INVESTIGATION OF THE INFLUENCES OF ARTICLE AND ORDER STRUCTURE ON THE DIMENSIONING OF ZONE-PICKING-SYSTEMS

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KEYWORDS

order-picking systems, rough planning, simulation modules, zone-picking, dimensioning, decision making, influences on picking systems, logistics, material flow

ABSTRACT

"First, the order picking then the stock planning – In the order picking area the most stuff is usually employed. Here the customer service and the logistics quality are decided. The highest costs incur here." [7]. The planning of an order picking system is characterized by the complexity of the system. Through the use of simulation in rough planning, more precise statements about the performance of order picking systems can be made. The planning process with the PlanKom tool, which uses the simulation, is described at the beginning of this paper. Focus is the investigation from the so-called zone-picking. The planning of such a system raises the question of how long a zone should be, so that performance is maximized. In this context, the influence of article structure, storage strategy, order structure and number of zones on the performance is examined. For this study 1.080 simulation runs have been performed. The results show that the article structure has a large impact on performance by picking in a small number of zones. With increasing number of zones, the influence of the article structure is less. Furthermore, the results show that the storage strategy "concentration of fast moving parts" has a higher performance than a chaotic storage strategy.

PLANNING AND OPTIMIZATION OF ORDER PICKING SYSTEMS

The order picking is the central function of the warehouse logistics and has significant influence on areas like production and distribution [8]. Despite the trend towards automation, order picking is a costly area in modern logistics systems [12]. This is mainly due to the high personnel section [11]. In order picking systems from a total quantity of parts (the assortment) subsets are assorted by a customer order and then sent to the customer [11, 14]. These are the most difficult tasks of the in-house (intra) logistics [7]. This is due to the complexity of order picking systems, because there is a multitude of ways to realize the picking task [11, 4, 10].

Due to the requirements of the order picking, the most efficient mix of the spectrum of order picking technologies has to be selected. It is important to achieve a high delivery quality and simultaneously a high economic efficiency [8]. Often the right solution does not consist only of one specific order picking technology, but from multiple different order picking technologies, which can be arranged in a useful combination [1, 4, 10]. Such hybrid or heterogeneous order picking systems allow to adapt the complete system to the specific requirements.

The requirements for an order picking system become higher and higher. The requirements increase due to smaller individual orders, followed by a higher delivery frequency [9, 4]. Furthermore, the growing diversity of parts and the high standards of material availability advance the requirements. The delivery times are shorter and shorter and thus the cycle times too [1, 4, 8, 6]. Also additional services, such as the labelling of parts for customers, increase the requirement for order picking systems [9].

The planning process is complex due to the very different requirements, so it can be advantageous to use planning software. One possibility is the use of simulation. Within the 21st ECMS we have explained the advantages of simulation in rough planning and the necessity of standardisation [13]. Figure 1 illustrates the planning process. The planning tool supports the planner in phase of preparation and rough planning. Simulation can be used for investigation of the performance of order picking systems.

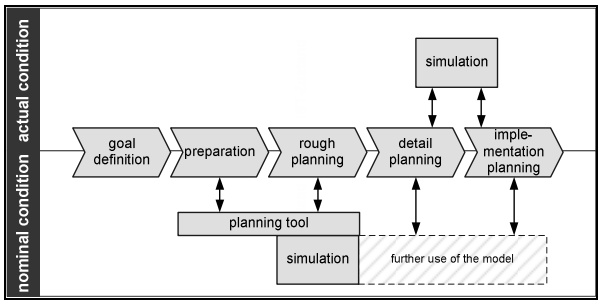

Figure 1: Usage of simulation environments in planning processes

The planning tool called PlanKom can be used for different kinds of investigation. The main field of

Proceedings 22nd European Conference on Modelling and Simulation ©ECMS Loucas S. Louca, Yiorgos Chrysanthou, Zuzana Oplatková, Khalid Al-Begain (Editors)
ISBN: 978-0-9553018-5-8 / ISBN: 978-0-9553018-6-5 (CD)

application is the investigation of system versions. But systematic investigations for generation of shaping notes can also be performed.

