# Simulation as a Method of Choosing the Order Picking Concept

Marek Gałązka,
*Adam Mickiewicz University In Poznań, Poland*

Michał Jakubiak
*Wrocław University of Economics, Wrocław, Poland*

The analysis of the three, main, heuristics approaches outlining the order picking routes in a warehouse, is a subject of this paper. Order picking is the most laborious warehouse process and it contributes to 55% - 65% of all the costs of operations performed in a warehouse. The most time consuming order picking activity, according to the research, is transfer which is closely related to, adopted by a given company, system of transfer and movement between the points of taking the order, places of pick up, and points of release. Even the small shifts of commodities, on short distances, play a very important part in modern dynamic economy. On the basis of a simple model of a warehouse owned by an authentic company, a computer program was created, which helps in simulation of the three, main heuristics approaches to outline the routes, so as to make the order picking process as short as possible.

## 1. INTRODUCTION

In order to be competitive in a dynamic environment, companies keep on looking for some new managing concepts. In recent years there was a focus on logistics concept of management which is based on the complex analysis of the flow of goods and information. The understanding of the way in which the goods are moved between the specific elements of logistic chain allows to plan and optimize individual stages of goods movement. In the modern logistic system every manipulation of materials is subjected to detailed verification at the stage of planning. The small shifts of goods on a short distances, which happen in the premises of a given building (warehouse, production plant), and between the building and transport intermediary, are starting to play a very important part.[1] The order picking problems are especially visible in logistic centres which are becoming more and more important in the modern supply chain management.[2] They focus on: finding the best possible way to locate the goods on a given space, using the limited capacity of the building to the utmost, and reducing the number of manipulations with a given product.

## 2. ORDER PICKING SYSTEMS

Order picking is a process of logistic activities, operational and organizational. It is based on the combination of specific subsets ( goods), from the prepared set ( assortment), on the basis of order information in the form of commission . There also occur a change of a specific state of stored goods into a characteristic state released goods.[3] In other words order picking is searching for and completing, from storing places in a warehouse, specific goods which are on the order list placed by

[1] Coyle J.J., Bardi E.J., Langley C.J. Jr., Zarządzanie logistyczne, Polskie Wydawnictwo Ekonomiczne, Warszawa 2002

[2] Chiang Y., Chen S., Wu K., A Robust Approach for Improving Computational Efficiency of Order-Picking Problems, Springer – Verlag Berlin Heidelberg 2005

[3] Ghiani G., Introduction to Logistics Systems Planning and Control, JohnWiley & Sons Ltd, The Atrium, Southern Gate, Chichester, 2004

a customer.[4] According to the research, transfer is the most laborious activity. In other words transfer can be defined as covering a given distance, between the points of taking the order, and places of picking up and release of goods.[5]

Works of scientists and researchers aim at speeding up and reducing the costs of completing the order. In order to meet the requirements of general system efficiency the three basic questions, which determine the overall time of order picking process, need to be answered. First of all, how to pick up goods (complete), secondly, how to store (stock up), and finally how to move to get the ordered commodity?

Picking policies focus on the division of labour among workers, so that the time of picking the goods, according to the order picking list, is as short as possible.

In accordance with the division made by Ackerman, there are three approaches in order picking policy: strict order picking, batch picking, and zone picking.[6] Strict order picking assigns an individual worker who directly completes a single order. Batch picking assigns a single warehouseman to the bigger number of orders during the order picking route, whereas zone picking assigns a warehouseman to one zone where he is responsible for the goods which are on his order picking list.[7]

We can distinguish three types of zone picking: *sequential zone, batch zone and wave zone*. *Sequential zone picking* is typical for one order which is completed at a single carrier. In this type the carrier is transported by means of sequential vehicle from one zone to another, and in every zone a warehouseman, responsible for a given area, completes the order which is assigned to a given part. In *batch zone picking* the order is picked separately but simultaneously in every picking zone, and at the end of the process it is put in to one complete whole which goes to the client. *Wave picking* is a special type of *batch zone picking* in which a warehouseman picks some large batches of goods and his actions are not based on the number of products from the order list but on the order picking time (usually from 30 min to 2h). After the process of continuous order picking, which is discontinued only for unloading a full carrier, there is a consolidation process of a given order which is done by the workers on the basis of goods brought in.[8]

The way of goods storage - storage *policies* is another topic analyzed and considered by scholars and logistic practitioners. Storage policies deal with assigning some specific locations for given goods (storage). There can be some different ways of storage. The first one is called *random storage.* This approach is based on storing the goods in a warehousing space in which there is a free room for it. In this way the time is reduced which is needed for putting the product down, yet it increases it in the order picking process.

