

Whitepaper

# Automation in Warehouse Logistics

Success factors, potential and benefits  
of automated storage systems

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# Introduction

## Automation as a trend

The logistics industry both in Europe and worldwide is currently facing major challenges across all sectors. National and international competition is leading to increasing cost pressure, while customers are demanding higher quality and faster delivery times. A further problem is the shortage of skilled workers in the warehouse sector. It is becoming more and more difficult for companies to find suitable personnel to help them meet customer expectations. Especially in manual warehouses, where storage, handling and racking systems are operated by humans, the level of personnel costs and effort is high. There is therefore a growing trend towards warehouse automation, where processes are either partially or fully supported and optimised by machines.

Already, more than half of the 2,000 warehouse management projects implemented each year in Germany are either partially or fully automated.<sup>1</sup> The figures for shuttle systems show that this trend is set to continue: The number of projects involving shuttle systems rose by almost 30 percent between 2012 and 2018 – from 35 to 62 percent – the largest increase over this period.<sup>2</sup> The purpose of this white paper is to provide an overview of the basic principles, the potential and the benefits of warehouse automation.

<sup>1</sup> Cf. WMS MARKTREPORT KOMPAKT 2018 – Trends und Entwicklungen auf dem Markt für Warehouse Management Systeme, page 41

<sup>2</sup> Cf. WMS MARKTREPORT KOMPAKT 2018 – Trends und Entwicklungen auf dem Markt für Warehouse Management Systeme, page 48

# Basic principles

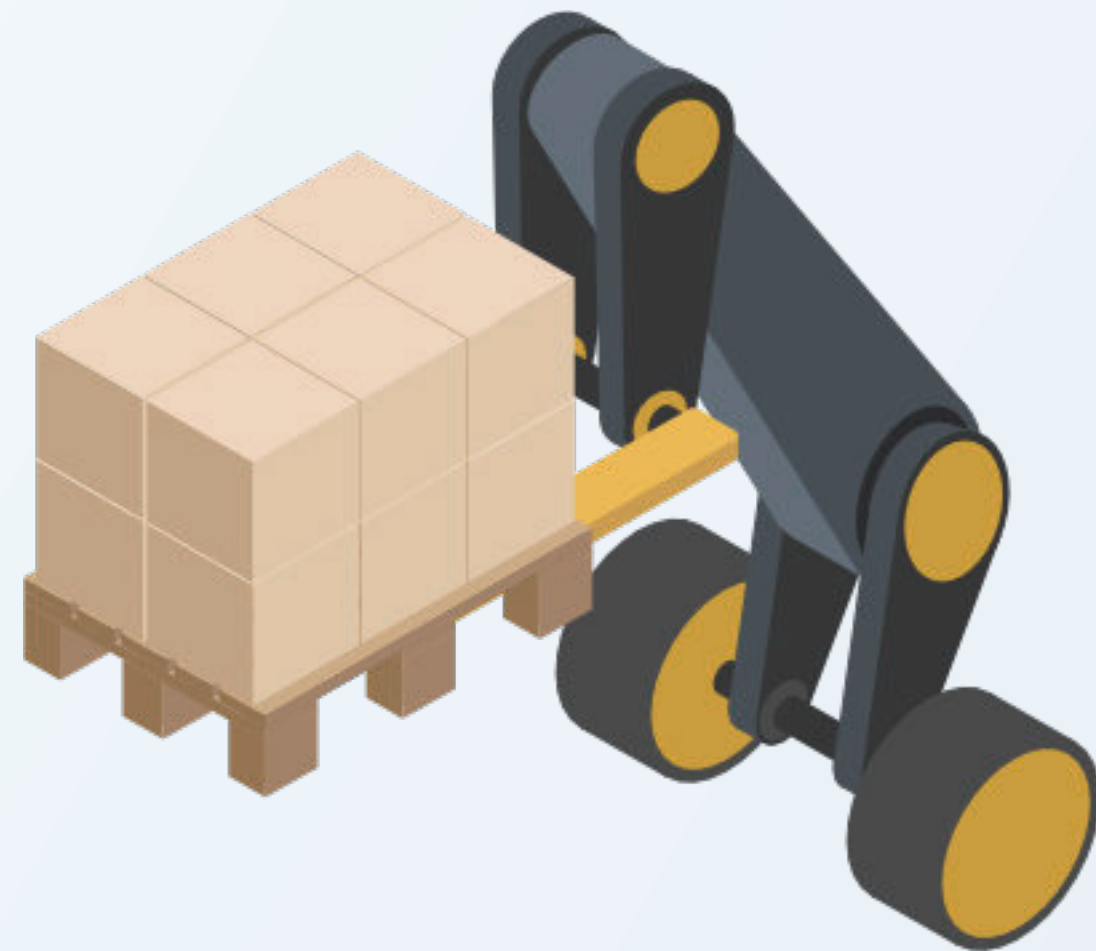


**Components of the  
automated warehouse**



# Robots

The use of robots is on the rise in automated warehouses. A distinction is made between stationary and mobile robots. Stationary robots include handling robots that load and unload machines or conveyors, and palletising robots which enable high working speeds, a high payload capacity and a wide range of motion. One of the main areas where mobile robots are used is order picking. Thanks to their high payload capacity, they are able to move entire racks and achieve high efficiency in terms of goods-to-person picking strategies.