RESEARCH OBJECTIVE

In this study the so-called zone picking is investigated. Thereby the parts are provided statically in e.g. flow racks. The entire rack front is subdivided in sections (so-called zones). Figure 2 shows a zone picking system with two zones. Every zone has a basis. At the basis the order bins are available for the picker.

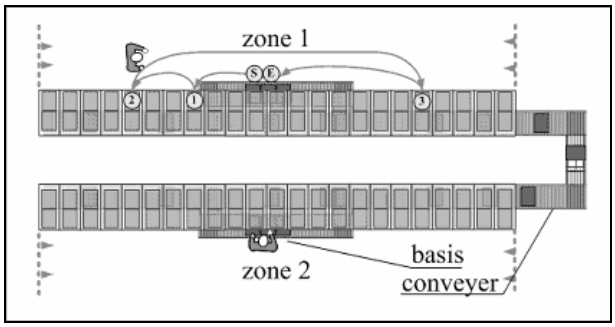

Figure 2: Real layout from a zone picking system with two zones

For the full development of an order, the bins must be filled with parts in one or more zones. Therefore the bin is transported in the zones by conveyor technique. In a zone a picker (human) receives the bin at the basis. For a better understanding the way a picker has to walk for an order in a zone is described next. In our case the picker takes the bin along (compare "S" in figure 2). A picking list is in the bin. The picker has to pick three orderlines (3 parts). He walks to the first part (1) and takes it. He puts the part in the bin and confirms the taking at the picking list. After this, he walks to the second (2) and 3rd (3) part and takes them. Following that, he walks back to the basis and places the bin on the conveyer (E). The basis is in the middle of a zone. Parts can be stored left or right from the basis. The way is determined by the longest distance from the basis to the storage place of a part in the left and in the right side.

In the planning process the length of a zone and therefore the number of zones must be defined. The length of a zone affects the performance of the picker. One planning task is to find the optimal length of zone, which provides the best performance. Further influencing variables have to be considered, because they also affect the performance. These are predominantly:

- the article structure (distribution of access frequency),
- the order structure (number of order lines) and
- the storage strategy.

The last one can be defined in the planning process, but the others cannot be affected by the planner.

The aim of study is to find out the impact of the various influencing variables on the performance. Based on the simulation results shaping notes for zone picking systems are derived.

MODELLING THE ZONE-PICKING SYSTEM

For this investigation one of our standard modules (Zone-Picking-Module) is used and allocated with different parameters focuses the number of zones. Each different layout has to be modelled as a different model. To show the differences between the lengths of zones, the number of zones is duplicated from version to version beginning with 1 and ending with 32. In figure 3 an example of the module allocated with four zones is shown.

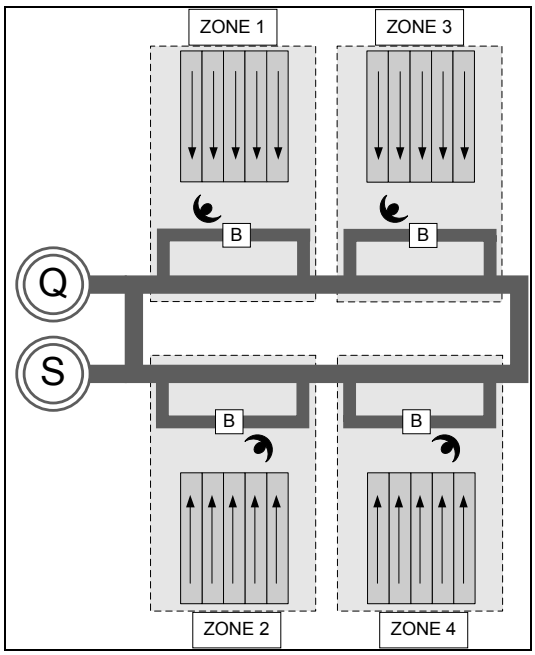

Figure 3: Example of the module with four zones

The planner is supported during the whole modelling process by PlanKom-Software and can allocate parameters independent from his simulation expertise. Figure 4 shows the modelling area, implemented as Drag & Drop GUI (Graphical User Interface), in the PlanKom-Software.