The second approach is based on allotting a specific place in a warehouse, which can be distinguish taking into account several factors, to a given good. Storing goods on the same carrier ( euro-pallet) together is the first factor. It's very convenient for the technological reasons as it helps to optimize the storing space on the pallet rack. The second factor comes down to a simple rule according to which goods with the fastest rotation have to be located as close as possible to warehouse's exits so as to minimize the order picking time. [9]

*Routing policies* are the last major point in the order picking research. The most important point of this studies is to find some ways to minimize the distance that warehousemen have to cover on a route, in order picking process. Out of different algorithms, which try to solve the problem of minimizing and shortening the length of order picking route, the most popular are heuristics algorithms. Their universality results from the facts that they are very easy to implement and have

[4] Petersen C., Aase R., Heiser D., Improving order-picking performance through the implementation of class-based storage, International Journal of Physical Distribution & Logistics Management, Volume 34, Issue: 7, 2004

[5] Kłodawski M., Jacyna M., Wybrane aspekty problematyki komisjonowania w funkcji pracochłonności procesu, Prace Naukowe Politechniki Warszawskiej zeszyt 70, Warszawa 2009

[6] Ackerman K.B., Practical Handbook of Warehousing, Van Nostrand Reinhold, 1990 New York

[7] Kizyn M., Problemy kompletacji w procesach magazynowych cz. 1, Logistyka, 1/2006

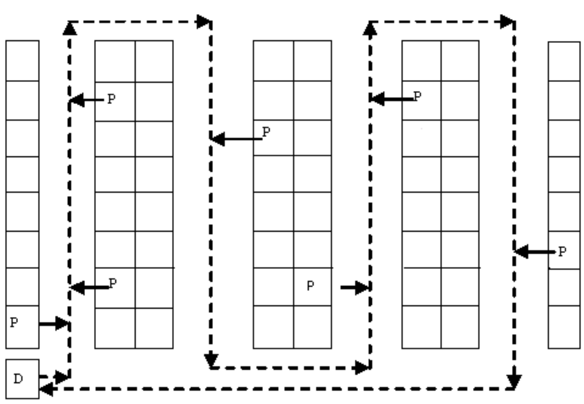
[8] Frazelle E.H., Apple J.M., Warehouse Operations in The Distribution Management Handbook, McGraw-Hill, New York 1994

[9] Manning A., Master order picking and improve how you get product out of your building and into your customer's hands, Modern Materials Handling, 10/1/2008

similar results to algorithms with accurate results.[10] The limitations with using algorithms with accurate results are caused by too big number of variables, and difficulties in creating new models for such varied order picking lists.

## 3. HEURISTICS APPROACH OUTLINING THE ORDER PICKING ROUTES

*S –shape (traversal strategy*), *midpoint strategy*, and r*eturn strategy* are the main heuristics methods of outlining the order picking routes. The method S-shape is one of the simplest approaches to outline a route for the person who works on completing the order. A warehouseman who works according to this strategy moves between the pallet racks, where the commodities for order picking are placed, in a particular way: Starting the route at the beginning of the passage and proceeding to the next one only when all goods have been collected from the previous passage. The whole order picking route resembles the letter "s" , this is presented in the picture 1.



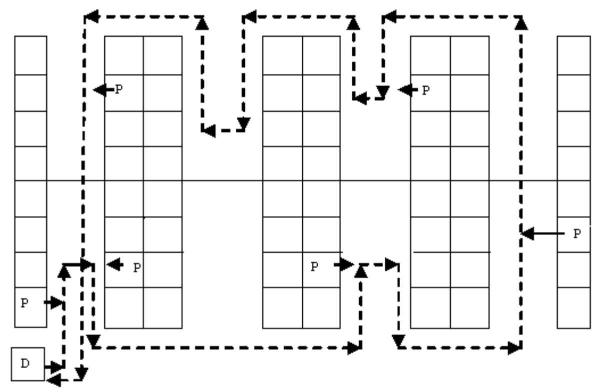
Picture 1. S –shape strategy (traversal strategy)

Source: Own elaboration on the basis of De Koster R., Le-Duc T., Roodberger K., Design and control of warehouse order picking: A literature review, European Journal of Operational Research 182 (2007)

In the pictures 1, 2, and 3 the letter D stands for the start and the end point, where the warehouseman starts and finishes route in which he picks the goods (letter P) designed for shipment.

