated with them (specific ways of handling and unloading / loading),
- qualitative and quantitative form of packaging and load units handled by the warehouse facility,
- delivery and shipping of materials schedule, allowing to meet the needs and requirements of suppliers and recipients, as well as the appropriate use of available resources of warehouse facility,
- space and shape and other requirements for land for building,
- close environment of the analysed or designed facility, including access to the main transport routes, modes of transport and so on,
- possible to use equipment for storage and means of internal transport, which will be furnishing of warehouse.

Integrated database of the system SIMMAG 3D for modelling and visualization in 3D of warehouses will serve the following functions:

- power of the system in the value of certain parameters,
- collecting of data entered into the system and storing of them in different ways,
- processing of data entered into the system and generate specific collections of them,
- perform of operations on data (such as mathematical operations, sorting, merging, etc.).

5. SUMMARY AND CONCLUSIONS

Implementation of the project SIMMAG 3D, which object is to develop a system for modelling and visualization in 3D of warehouses, will provide unique tools that will support the designing of warehouses by allowing for the creation of models cooperating with Warehouse Management Systems and systems for simulation, providing map and visualization of materials flow processes and state of inventories. At the moment there are no tools to support this process comprehensively, i.e. taking into account the analysis of the links of material flow in the warehouse with the logistics network, distribution of loads, etc. This tool will also allow for the identification of important factors affecting the designing process, as well as the relationships between the various elements in the facility.

Designing of warehouses is a complex decision-making process. It requires consideration of a number of external factors. In addition to properly design the warehouse it should be adopt a number of assumptions and collect a wide set of input data. The most convenient tool for collecting and storing of data is a database. Database used in tools for modelling and visualization are the foundation to conduct research on designing of objects and visualization in 3D of processes occurring in facility. Nowadays, the

most important group of databases are the integrated database. They contain many kinds and types of data that allow for design the facility in a comprehensive manner.

Presented in the article database, which is being developed for the project SIMMAG 3D has been designed as an integrated base. It means that it is not only a collection of data, but a complete tool to support the process of modelling and visualization in 3D of warehouses. The development of such a comprehensive database tool results from the need to designing of different variants of warehouse facility equipment and need to visualization of warehouse processes. Using integrated database it is possible to quickly prepare a project of facility and optionally easy making of changes in designed structure. In the next phase of work it will be prepared outline of the database from the information technology point of view (such as database schema) and a description of the implementation of the base in the model SIMMAG 3D.

Aknowledgement

The scientific work carried out in the frame of PBS 3 project SYSTEM FOR MODELING AND 3D VISUALIZATION OF STORAGE FACILITIES (SIMMAG3D) financed by the National Center for Research and Development.

Note

This paper is based on the paper presented at The International Conference Management of Technology – Step to Sustainable Production (MOTSP 2016), organized by the Faculty of Mechanical Engineering and Naval Architecture, Croatian Association for PLM and the University of North, in Porec/Parenzo, Istria, CROATIA, June 01–03, 2016.