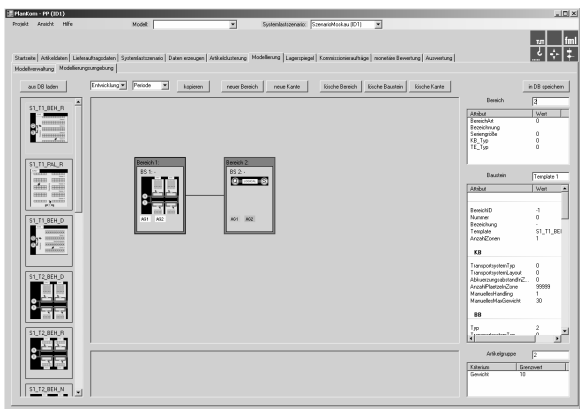

Figure 4: Modelling environment of PlanKom

INPUT DATA FOR SIMULATION

The input for every simulation run contains the picking orders, the storage place for every part (bin location) and the allocation of employees to the zones. Picking orders depend on the customer orders and the model and version respectively can be generated by PlanKom. The allocation of parts and storage places due to the storage strategy can also be created by PlanKom. The allocation of employees to the zones has to be done by the planner in the modelling environment of PlanKom for every version, which should be investigated. For the handling process the times required for simulation have to be defined by MTM (methods time measurement).
Thus, the influence of input data on the systems' performance can be investigated by gradually changing the article structure and order structure. In addition to these changes the number of zones and the storage strategy (chaotic storage and concentration of fast-moving parts (abbreviated cfm) is varied.

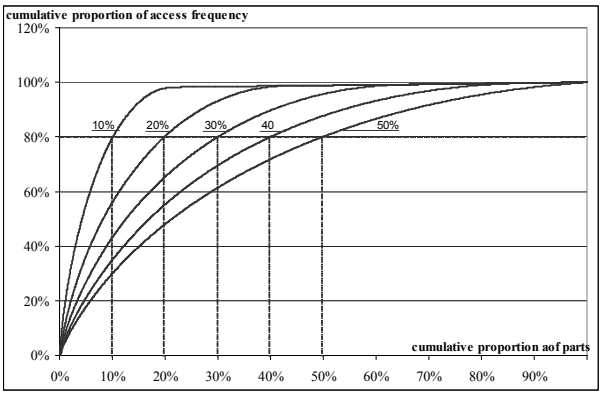

Figure 5: Different article structures - access frequency described by an exponential distribution

Figure 5 shows five different article structures. The article structure is defined by the percentage of articles ordered from the highest to the smallest access frequency, which lead to 80% of the total access frequency. The article structure can be described by an exponential distribution with the parameter lambda (λ). The value of Lambda is chosen in such a way that 10%, 20%, 30%, 40% or 50% of the parts lead to 80% of the total access frequency.
The customer order structure is raised by the variation of orderlines per order. In total 360 combinations of influencing variables are investigated. Figure 6 shows the combinations of influencing variables.

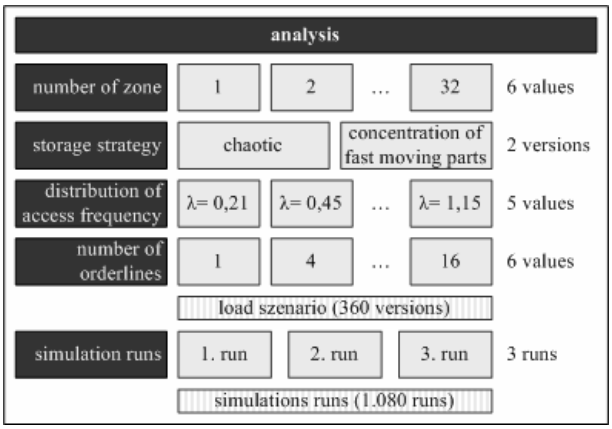

Figure 6: Combinations of influencing variables for analysis

For a high confidence level three simulation runs have been executed for every combination of influencing variables. From this it follows that 1.080 simulation runs have been performed for this study.
The picking and basis time were calculated by MTM. Therefore the process has been described in detail. Each process step is assigned a time. The sum of all times is the total time [2, 3]. Table 1 lists the times for picking an orderline (ol) and the basis time per bin and order (o) respectively. The basis time can be split into the process time for the receiving of a bin and the delivery of a bin after the picking process. In addition, the speed for the picker and the conveyor technique are listed.

