Order Picking Systems - How to Choose the Right One?

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Numerous design and cost parameters, combined with an endless variety of equipment types, make it difficult to choose the right order picking system (OPS).

This article presents a proposal of OPS classification by functioning, based on an in-depth survey we carried out on over 40 distribution centres that have been recently built in Italy. The results of the analysis allowed to develop a model in order to support warehouse designers in choosing the most suitable order picking system.

Background

According to major researchers, order picking can be defined as the activity by which a small number of goods is extracted from a warehousing system, to satisfy a number of independent customer orders.

In recent years picking activity has achieved more and more a crucial role in the context of the supply chain, both from the production system point of view of (i.e. the supply of assembly stations with assembly kits) and from the point of view of the distribution activities (i.e. preparation of the goods for the final customer). In fact this activity is characterized by high intensity of manual work, which deeply impacts both upon overall logistic costs and upon the level of the service provided to the customer. In many cases, as some researchers have highlighted, the costs related to the order picking activity impact for more than a half of the total costs of a warehouse.

The relevance and the complexity of the topic induced material handling system suppliers to increase their product range and, at the same time, stimulated researchers to propose numerous policies to optimise OPS performances. In the literature there are many operative strategies to improve order picking productivity (e.g. sequencing, batching and sorting, items allocation in the forward area) and to design the forward area (Frazelle, 1994; Van der Berg, 1998). However studies referring to the OPS choice are very rare.

In this article first we propose an OPS classification into 4 categories. Each system is described in its basic components, pointing out the real characteristics that make them different from one another. Then, we study optimal regions of the 4 categories with reference to a sample of about 40 distribution centres. Finally, on the basis of the critical analysis of empirical results, we propose some guidelines for OPS selection.
Order Picking System Classification

Moving from the original classification proposed by Sharp (1992), we classify OPS solutions into four categories:

- “picker-to-part” system (also known as “man-to-materials”);
- “part-to-picker” system (also known as “materials-to-man”);
- “sorting” system;
- “pick to box” system.

Each solution will be briefly described on the basis of the main equipment components, highlighting the impact on the resources (labour, space, capital) and on the service level (above all order picking accuracy and response time). Completely automated picking systems (i.e. robots or dispensers) has not been considered, because they are employed in very specific cases. We assume that only one of the four OPS categories can be adopted. Actually, it is possible to separate order picking system in subsystems, and apply for each a different solution.

1.1. “Picker-to-part” solution

The “Picker-to-part” solution represents one of the most common cases and can be considered as the basic solution for the picking activity. It generally consists of a storage area, a forward area (called also picking area) and a material handing system to connect them (basically reach trucks that refill picking locations). The use of a forward area physically separated by the storage area allows the execution of retrieval missions in a smaller area, if compared with the storage one, thus increasing the order picking productivity. During the picking activity, operators retrieve from the picking locations the items to complete a single order or a batch of multiple orders (whenever an order picking or a batch picking policy is adopted). Generally this solution is set up with a storage area for pallet unit loads with a storage system made up of pallet racks. Conversely, a gravity flow racks with storage of cartons or pallet unit loads can be used. In the “Picker-to-part” system further optimisation can be carried out with routing algorithms, items allocation, batching policies, “paperless” operations (such as radio frequency and voice picking). Therefore the advantages and disadvantages come also from the level of use of the above-mentioned optimisation drivers.

1.2. “Part-to-Picker” solution

The logical elements which compose the “part-to-picker” solution are: storage area, forward area, material handling system (i.e. conveyors or trucks) which connects them, called also “feeding system” of the forward area. The forward area is constituted only by picking bays. The unit loads required to fulfil a given number of orders are retrieved from the storage area and moved to the picking bays. An operator is present at each bay, picking up goods from the unit loads. When all the required items have been picked up from all the operators, the remaining ones (on unit load) go back to the storage area, waiting to be selected for a new retrieval operation. Unit loads can be both of large (i.e. pallets) and small dimensions (i.e. cartons and totes). In the latter case this solution includes equipments such as carousels (horizontal and vertical), miniloads and vertical storage systems. The advantages of these systems derive from the reduced picking costs (in terms of labour hours and space required). On the other hand, the costs of the forward area replenishment
and the additional material handling activities in the storage area should be carefully considered. For such reason most material handling activities foresee the automation of the unit load handling. This solution presents a high risk of creating bottlenecks in the picking bay “feeding system”, reducing the percentage of labour time and the retrieval productivity.