# Cranes

Crane systems are used for moving bulky, overlength or heavy goods. The technical spectrum ranges from manual and semi-automated solutions right through to fully automated crane systems. Entire crane systems or automated crane warehouses can be implemented.



# Shuttle systems

Autonomous, motorised vehicles – or shuttles – are used in automated small parts or tote storage systems and in automated pallet storage systems. A shuttle system is an extremely compact form of storage with multiple-deep racks known as channels. The pallets or totes are removed from these channels by shuttles and transported to a handover area. The goods can then be passed on to a person, forklift or conveyor. Shuttles enable optimal use of warehouse space thanks to their high density, and they also contribute to a reduction in workplace accident rates.

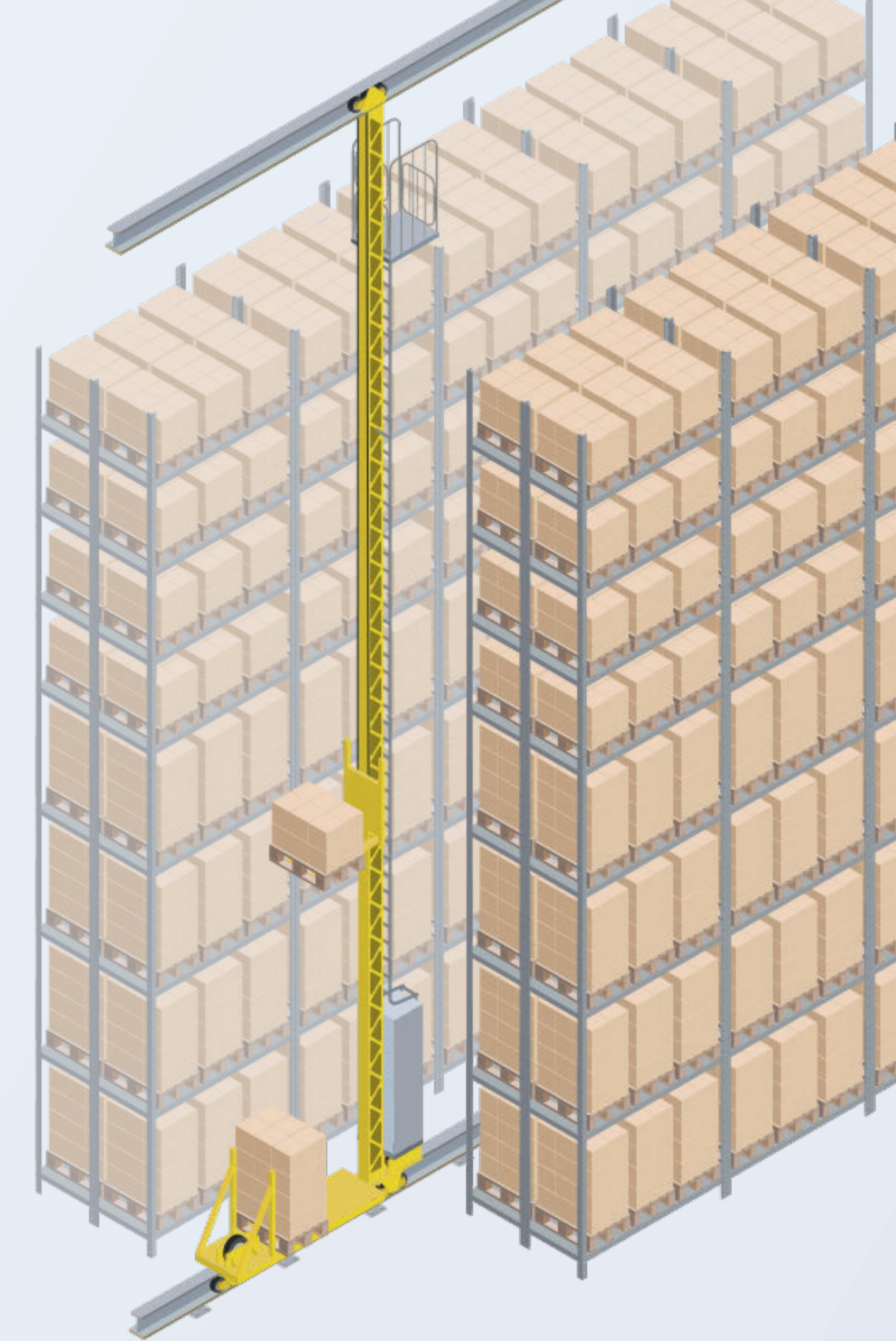
Shuttle storage systems are suitable for both the FIFO and LIFO method and are a great choice for cold-store and deep-freeze warehouses.