Table 1: Process times and velocities

	unit	value
basis process (receiving)	[sec/o]	14,05
basis process (delivery)	[sec/o]	12,2
picking process	[sec/ol]	15,2
speed of pickers	[sec/m]	0,9
speed of conveyors	[sec/m]	0,5

WORKFLOW OF SIMULATION

All data needed for simulation is previously saved by PlanKom in a database. The Workflow of the simulation is oriented on figure 7.

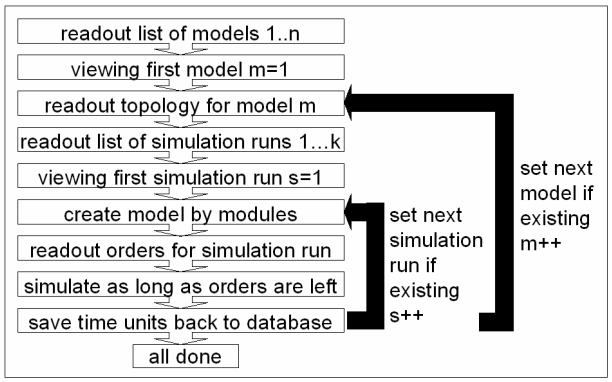

Figure 7: Workflow of simulation

First of all the list of models is read from database. Parameters are set to the first model and the topology and the simulation runs which have to be executed for this model are read. After this the model is created by the simulation automatically for the first simulation run by the information of topology and known modules. Also the order information is loaded and the simulation run is executed. After saving the time units to the database, the next simulation run for the actual model can be loaded and executed or if no more exist, the next model can be loaded and execute the simulation runs accordingly.

RESULTS AND INTERPRETATION OF SIMULATION OUTPUT

In this study the picking time and performance of zone picking systems are focused on especially. After that the costs per pick are shown in an example.
The time for receiving and delivery of an order (bin) in a zone will be called as basis time.
Generally the basis time is depending on the number of zones in which picking for an order has to be done. This time unit is always equal if there are only orders with one orderline because only one zone has to be reached to fulfill the order. If there is a great number of orderlines which have to be picked in a single zone, much time can be saved.
By increasing the number of zones, the basis time per orderline approaches the value of one orderline per order, because on average there will only be picked one orderline per zone. Thus, for almost every orderline of an order, a zone has to be reached.

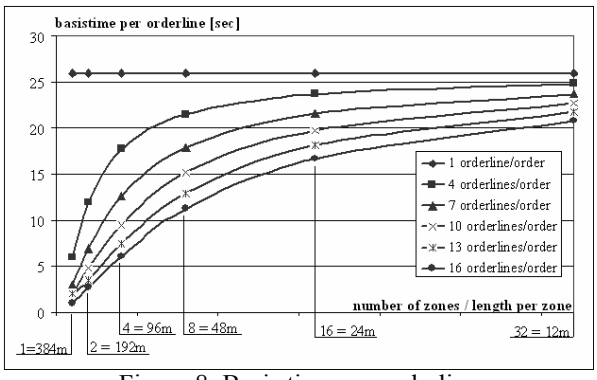

Figure 8: Basis time per orderline

By determining the bin location for every article by their access frequency, so that high-frequency articles are located near the basis, there is an influence on the walking time.
There is a big variation of the walking time in the values between the values with the same number of orderlines and the same number of zones as long as the number of zones is small. With a greater number of zones the values are almost equal between the different strategies and article structures.
By using an equal distribution of articles in the zone, the walking time is independent from the article structure.