1.3. Sorting system

The logical elements which compose the “sorting” system are: storage area, forward area, replenishment system of the forward area, sorter. Operators in the forward area retrieve the amount of each single item resulting from the batching of multiple orders and put it on a conveyor connecting the forward area with the sorting area. The conveyor crosses the isles of the forward area, so that each operator can work in a smaller part of the forward area. Most of the times the sorting is carried out by an automatic material handling system consisting in multiple conveyors and sorting devices. The opportunity of using the considered system depends on various factors. The first aspect to be considered is certainly represented by the physical characteristics of goods: dimension, weight and shape of the item to be handled affect the possibility of using the automatic sorting system and the choice of the proper equipment to be used. Concerning the picking activity, there is a higher productivity in comparison with the “picker-to-part” solution, since retrieval locations are visited less frequently, reducing therefore the operator's travel. Such reduction is greater as far as the operators work in a small part of the forward area.

1.4. Pick-to-box system

The “Pick-to-box” system represents an alternative to the “sorting” system, and it’s composed by similar logical elements: storage area, forward area, replenishment system of forward area, sorter. The forward area is separated in multiple picking zones, each of them being assigned to an operator. The picking zones are connected by a conveyor on which boxes filled up with picked items are placed, each of them corresponding (partially or completely) to a customer order (“order picking” policy). Therefore a line-end sorting per each order is not necessary any more, but box sorting on the basis of the destination (i.e. carrier) is sufficient, since the order has been already prepared. The resulting advantages of separating the forward area in multiple picking zones mainly are in the reduction of the picker travel time. Higher costs and complexity of this system are related to balancing work loads among the picking zones. This solution seems to be preferable when a high number of items, medium-size flows, and small-size of orders are present. In fact if an increase of the order size occurs, there could be the risk of not being able to manage the increase of the box number (both total and for single order) and other systems could turn out more effective.

Empirical analysis of OPS

We analysed the most recent warehouses that have been built in Italy between 2000 and 2004, in order to identify possible drivers which move to an automated material handling solution in the forward area. We considered only recent warehouses, because a change in business requirements could reduce effectiveness in older warehouses.

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1 In this configuration a batch picking policy is used only, with a high batch size (at least 20 orders per wave)
2 Number of picks from a location is also function of the number of picking waves.
We obtained data from material handling providers, and from three main Italian logistics reviews. We collected data on 42 warehouse facilities, belonging to companies with revenues greater than 10 million euro. In this way we avoided studying situations in which the investment in automated solutions would represent a too significant part of the revenues.

Each warehouse has been classified according to different criteria, such as: general information about the warehouse, type of OPS adopted and material handling requirements (i.e. number of items, picking volume, expressed by order lines picked per day, order size, type of unit load, warehouse response time from the order receiving, outflow, storage needs).

We studied the relationship between the four order picking systems and the material handling requirements. When more than one OPS was found in a warehouse, data were decomposed for single OPS. The most significant results have emerged considering the relationship of the 4 OPS with the daily retrieval activity (expressed by order lines picked per day) and the number of items managed in the picking area. The analysis has been developed with three detail levels: an aggregate analysis within the whole sample of warehouses, a segmented analysis by order size and an analysis by industry.

The 42 warehouses analysed have been represented in Figure 1, with the number of items on the x axis and the picking volume (number of order lines/day) on the y axis. Because of the high concentration of data, the logarithmic scale has been used for both axes.

![Figure 1 Empirical analysis of investigated OPS](image)

The legend explains the different symbols representing the four order picking systems:
- "Picker-to-part" system
- "Part-to-picker" system
- "Sorting" system
- "Pick to box" system

**Figure 1 Empirical analysis of investigated OPS**

There are three main findings:

- when the number of items is lower than 1,000, order picking follows a “picker-to-part” approach anyway. This system is used also with a number of items higher than 1,000;
- high incidence of “part-to-picker” system can be observed in case of high number of items and medium-low number of order lines/day. In fact the higher number of items makes it critical to manage the picking area (in terms of space and handling activities) using a “picker-to-part” system. Furthermore, there is a physical constraint to employ this configuration, related to the replenishment flow towards the picking bays;
- presence of “sorting” system and “pick-to-box” system when both retrieval activity and number of managed items are high (number of order lines/day higher than 1,000 and number of managed items higher than 1,000).

The analysis has been studied in depth according to the size of the customer order. We determined order size by cubic volume. Two main order classes have been defined:

- average order volume lower than (or equal to) 0.5 m$^3$;
- average order volume greater than 0.5 m$^3$;

The results (represented in Figure 2 and Figure 3) refer to a smaller sample, because not all the companies provided that data.