[10] Ratlif H.D., Rosenthal A.S., Order-picking in a rectangular warehouse: A solvable case of the traveling salesman problem. Operation Research 31 (3)

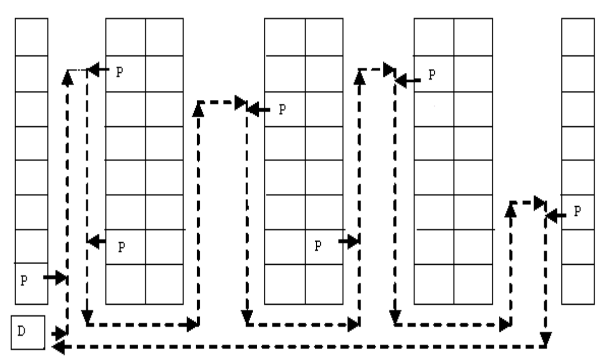
*Midpoint* is another strategy outlining the order picking route. This approach divides the warehouse into two zones. Here, the warehouseman moves, through the passage, only to the middle of the warehouse which is a border point of the first zone. The remaining commodities, which are located in the second zone of the warehouse, are picked on his way back. The outline of the *midpoint* method is shown in the picture 2.



Picture. 2 Midpoint strategy

Source: Own elaboration on the basis of De Koster R., Le-Duc T., Roodberger K., Design and control of warehouse order picking: A literature review, European Journal of Operational Research 182 (2007)

*The return strategy* is the last heuristics approach, outlining the order picking route in a warehouse, described in this paper



Picture 3. Return strategy

Source: Own elaboration on the basis of De Koster R., Le-Duc T., Roodberger K., Design and control of warehouse order picking: A literature review, European Journal of Operational Research 182 (2007)

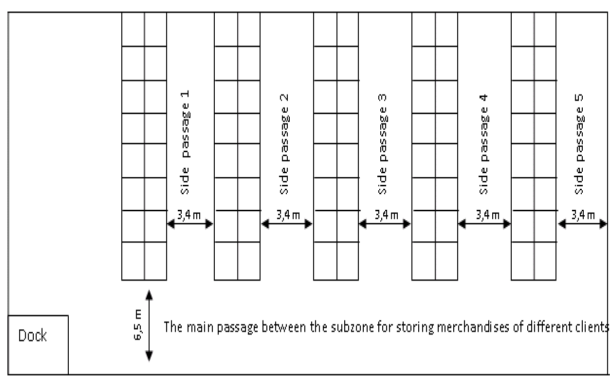
According to this strategy, a warehouseman moves along the passage up to the last commodity which is itemized on the order picking list, and located on the racks which are adjacent to the passage. After collecting the products, a warehouseman goes back to the main passage, which is at right angles to the racks, and proceeds to the next items on order picking list following the above-mentioned rule.

Heuristics algorithms outlining the order picking routes are especially popular in some warehouses where the order picking process is done by human. Simplicity of their implementation and correspondence, in results, to the algorithms with accurate results are the main reasons for this situation.[11] Limitations of using accurate algorithms in the warehouses, where order picking process is done by hand, are caused by the facts that new mathematical models need to be built all the time, and there are a lot of variables which one has to take into consideration while doing calculation. Furthermore, a warehouseman would have to learn the new routes, which would change along with the order picking list, all the time. Owing to heuristics algorithms, a warehouseman can learn certain habits while moving through the warehouse. These habits are unchanging, and in this way the threat of possible mistakes is minimized. A completely different situation occurs in the automatic warehouses of AS/RS type, where the algorithms with accurate results are in the lead. In these warehouses the order picking systems are supported by the computers with a big computing power. Computers are able to outline the optimal route for a given order picking list in a very short time. Due to the fact that the order picking process is done automatically by a machine, which moves to the places indicated by the main computer, mistakes are almost impossible to happen.

