

# Omni-Channel Last Mile Delivery - Pick Penetration for Micro Fulfillment Centers

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**Abstract:-** This paper discusses the concept of pick penetration in micro fulfillment centers, which refers to the efficiency and effectiveness of the picking process within these facilities. The picking process involves selecting and retrieving items from inventory to fulfill customer orders. Achieving high pick penetration is crucial for minimizing operational costs, improving order accuracy, and meeting customer expectations for fast delivery. This abstract highlights the importance of optimizing pick penetration in micro fulfillment centers and explores various strategies and technologies that can be employed to enhance this process. It discusses the role of automation, such as robotic picking systems and conveyor belts, in streamlining and speeding up the picking process. Additionally, it examines the use of data analytics and machine learning algorithms to optimize inventory placement and predict order patterns, enabling faster and more accurate picking. The research will also discuss the challenges and potential solutions associated with improving pick penetration. These challenges include the need for careful planning and layout design, effective inventory management, and training of personnel.

Potential solutions include the adoption of real-time tracking systems, the use of intelligent algorithms for order batching and routing, and the implementation of performance metrics to monitor and improve pick penetration. In conclusion, this abstract emphasizes the significance of pick penetration in micro fulfillment centers and highlights the need for continuous improvement and innovation in this area. By optimizing the picking process through automation, data analytics, and strategic planning, organizations can enhance their operational efficiency, reduce costs, and deliver a superior customer experience.

**Keywords:-** *Micro Fulfillment Centers, Omni-Channel, E-Commerce, Retail, Inventory Management, Order Processing, Order Fulfillment, Pick Penetration and Data Analytics.*

## I. INTRODUCTION

Micro fulfillment centers (MFCs) are small-scale warehouses that are designed to fulfill online orders quickly and efficiently. They are typically located in urban areas and are often integrated with existing retail stores or distribution centers. MFCs serve as central hubs for fulfilling orders across multiple channels, including online, in-store, and curbside

pickup. The main purpose of MFCs is to bring products closer to customers, reducing the time and cost of delivery. By having multiple small fulfillment centers scattered throughout a city or region, retailers can ensure faster delivery times and potentially lower shipping costs. MFCs can be equipped with advanced automation technologies, such as robots and conveyor systems, to optimize the order fulfillment process. These technologies enable faster picking, packing, and sorting of products, as well as efficient inventory management.

This flexibility allows customers to choose the most convenient method for receiving their orders, enhancing their overall shopping experience. MFCs for omnichannel also provide retailers with valuable data and insights. By centralizing order fulfillment and inventory management, retailers can gather data on customer preferences, demand patterns, and inventory levels, which can be used to improve forecasting, inventory planning, and overall business operations. Overall, MFCs for omnichannel are crucial in enabling retailers to deliver a seamless and consistent customer experience across various channels. They optimize inventory management, improve order fulfillment efficiency, and provide flexible fulfillment options, ultimately driving customer satisfaction and loyalty.

One of the key benefits of MFCs is their ability to handle high volumes of online orders, especially during peak periods. With their smaller size and proximity to customers, MFCs can quickly process and ship out orders, reducing the risk of delays or backlogs. Additionally, MFCs offer flexibility and scalability for retailers. They can easily be expanded or added to existing infrastructure, allowing retailers to adapt to changing demand patterns and customer preferences. Overall, MFCs play a critical role in the Omni-channel retail industry by providing efficient order fulfillment solutions that enhance the customer experience and improve operational efficiency for retailers.

## II. CURRENT MICRO FULFILLMENT CENTERS

The current micro fulfillment centers are designed to enable seamless order fulfillment and provide a consistent customer experience regardless of the channel chosen by the customer. By consolidating inventory from various channels into a central location, retailers can ensure that products are readily available for fulfillment, improving order accuracy and reducing out-of-stock situations. MFCs for omnichannel use advanced technologies, such as automation, robotics, and

warehouse management systems, to streamline the order fulfillment process. These technologies enable efficient picking, sorting, and packing of products, as well as real-time inventory visibility across all channels. This allows retailers to fulfill orders quickly and accurately, regardless of whether they originate from online or in-store channels. Furthermore, MFCs for omnichannel facilitate flexible and convenient fulfillment options for customers. They enable retailers to offer options like buy online, pick up in-store (BOPIS), same-day delivery, and curbside pickup. Some advantages of the current MFCs are:

- **Efficient order processing:** Micro fulfillment centers are designed to handle large volumes of orders efficiently. They have advanced technologies and automated systems in place to ensure smooth and fast order processing thereby reducing the time it takes for customers to receive their products.
- **Cost savings:** By utilizing a micro fulfillment center, businesses can save on various costs associated with order fulfillment. They can avoid the need to invest in warehouse space, equipment, and staff, as the fulfillment center takes care of these aspects. This can lead to significant cost savings for businesses, especially small and medium-sized enterprises.
- **Scalability:** Micro fulfillment centers are equipped to handle fluctuations in order volumes. They have the infrastructure and resources to quickly scale up or down for the available items based on demand. This flexibility allows businesses to expand their operations without worrying about the logistics of order fulfillment.
- **Access to a wider customer base:** Micro fulfillment centers often have multiple distribution centers strategically located in different regions. This enables businesses to reach customers in various locations quickly and cost-effectively. It also helps reduce shipping costs and transit times, improving the overall customer experience.
- **Expertise and specialization:** Micro fulfillment centers specialize in order fulfillment and logistics. They have industry expertise and knowledge of best practices, ensuring that orders are handled efficiently and accurately. This expertise can help businesses streamline their operations and improve customer satisfaction.
- **Integration with e-commerce platforms:** Many micro fulfillment centers offer seamless integration with the retailers e-commerce platforms. This integration allows businesses to automate order processing and inventory management, saving time and reducing the likelihood of errors.
- **Enhanced customer experience:** Micro fulfillment centers focus on providing a positive customer experience. They ensure that orders are shipped promptly, accurately, and in

proper packaging. This can lead to higher customer satisfaction, positive reviews, and repeat business.

- **Reduced risk of inventory management for smaller businesses:** By outsourcing order fulfillment to an external micro fulfillment center, businesses can minimize the risks associated with inventory management. The fulfillment center takes care of inventory storage, tracking, and replenishment, reducing the chances of overstocking or stockouts.
  - **Time savings:** By delegating order fulfillment to a micro fulfillment center, businesses can save valuable time that can be redirected towards other core activities, such as product development, marketing, and customer service.
  - **International reach:** Micro fulfillment centers, when it is external to the retailer often have global distribution networks, enabling businesses to reach international customers efficiently. This can open up new markets and opportunities for growth.
- Every system has scope for improvement, and considering that for the micro fulfillment centers, the below may need to be taken care of for performance improvement and optimization.
- **Space Utilization:** As businesses grow, fulfillment centers may struggle with space constraints. Properly organizing and using the available space effectively is a common issue. The space usage is directly proportional to the financial resources.
  - **Labor Management:** Fulfillment centers often face problems in managing labor efficiently. This includes issues like worker productivity, scheduling, and maintaining a safe working environment.
  - **Order Accuracy:** Mistakes in order picking and packing can lead to incorrect orders being shipped out, resulting in customer dissatisfaction and returns.
  - **Technology Integration:** Lack of proper technology can lead to inefficiency and errors. Fulfillment centers need to have up-to-date technology systems for tracking inventory, managing orders, and shipping products.
  - **Scalability:** During peak seasons or periods of rapid growth, fulfillment centers may struggle to keep up with the increase in order volumes, especially when the products are not standard across the year.
  - **Sustainability:** With growing awareness about environmental issues, fulfillment centers are under pressure to adopt sustainable practices, which can be a challenging task.

- **Cost Management:** Maintaining profitability while managing the costs of labor, shipping, storage, and technology is a constant challenge for fulfillment centers.

So, an MFC cannot be set-up without considering the above aspects. The success of MFC highly depends on location, inventory management, order processing, technology aspects, etc.

### III. WHY CONSIDER PICK PENETRATION FOR MFCS?

In the context of micro fulfillment centers (MFCs), pick penetration refers to the efficiency and accuracy of the picking process within these facilities. MFCs are small-scale, so these can be automated warehouses that use robotics and technology or manual that are used to quickly fulfill online orders. Pick penetration in MFCs involves optimizing the picking process to achieve the highest possible number of successful picks within a given timeframe. This includes maximizing the accuracy of item selection, minimizing errors, reducing the time taken to locate and retrieve items, and increasing the overall speed of the picking process. Efficient pick penetration in MFCs is crucial for meeting customer demands and ensuring timely order fulfillment. By effectively managing and optimizing the picking process, MFCs can improve productivity, reduce operational costs, and provide a seamless online shopping experience for customers.