# Storage and retrieval machines

Storage and retrieval machines (S/R machines) are mono or multi rail-guided vehicles for storing and retrieving goods. They are also used in automated small parts and pallet storage systems. S/R machines come in many different shapes and sizes: Aisle-bound storage and retrieval machines can only operate in one aisle or lane, while curve-going models can reach any aisle in the warehouse via special rails and points. S/R machines have three axes of motion: The direction of motion on the horizontal/longitudinal axis, the lifting unit on the vertical axis, and the fork on the transverse axis for reaching into the rack.

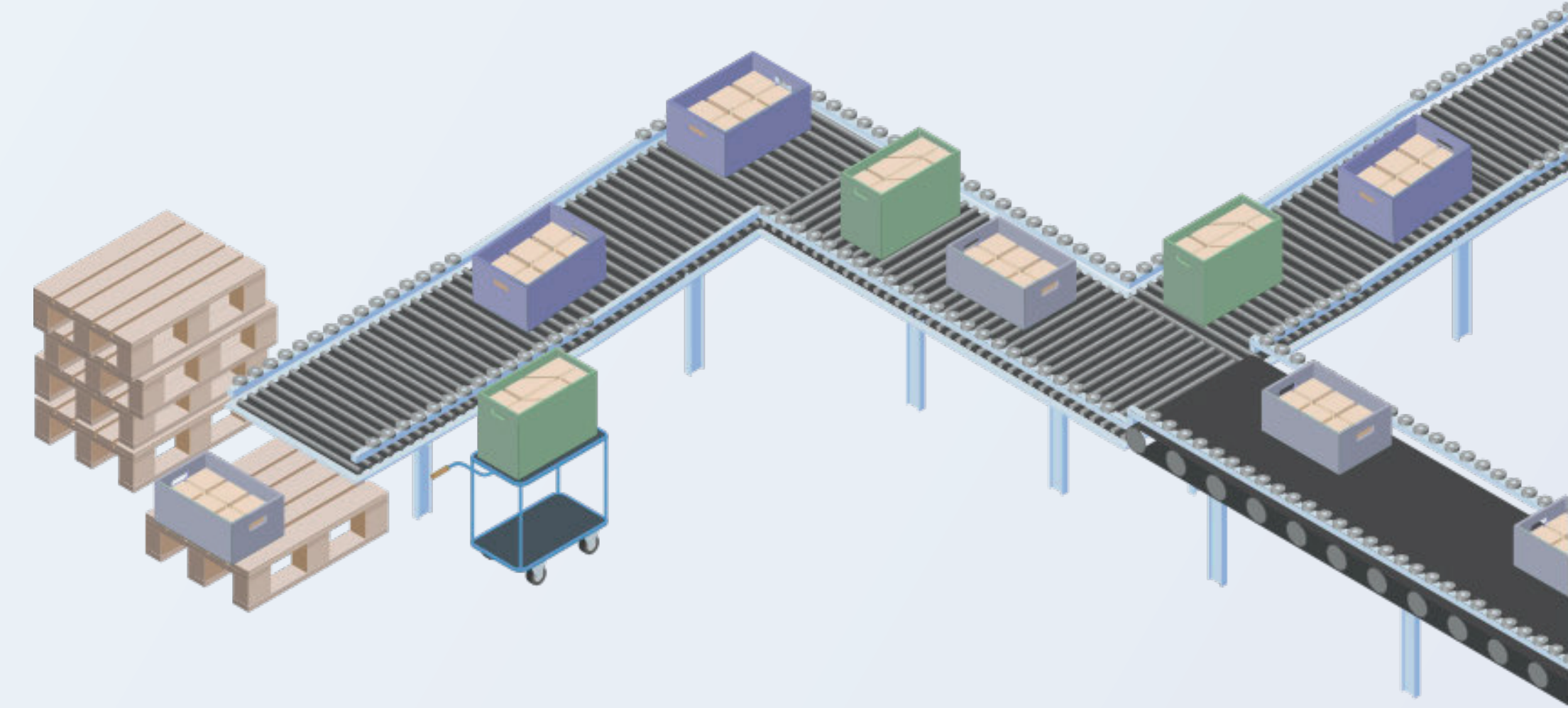
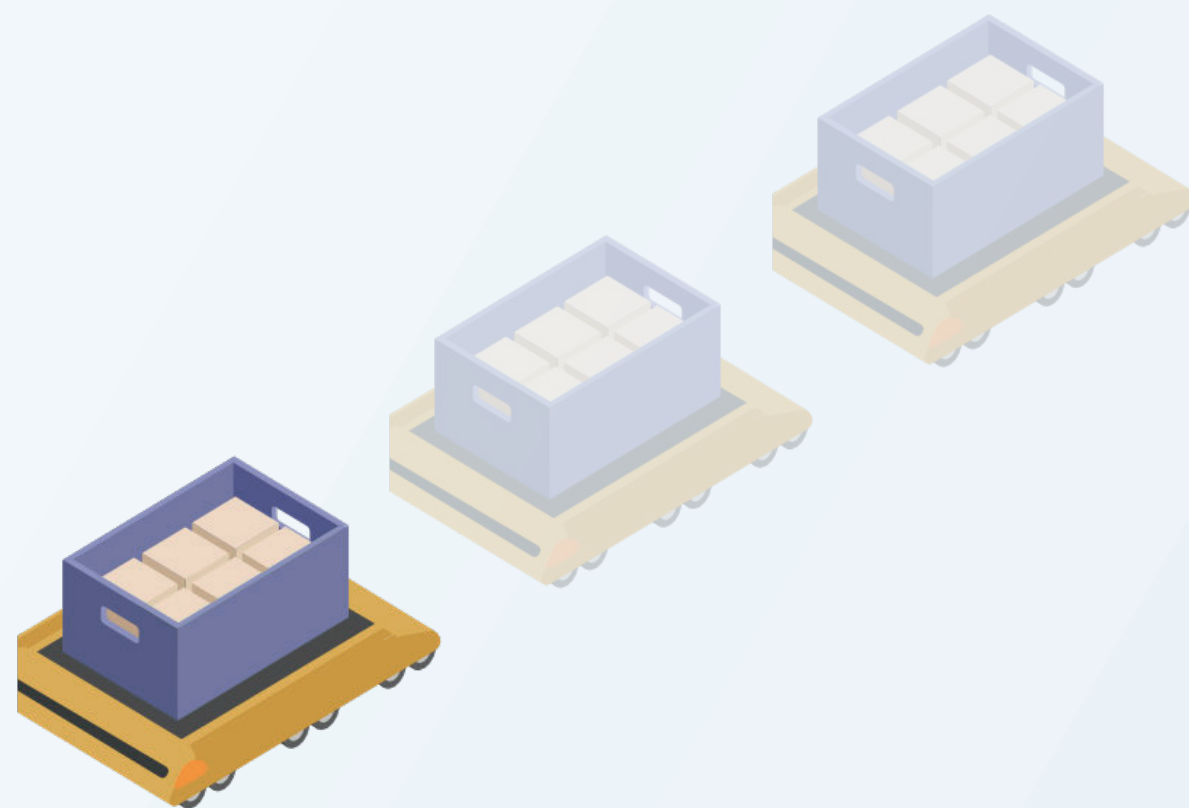
Storage and retrieval machines offer benefits such as higher storage density, faster reaction times, a high degree of operational safety and a significant reduction in errors.