References

[1] Coyle, J.J., et al.: Zarządzanie logistyczne, Polskie Wydawnictwo Ekonomiczne, Warszawa, 2002.
[2] Jacyna, M. (Ed.): System Logistyczny Polski. Uwarunkowania techniczno-technologiczne komodalności transportu, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2012.
[3] Hunt, V.: Process Mapping. How to Reengineer Your Business Processes, John Wiley & Sons, New York, 1996.
[4] Fijałkowski, J.: Technologia magazynowania. Wybrane zagadnienia, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 1995.
[5] Manzini, R., et al.: Decision models for the design, optimization and management of warehousing and material handling systems, International Journal of Production Economics, 170(2015), 711-716.
[6] Bieniek, M.: Service level in model of inventory location with stochastic demand, The Archives of Transport, 31(2014)3, 7-21.
[7] Popiela, K., Wasiak, M.: Optimization of Unit Load formation taking into account the mass of packaging units, The Archives of Transport, 32(2014)4, 73-80.
[8] Moncer, A., et al.: The warehouse scheduling problem: formulation and algorithms, IIE Transactions, 28(1996) 2, 115-127.
[9] Ratkiewicz, A.: A combined bi-level approach for the spatial design of rack storage area, Journal of the Operational Research Society, 64(2013)8, 1157-1168.
[10] Van den Berg, J.P., et al.: Forward-reserved allocation in warehouse with unit-load replenishments, Eurpean Journal of Operational Research, 111(1998), 98-113.
[11] Karkula, M.: Selected aspects of simulation modelling of internal transport processes performed at logistics facilities, The Archives of Transport, 30(2014) 2, 43-56.
[12] Kłodawski, M., Jacyna, M.: Czas procesu kompletacji jako kryterium kształtowania strefy komisjonowania, Logistyka, 2(2011), 307-317.
[13] Kłodawski, M., Żak, J.: Order picking area layout and its impact on efficiency of order picking process, Journal of Traffic and Logistics Engineering, 1(2013) 1, 41-46.
[14] Le-Duc, T.: Design and control of efficient order picking processes, Erasmus University Rotterdam, Rotterdam, 2005.
[15] Lewczuk, K.: Zasady organizacji przepływów materiałowych w obszarach funkcjonalnych magazynów, Logistyka, 2(2012), 865-877.
[16] Tang, L.C., Chew, E.P.: Order picking systems: batching and storage assignment strategies, Computer & Industrial Engineering, 33(1997) 3, 817-820.
[17] Jacyna-Gołda, I.: Decision-making model for supporting supply chain efficiency evaluation, The Archives of Transport, 33(2015) 1, 17-31.
[18] Macro, J.G., Salmi, R.E.: A simulation tool to determine warehouse efficiencies and storage allocations, Proceedings of the 2002 Winter Simulation Conference, 2002, 1274–1281.
[19] Żak, J., Jacyna-Gołda, I.: Using Queue Theory to Analysis and Evaluation of the Logistics Centre Workload, The Archives of Transport, 25-26(2013)1-2, 117-135.

[20] Matulewski, M., et al.: Systemy logistyczne. Komponenty, działania, przykłady. Wydanie 2, Instytut Logistyki i Magazynowania, Poznań, 2008.
[21] SSI Schaefer: Kompleksowe rozwiązania od jednego producenta. Wyposażenie magazynów, zakładów i warsztatów. Katalog, 2007.
[22] Rozporządzenie Ministra Pracy i Polityki Socjalnej z dnia 26 września 1997 r. w sprawie ogólnych przepisów bezpieczeństwa i higieny pracy, Dz.U., (1997)129, 844.
[23] Lewczuk, K.: The concept of genetic programming in organizing internal transport processes, The Archives of Transport, 34(2015)2, 61-74.
[24] Jacyna, M., Gołębiowski, P.: Traffic Organization on the Railway Network and Problem of Construction of Graphic Train Timetable, Journal of KONES Powertrain and Transport, 22(2015)2, 79-87.
[25] Naumov, V., et al.: Model of Multimodal Transport Node Functioning, The Archives of Transport, 36(2015)4, 43-54.
[26] Szczepański, E., Jachimowski, R.: Simulation analysis of vehicle routing problem solution, CLC 2013: Carpathian Logistics Congress - Congress Proceedings, 2014, 446-452.
[27] Tarapata, Z.: Modelling and analysis of transportation networks using complex networks: Poland case study, The Archives of Transport, 36(2015) 4, 55-65.
[28] Dong, Y., Goh, A.: An intelligent database for engineering applications, Artificial Intelligence in Engineering, 12(1998)1, 1-14.
[29] Hasselbring, W.: Information system integration, Communications of the ACM, 43(2000)6, 32-38.
[30] Ullman, J., Widom, J.: A First Course in Database Systems, Prentice-Hall, Inc., Upper Saddle River, 1997.