When considering the factors for improving the Pick-penetration, some case studies that were considered are as below:

- Ocado is a UK-based grocery technology and online retailer, has implemented a highly innovative system for pick penetration in their automated warehouses. Their system utilizes a combination of robotics, artificial intelligence, and advanced algorithms to optimize the picking process. Robots move along the shelves, picking products and delivering them to human workers who pack them for delivery. This automated system has significantly improved pick penetration, reducing the time taken for each pick and increasing overall efficiency.
- Amazon has been at the forefront of innovation in pick penetration. They have implemented various technologies, including robotics and AI-driven algorithms, to optimize their picking process. One notable example is their use of Kiva robots in their fulfillment centers. These robots autonomously navigate the warehouse, bringing the shelves to the human workers for picking. This combined automated and manual picking system has dramatically increased pick penetration, allowing for faster and more efficient order fulfillment.

- JD.com, one of China's leading e-commerce companies. It is one of the two massive B2C online retailers which has implemented an innovative pick penetration solution called "smart sorting robots." These robots are equipped with advanced sensors and AI capabilities that allow them to navigate the warehouse and locate the products for picking. The robots work in collaboration with human workers, reducing the need for manual labor and significantly improving pick penetration. JD.com has reported a significant increase in efficiency and reduced costs since implementing this solution.
- Kroger, a major US supermarket chain, has partnered with British robotics company Ocado to build highly automated warehouses for pick penetration. These warehouses utilize a combination of robotics, AI, and advanced automation technologies to optimize the picking process. The system includes automated storage and retrieval systems, robotic arms for picking items, and sophisticated algorithms for efficient routing. This innovative solution has resulted in improved pick penetration, faster order fulfillment, and reduced labor costs for Kroger.

By leveraging technologies such as robotics, AI, and advanced algorithms, companies have been able to optimize their picking processes, increase efficiency, and reduce costs. These case studies demonstrate the effectiveness of innovative solutions in improving pick penetration. We will be exploring on some additional factors which can further improve pick penetration for the micro fulfillment centers.

### IV. PICK PENETRATION AND WAREHOUSE SPACES

Pick penetration, also known as pick density or pick face utilization, is a measure of how efficiently the available storage space in a micro fulfillment center (MFC) is being utilized for picking operations. It refers to the percentage of available pick faces or locations that are occupied by products. In an MFCs, pick faces are the designated locations where items are stored and picked for order fulfillment. These can be shelves, bins, totes, or any other storage units. Pick penetration is calculated by dividing the number of occupied pick faces by the total number of available pick faces and multiplying the result by 100 to get a percentage. A high pick penetration indicates that a large portion of the available storage space is being effectively used for picking operations, maximizing the efficiency of the MFC. On the other hand, a low pick penetration suggests that there is excess unused space, which may indicate inefficient organization or underutilization of the available storage capacity. Optimizing pick penetration is important for efficient order fulfillment and maximizing the storage capacity of an MFC. It helps ensure that products are stored in a way that minimizes travel distances for pickers and reduces the time and effort required to complete orders. By maximizing pick penetration, MFCs can improve productivity, reduce labor costs, and enhance overall operational efficiency.

## V. SOLUTIONS FOR IMPROVING PICK PENETRATION

Improving pick penetration in a micro fulfillment center (MFC) involves optimizing the utilization of available storage space for picking operations. Here are some strategies to consider:

- **Slotting Optimization:** Analyze the demand patterns and product characteristics to determine the most efficient slotting strategy. Place frequently picked items closer to the picking area and ensure that high-demand products are easily accessible. This reduces travel time for pickers and increases pick density.
- **ABC Analysis:** Conduct an ABC analysis to classify products based on their demand and value. Class A items, which are high-demand and high-value, should be located in easily accessible areas to maximize pick penetration. Class B and C items can be stored in less accessible areas.
- **Dynamic Slotting:** Implement a dynamic slotting strategy that allows for reorganizing pick faces based on changes in demand patterns or seasonal variations. Regularly review and adjust the location of products to ensure optimal pick penetration.
- **Efficient Storage Systems:** Utilize storage systems that maximize the use of available space. Consider options like high-density shelving, flow racks, automated storage and retrieval systems (AS/RS), or vertical lift modules (VLMs) to increase pick density and reduce wasted space.
- **Minimize Aisles and Walk Paths:** Design the layout of the MFC to minimize the number of aisles and walk paths. This can be achieved by optimizing the placement of storage units and ensuring efficient flow of pickers. By reducing non-productive areas, you can increase the overall pick penetration.
- **Automation and Robotics:** Implement automated picking systems, such as robotics or conveyors, to increase pick density and reduce the need for manual labor. These systems can optimize space utilization and improve pick penetration by efficiently handling a larger volume of orders.
- **Inventory Management:** Implement robust inventory management practices, including regular cycle counts and accurate stock replenishment. This helps avoid overstocking or understocking of products, ensuring that pick faces are appropriately utilized.
- **Continuous Improvement:** Regularly monitor and analyze pick penetration metrics to identify areas for improvement. Seek feedback from pickers and warehouse staff to identify

bottlenecks or inefficiencies and implement process improvements accordingly.