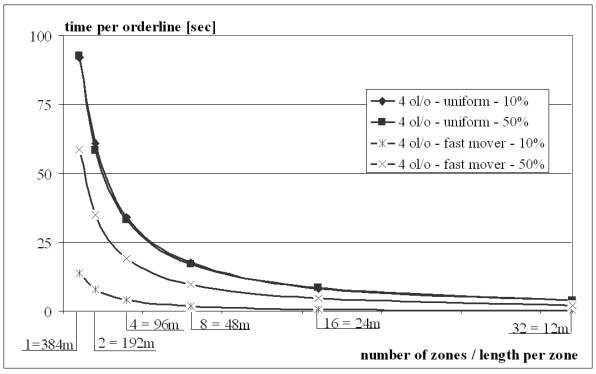

Figure 9: Influence of the article structure in combination with the storage strategy on the walking time

The total time per orderline is the sum of basis, walking and picking time.
There is no influence of the length of zones, article- or order structure on picking time. This will be the same time value for every zone. Because of that there will be no further view on the picking time.
The curve progression in figures 10-15 is caused by the basis and walking time.
Basis time increases by increasing the number of zones and decreasing length of zone respectively (except for one orderline per order as mentioned previously).
By decreasing length of zone, walking time per position decreases accordingly.
If there are only orders with single orderlines it seems to be optimal to choose a very short length of zone. At the same time every additional zone is associated with additional investments. In addition to that, the work load of the pickers will not be ensured any more, so they have to change zones from time to time. This decreases the efficiency.
If the order structure mainly contains orders with a great number of orderlines and at the same time there is a strong ABC distribution in the article structure there is a great savings potential for the total time per orderline (compare figure 5). This combination leads to an optimal length of zone which is relatively short.
If there are average 10 orderlines per order and an ABC distribution where 20% of articles lead to 80% of sales the optimal value of the length of a zone is about 30-50% of the complete required length.

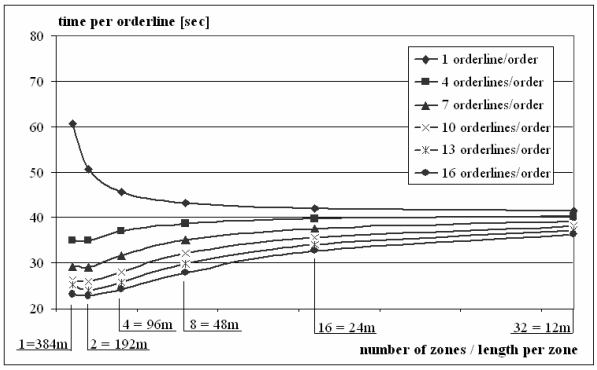

Figure 10: Picking time per orderline for the storage strategy “cfm” and the article structure 10% depending on the number of zones and the orderlines per order

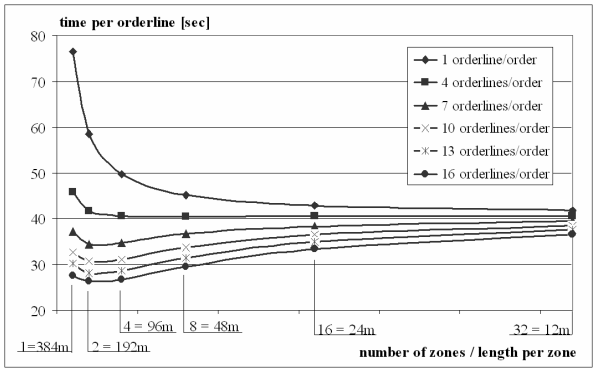

Figure 11: Picking time per orderline for the storage strategy “cfm” and the article structure 20% depending on the number of zones and the orderlines per order