## 4. DESCRIPTION OF THE RESEARCH

Described problem concerns the warehouse of a logistic operator. This is a warehouse which basic functions are limited to reception, storage, order picking, and release of goods which belong to various production and retail companies, which have the basic warehouse processes carried out by external companies. Warehousing premises are located near Wrocław. The warehouse has got the shape of cuboid, and it consists of 30 pallet racks where the high storage is possible. In addition, every rack is 30.8 metres long. The warehouse is divided into several zones. The space allotted to receiving and releasing goods is mutual for every delivery. Whereas, the biggest warehousing area, designed for storing goods, is divided into several smaller subzones. In every subzone the goods of the similar kind are stored.

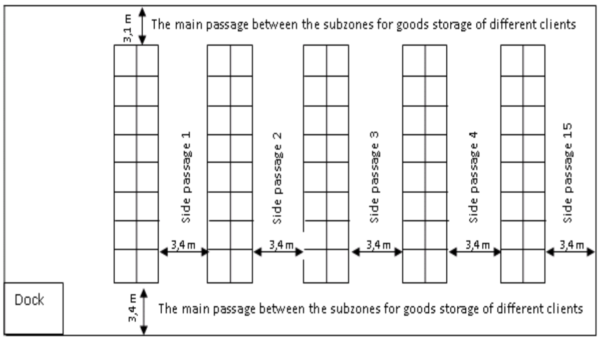
The examined subzone is meant for the clients selling AGD/RTV equipment. After the meeting between the logistic operator and a new client it was agreed that AGD/RTV equipment will be stored on the five, four-storey pallet racks. Between the racks there will be side passages 3.4 metres wide, which is a standard adopted by the operator. The fact how the racks will be placed and located in a warehouse is unknown. Therefore, two variants are considered. In the first one, the racks will be located by a partition wall of the warehouse, because of this the warehouseman won't be able go around the rack from both sides, but only from the main passage side. In the second option the racks will be placed 3.1 meter far from the partition wall, which will ensure the access to the racks from both sides. The diagram of the two variants is presented in the picture 4 and 5.




Picture 4 The first variant of pallet racks placement in the subzone chosen for a new client

Source: Own elaboration

[11] Ratlif H.D., Rosenthal A.S., Order-picking in a rectangular warehouse: A solvable case of the traveling salesman problem. Operation Research 31 (3)




Picture 5 The second variant of pallet racks placement in the subzone chosen for a new client

Source: Own elaboration

The choice of a specific variant for pallet racks placement has an influence on the later order picking methods for a given customer. The first variant limits the range of possible order picking methods which can be used by a warehouseman. The lack of a passage separating the racks from the partition wall of the warehouse results in the fact, that a forklift truck can move between the racks only through the main passage which separates two subzones. In this case, the order picking is possible only through the return strategy in which a warehouseman, who moves between the racks, uses only one main passage, which is at right angles to the racks. The second variant of allocating goods in a warehouse makes it possible to implement the three main heuristics strategies of movement through a warehouse. The reduction in the size of the passage, separating given subzones of the warehouse, and as a result making the movement of forklift trucks much more difficult, is a disadvantage of this variant.

**The main objective** is to compare the influence, of the two aforesaid variants of pallet racks placement, on the order picking time in a warehouse. The order picking process, in the examined case, was simplified by the authors, that is way it could be generalized and implemented by different companies. Moreover, the authors mainly focused on the process of transfer and movement. Due to the fact that the company hasn't got any detailed information, as far as future orders are concerned, it was assumed that the transport cycle, during which 5-10 products can be collected, will be examined. The work of a forklift truck, in the examined company, starts when an operator takes the order for order picking, it lasts depending on the number of products he can collect during one cycle, and it ends when the commodities are put on the allotted place. It was assumed that the commodities are placed in the warehouse at random. The distances between the goods, the order picking places, and internal transportation norms were also taken into consideration.

Table 1. represents the time norms for a forklift truck with the load capacity of 20kN, which will be used in the task.