Figure 2: Empirical analysis of order pick systems, when order size is lower than 0.5 m$^3$
The results highlight:

- use of “pick-to-box” system only when the average order size is lower than 0.5 m$^3$. In fact this system is often applied for the retrieval of a single item;
- use of “picker-to-part” and “part-to-picker” systems in case of order size greater than 0.5 m$^3$, regardless the number of order lines picked per day and the number of items managed. In fact when “picker-to-part” is used the growth of the order size makes the adoption of optimising techniques easier (i.e. warehouses in the retail industry are mainly managed according to this solution, along with a “zone picking” policy);
- application of “sorting” system seems not to be highly correlated to the order size. On the contrary it seems to be applied for a small number of items (less than 5,000). In fact ceteris paribus$^4$, the bigger is the number of items, the lower is the awaited overlap among the items, making the sorting system less performing. The examined sample highlights an implementation area in particular for high-moving items: most of the warehouses adopt the “picker-to-part” solution, while the high-moving items are picked with “sorting” system. Furthermore, in case of high number of order lines/day, the implementation of

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$^4$ For instance picks-items ABC curve.
“sorting” system could involve a medium-high handled volume, which is a precondition for a faster pay-back time of the investment. The above mentioned results have been validated by studying separately some specific industries. In fact the convenience of a system is based on the typical values of the industry referring to the number of order lines/day, the order size and the number of items. For instance in the pharmaceutical industry, characterized by small order size, item (less-than-case) retrieval, and very high number of items, the “pick-to-box” system is the most used (often together with automatic dispensers). In the grocery industry instead, where the number of items for the manufactures is not high (maximum 500 items) and the order size is large (several pallet unit loads per order), the “picker-to-part” system is the most used.

**OPS Model**

The results coming from the analysis in the field, show two distinct cases in OPS design: OPS for small size orders and OPS for medium-large size orders. In the first case (Figure 4) it is convenient to use “pick-to-box” system and “sorting” system for a high number of retrieval operations (order lines/day) and a high number of items. The difference between these solutions is mainly concerned with the number of items managed. In fact as the number of items increases, the “sorting” system is less performing because of the smaller overlap among the items. Furthermore the “pick-to-box” system is more suitable for the retrieval of small items. Conversely, in case of middle-low retrieval activity, it seems convenient to adopt the “picker-to-part” system. This system represents a good solution especially when the number of items is not high (less than 1,000). The “part-to-picker” solution represents an intermediate case, since its application field is represented by a significant number of references (greater than 1,000) and a middle number of retrieval operations (about 1,000-2,000 lines/day).

![Figure 4: Suitable areas for order picking systems, when order size is lower than 0.5 m³](image-url)
The most convenient solution for large orders in most cases seems to be the “picker-to-part” solution (see Figure 5). Such advantage is as greater as the order size grows. In fact, as we mentioned above, a significant order dimension allows to apply optimization techniques (for instance zone-picking). However it could be necessary to use the “part-to-picker” solution in case of high number of items (greater than 1,000) and middle number of order lines/day (about 1,000-2,000 order lines/day).

![Figure 5 Suitable areas for order picking systems, when order size is greater than 0.5 m³](image)

**Conclusions**

The analysis over 40 order picking systems (OPS) set up in Italian warehouses since 2000, shows that the volume activity (expressed by order lines/day), the number of items and the average order size are main parameters for the selection of OPS. On the basis of such analysis, a model has been proposed as a support tool to the warehouse designer during the initial phase of OPS selection. After choosing the most appropriate order picking system, also with the help of the proposed model, the warehouse designer will have to choose the equipment type on the basis of an economic evaluation. For instance, in case of adoption of a “part-to-picker” solution, the designer will have to evaluate if the use of a horizontal carousel or a miniload is more convenient. It must be underlined that such results represent a sort of road-map to an effective OPS choice; for every solution (especially for “picker-to-part”) we can find some optimization policies, which can modify, at least in part, the optimal region.

Furthermore, besides the above-mentioned elements, it is necessary to take into account other factors which are harder to generalize, such as the cost of labour in the Country and the risk attitude of the company (i.e. payback time). For instance the “picker-to-part” system is the most widespread system across Italian logistics service providers, even when it is not the most convenient solution, due to its remarkable operating flexibility, along with the short life of outsourcing contracts.

A further development of this research could be focused on studying how to combine two or more different OPS in the same warehouse, in order to appropriately fit the characteristics of each item.
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