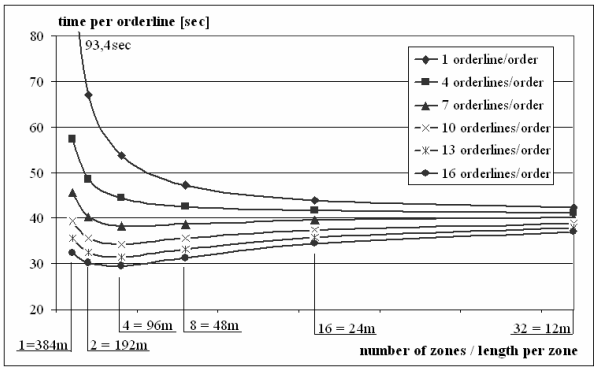

Figure 12: Picking time per orderline for the storage strategy “cfm” and the article structure 30% depending on the number of zones and the orderlines per order

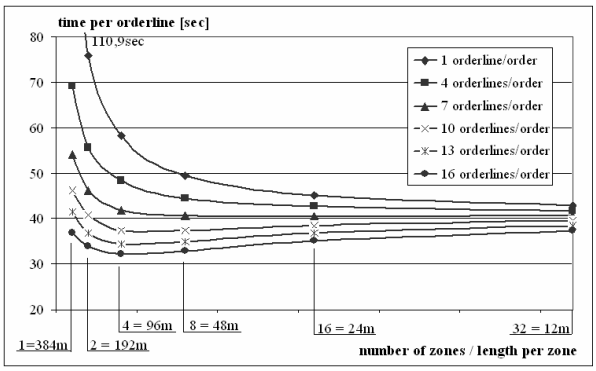

Figure 13: Picking time per orderline for the storage strategy “cfm” and the article structure 40% depending on the number of zones and the orderlines per order

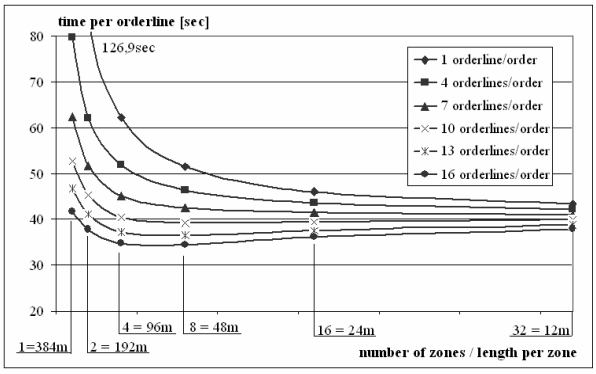

Figure 14: Picking time per orderline for the storage strategy “cfm” and the article structure 50% depending on the number of zones and the orderlines per order

By using a uniform distribution for the allocation of articles to bin locations, the total times of picking for all cases of study were inferior to using an ABC distribution. In the present basic conditions a uniform distribution for reposition strategy should not be chosen. If there is a necessity to use a uniform distribution, the optimal zone length could be determined only if investments and costs are considered, because the results of simulation show that a very short length of a zone is beneficial.

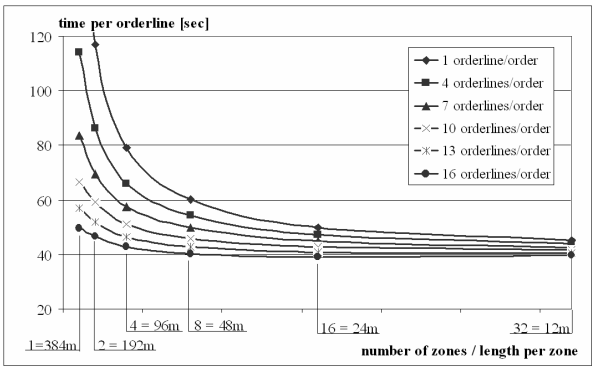

Figure 15: Picking time per orderline for the storage strategy “chaotic” and the article structure 20% depend from the number of zones and the orderliness per order

For determining the expense-optimum of zone length, the investments have to be considered. Based on the investments the accrual, imputed interests, maintenance and running costs could be calculated. The determined times are the basis for calculation of the personnel costs. The costs progression shown in figure 15 depends on the applied investments, personnel cost and the effort per year (business days/orderlines per day). These factors are project-specific. Because of that there is no conclusion to generality feasible. In the example shown in figure 16 the number of zones set to two (length of 192 metres) is cost-optimal in case, that the number of orderlines is greater than four. In case, there is only one orderline to pick for each order, it is advisable to set the number of zones to 16.