Table 1 Unit time norms of the basic movements of an accumulator forklift truck with a carrying capacity of 20 kN

| LP | Basic forklift truck movements | loading | unit | Symbol of the operation | Time norm (min) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | Acceleration , empty or loaded (It appears every time when the forklift accelerates from the stop to the full speed) | empty | Full period | AE | 0,0300 |
| | | loaded | | AL | 0,0300 |
| 2 | Moving forward at a full speed (It starts, when the forklift reaches full speed after finishing the acceleration, and ends when the forklift starts to break) | empty | Per 1 metre | FE | 0,0076 |
| | | loaded | | FL | 0,0089 |
| 3 | Moving backwards at a full speed as in the example 2. | empty | Per 1 metre | RE | 0,0076 |
| | | loaded | | RL | 0,0089 |
| 4 | Stoppage (It includes breaking in order to stop the forklift from the top speed to the stoppage ) | empty | Full period | SE | 0,0200 |

| | | | | | |
|---|---|---|---|---|---|
| | | loaded | | SL | 0,0360 |
| 5 | Simple entrance at the first height (includes movement of the fork lift at a very low speed, starting from the stoppage, in order to put the forks into the pallet or to position the pallet , when forks have already been lifted. The stoppage is included in the time measurement. The horizontal distance which forklift covers is 1.2 m. | empty | Full period | 1 NE | 0,0800 |
| | | loaded | | 1 NL | 0,0800 |
| 6 | Simple entrance at the second height | empty | Full period | 2 NE | 0,0800 |
| | | loaded | | 2 NL | 0,1100 |
| 7 | Simple entrance at the third height | empty | Full period | 3 NE | 0,1100 |
| | | loaded | | 3 NL | 0,1300 |
| 8 | Simple withdrawal at the first height (includes withdrawing forks from the pallet or taking out the pallet. The time is measured including moving and stopping | empty | Full operation | 10 E | 0,0600 |
| | | loaded | | 10 L | 0,0650 |
| 9 | Simple withdrawal from the second height | empty | Full operation | 20 E | 0,0600 |
| | | loaded | | 20 L | 0,0700 |
| 10 | Simple withdrawal from the third height | empty | Full operation | 30 E | 0,0600 |
| | | loaded | | 30 L | 0,0800 |
| 11 | Turning left moving forward (changing the direction of movement to the left angle 90 degrees with the minimum radius while moving forward) | empty | Full operation | TFL | 0,0550 |
| | | loaded | | | |
| 12 | Right turn while moving forward<br>(change the direction of movement to the right ) | empty | Full operation | TFR | 0,0550 |
| | | loaded | | | |
| 13 | Left turn moving backward | empty | Full operation | TRL | 0,0550 |
| | | loaded | | | |
| 14 | Right turn moving backward | empty | Full operation | TRR | 0,0550 |
| | | loaded | | | |
| 15 | Left turn while moving forward and stoppage (this movement is usually preceded by entrance or lifting) | empty | Full operation | TFLSE | 0,0600 |
| | | loaded | | TFLSL | 0,0700 |
| 16 | Right turn while moving forward and stoppage | empty | Full operation | TFRSE | 0,0700 |
| | | loaded | | TFRSL | 0,0750 |
| 17 | Left turn while moving backward and stoppage | empty | Full operation | TRLSE | 0,0650 |
| | | loaded | | TRLSL | 0,0750 |
| 18 | Right turn while moving forward and stoppage | empty | Full operation | TRRSE | 0,0650<br>0,850 |
| | | loaded | | TRRSL | |
| 19 | Tilting the mast to the back | empty | Full operation | LB | 0,0250 |
| | | loaded | | | |
| 20 | Tilting the mast to the front | empty | Full operation | LF | 0,0250 |
| | | loaded | | | |
| 21 | Lifting the forks on stoppage | empty | Per 1 | UE | 0,1120 |

| | | | | | |
|---|---|---|---|---|---|
| | | loaded | metre | UL | 0,1320 |
| 22 | Lowering the forks on stoppage | empty | Per 1 metre | DE | 0,1200 |
| | | loaded | | DL | 0,0720 |

Source: Fijałkowski J., Transport wewnętrzny w systemach logistycznych, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2003

The computer program, designed for this research, after entering the following data: dimensions of the warehouse, the number of order picking goods, and internal transportation norms, calculates, according to abovementioned **heuristics algorithms outlining order picking routes**, the time needed for completing the order.

## 5. THE RESULTS OF THE SIMULATION

Computer simulation was carried out in JAVA. The program uploads the information from the entering file in which three groups of information need to be determined:

1. Data concerning the size and measurements of the warehouse( number of pallet racks, number of rows in the rack, number of shelves in one row, the width of the shelves, the length of the section between the first rack and the centre of the warehouse dock, the width of the racks).
2. Data concerning the order ( number of commodities in the order, the number of orders, the place of the ordered commodity in a warehouse).
3. Time norms of the basic movements of a forklift truck.