By implementing these strategies, the optimization of pick penetration in the MFC DCs can be done which will improve overall operational efficiency and enhance order fulfillment capabilities.

## VI. AUTOMATIC AND MANUAL PICKING:

Automatic picking and manual picking are two different approaches to fulfill orders in micro fulfillment centers. Depending on the type of MFC, some key aspects to consider when comparing the two:

- **Efficiency:** Automatic picking systems, such as robotics and conveyors, are typically faster and more efficient than manual picking. They can handle a larger volume of orders in a shorter time frame, reducing order processing time and increasing productivity.
- **Accuracy:** Automatic picking systems are known for their high accuracy levels. They can precisely pick and pack items without errors, reducing the chances of incorrect orders or damaged products. Manual picking, on the other hand, is more prone to human error and may require additional quality control measures.
- **Cost:** Automatic picking systems often require a significant upfront investment in equipment and technology. They also require ongoing maintenance and operational costs. Manual picking, although less efficient, may be more cost-effective for smaller micro fulfillment centers with lower order volumes.
- **Flexibility:** Manual picking offers more flexibility in handling different types of products, especially those that are irregularly shaped or require special handling. Automatic picking systems may have limitations in handling certain types of products, requiring additional customization or adaptations.
- **Scalability:** Automatic picking systems are typically more scalable than manual picking. As order volumes increase, automatic systems can be easily expanded or modified to meet growing demands. Manual picking may require additional labor and resources to scale up, which may not be as efficient or cost-effective.
- **Labor requirements:** Automatic picking systems reduce the need for manual labor in the picking process. This can result in reduced labor costs and potentially alleviate labor shortages. Manual picking, on the other hand, requires more manpower and may depend on the availability and reliability of human workers.
- **Implementation time:** Implementing automatic picking systems may take longer due to the need for equipment installation, integration with other systems, and staff training. Manual picking can be implemented relatively quickly, requiring less setup and training time.



Ultimately, the choice between automatic and manual picking in micro fulfillment centers depends on factors such as order volume, product characteristics, budget constraints, and long-term growth plans. It may also be possible to combine both approaches, using automatic picking for high-volume items and manual picking for more complex or specialized products.

## VII. CONCLUSION

Optimizing pick penetration in a micro fulfillment center (MFC) is essential for maximizing efficiency, reducing costs, and ensuring timely order fulfillment. There are several strategies that can be implemented to achieve this optimization.

Firstly, implementing advanced automation technologies, such as robotic picking systems and conveyor belts, can significantly increase pick speed and accuracy. These technologies can automate the process of retrieving items from inventory, reducing the time and effort required for manual picking. Secondly, utilizing data analytics and inventory management systems can help optimize the placement of items in the MFC. By analyzing historical order data and demand patterns, businesses can strategically organize their inventory to reduce travel time and improve pick rates.

Furthermore, implementing efficient picking strategies, such as zone picking or batch picking, can further improve pick penetration. Zone picking involves dividing the MFC into different zones and assigning pickers to specific zones to minimize travel time. Batch picking involves picking multiple orders at once, improving efficiency by reducing the number of trips to the same location.

Regular monitoring and analyzing of pick penetration metrics, such as pick rates and order cycle times, is crucial for identifying areas of improvement and implementing continuous optimization strategies. Overall, by leveraging automation technologies, utilizing data analytics, implementing efficient picking strategies, and continuously monitoring performance, businesses can optimize pick penetration in their micro fulfillment centers, leading to improved operational efficiency and customer satisfaction.

In conclusion, the decision to invest in a micro fulfillment center (MFC) can be a strategic move for businesses looking to enhance their e-commerce operations and meet the growing demand for faster and more efficient order fulfillment. By leveraging automation technologies and compact designs, MFCs offer a cost-effective solution for picking and packing orders in a smaller footprint. When choosing an MFC, it is important to consider factors such as scalability, integration with existing systems, and the ability to handle a wide variety of products. Additionally, selecting the right software and hardware solutions for picking processes is crucial to maximize efficiency and accuracy. By carefully evaluating the specific needs and requirements of the business, and leveraging the advantages offered by MFCs, companies can streamline their fulfillment operations, improve customer satisfaction, and stay competitive in the rapidly evolving e-commerce landscape.

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