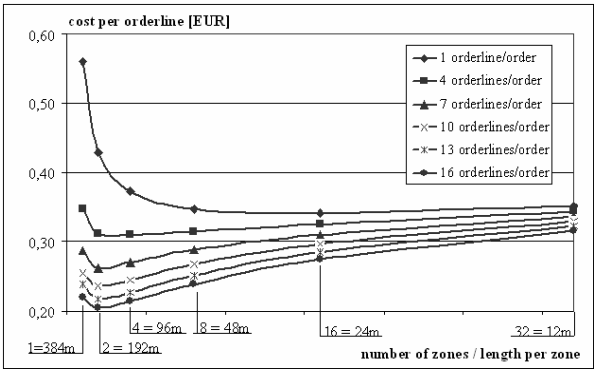

Figure 16: Costs per orderline in EUR for the storage strategy "cfm" and the article structure 20% to 80% depending on the number of zones and the orderlines per order

SHAPING NOTES FOR ZONE-PICKING-SYSTEMS

The storage strategy has an influence on performance. The results show that the concentration of fast moving parts is always better than the chaotic allocation of storage places. It is optimal to use the fast mover concentration. If it cannot be used, the article structure can be disregarded, because the results show that the article structure has no influence on the performance by chaotic allocation of storage places.

In contrast, the article structure influences the performance by using the concentration of fast moving parts. If the ABC distribution is great sharply increasing it is beneficial to dimension the picking system into a small number of zones (except for orders with one or two orderlines). This effect is enhanced by increasing the number of orderlines per order. It is beneficial to split the system in two zones if there is an order structure from more than 10 orderlines per order and a sharp increase of the ABC distribution (up to 20%). If the ABC distribution is even, it is better to split the system in three to six zones. For order structures with less orderlines per order it is better to have more zones. The investment must be considered for the decision, dimensioning the picking system in a great number of zones. The improvement of performance by an additional zone is small. This is shown into the flat rise of the curve into the range from 16 zones and more. Figure 15 shows that an additional zone can drive up the costs, though the time per pick is smaller (compare figure 10). In this case a universal statement cannot be taken because the investment and personnel costs are project-specific parameters.

Through an analysis of actual data the order mix (proportion of number of orderlines per order) can be determined. This proportion can be used customizing the results. So it is possible to convert the simulation results for project-specific parameters. Figure 17 shows five examples for the customization of these simulation results.

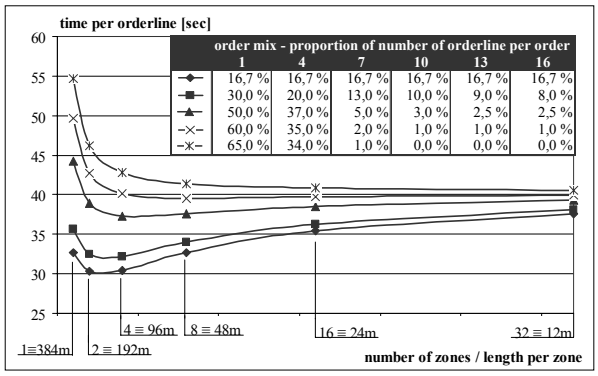

Figure 17: Time per orderline

OUTLOOK

Use of simulation in rough planning brings many advantages. For example:

- planning is based on a substantially more exact/broader database
- interactions between the individual ranges of an order-picking system are considered
- detailed investigation of several versions [13]

The standardized planning process with PlanKom software helps the planner structuring the planning task. The planner does not need extensive knowledge in using simulation software, because the simulation model can be designed by drag and drop with PlanKom software. The interface between PlanKom and the simulation is a relational database with 49 tables. The database is the core of the planning process with PlanKom. The data structure in the database allows the usage for all kinds of order picking systems.

At the moment PlanKom is being extended with functions for analytical methods. In future it is possible to choose between both - simulation or analytical methods. As part of the enlargement of PlanKom the results of simulation and analytical methods will be compared [5].

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