The *main* function of the program uploads the data from the entering file, and calculates the order picking time according to the three, implemented in the separate categories, heuristics algorithms: Traversal, Return, Midpoint.

In the program there is an option to place the goods in warehouse at random, or to do it manually. These pieces of information are saved in the form of four dimensional board which is the computer image of the warehouse and is the main structure of data in the program. Individual dimensions of the board have got the following meaning:

- the first dimension stands for the number of rack (racks are numbered from 0)
- the second dimension stands for the left or the right side of the rack (0 for left, 1 for right)
- the third dimension stands for the number of the shelf( shelves are numbered from 0)
- the fourth dimension stands for the number of row (rows are numbered from 0)

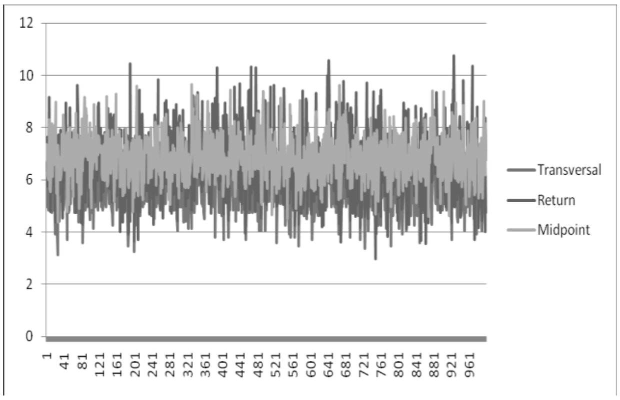
Simulation for this warehouses was carried out on the basis of 1000 randomly generated orders. It proved that, when the goods are placed in the warehouse at random, the order picking method based on the heuristics model outlining the route *Traversal* is the best. The average order picking time consisting of 5 commodities amounted to, using *S-shape(traversal) strategy,* 5 min. and 45 sec., whereas using *return and midpoint* strategy 6 min 41 s and 6 min 48 s. accordingly.

Table 2. The average order picking times for 1000 randomly generated orders

| Number of goods in one order | Traversal (S –shape) | return | midpoint |
|---|---|---|---|
| 5 | 5 min 45 seconds | 6 min 41 s | 6 min 48 s |
| 6 | 6 min 29 s | 7 min 41 s | 7 min 37 s |
| 7 | 7 min 7 s | 8 min 31 s | 8 min 22 s |
| 8 | 7 min 40 s | 9 min 18 s | 9 min 8 s |
| 9 | 8 min 15 s | 10 min 42 s | 9 min 55 s |
| 10 | 8 min 43 s | 10 min 46 s | 10 min 28 s |

Source. Own elaboration

Due to the fact that the number of AGD/RTV goods in an order placed to logistic operator is unknown, the simulation, which includes variable composition of goods in an order picking list, was carried out. The results of the simulation are presented in table 1.




Picture 6. The diagram of order picking times consisting of 5 commodities for three heuristics strategies outlining the order picking routes

Source: Own elaboration

According to the abovementioned research, *traversal strategy* is definitely the best method for outlining the order picking routes. However, we can only implement it using the second variant of pallet racks placement. This is a very simple strategy. We can achieve very good results, thanks to this method, especially when the orders are very random and changeable. *The return strategy* seems to be much worse method and according to the results is at the last place. Nevertheless, the differences between this strategy and *the midpoint strategy* are very small. *Return strategy* turns out to be good in some warehouses where the goods are ordered with the same frequency. It allows to use the goods allocation methods which put the goods, with the fastest rotation, as close as possible to the exit gates of the warehouse. In the examined by authors instance it would be places located in the vicinity of the main passage, which separates two storage subzones.

At this stage of the research, it can be said that it is much more reasonable to place the pallet racks according to the second variant of placement, as it does not exclude any of the strategies outlining the order picking route, and, at the very beginning of the process, the operator gains big time advantage using the traversal S-shape method.

## 6. SUMMARY

The implementation of simulation programs enables us to test different order picking variants and choose the best in a given moment and for a given purpose. Simulation methods helps in making decisions concerning designing, managing, and conducting many warehousing activities.