# Driverless transport systems/ Automated guided vehicles (AGVs)

Driverless transport systems or automated guided vehicles (AGVs) are battery-powered autonomous vehicles which are unmanned and guided automatically. These vehicles transport material, pallets or other containers on a defined path and can operate both indoors and outdoors. Orders are generally assigned through a central control system. Coordinated decentrally, self-organising solutions are becoming increasingly popular in today's marketplace. A good example is the LoadRunner®, an autonomous high-speed vehicle developed by the Fraunhofer Institute for Material Flow and Logistics. These vehicles have a special form of load handling. They can organise themselves highly dynamically and autonomously in a swarm and even attach to other vehicles for transport jobs. Thanks to artificial intelligence, the vehicles are able to accept and negotiate orders autonomously.<sup>3</sup>



## Conveyor technology

Conveyor technology refers to the technology of moving objects and covers technical systems such as belts, roller conveyors, lifting platforms and sorting systems for transporting pallets or other containers. A distinction is made between continuous conveyors and non-continuous conveyors. Continuous conveyors transport goods continuously and without interruption, ensuring a comparatively high throughput. By contrast, non-continuous conveyors such as forklift trucks and elevators transport goods at irregular intervals. They are used in companies where intralogistics is only partially automated. Conveyors can also be part of a shuttle storage system.

<sup>3</sup> Cf. [https://www.iml.fraunhofer.de/content/dam/iml/de/documents/OE%20983/Presse/Logistik%20entdecken/Logistik\\_entdecken\\_20.pdf](https://www.iml.fraunhofer.de/content/dam/iml/de/documents/OE%20983/Presse/Logistik%20entdecken/Logistik_entdecken_20.pdf), page 12

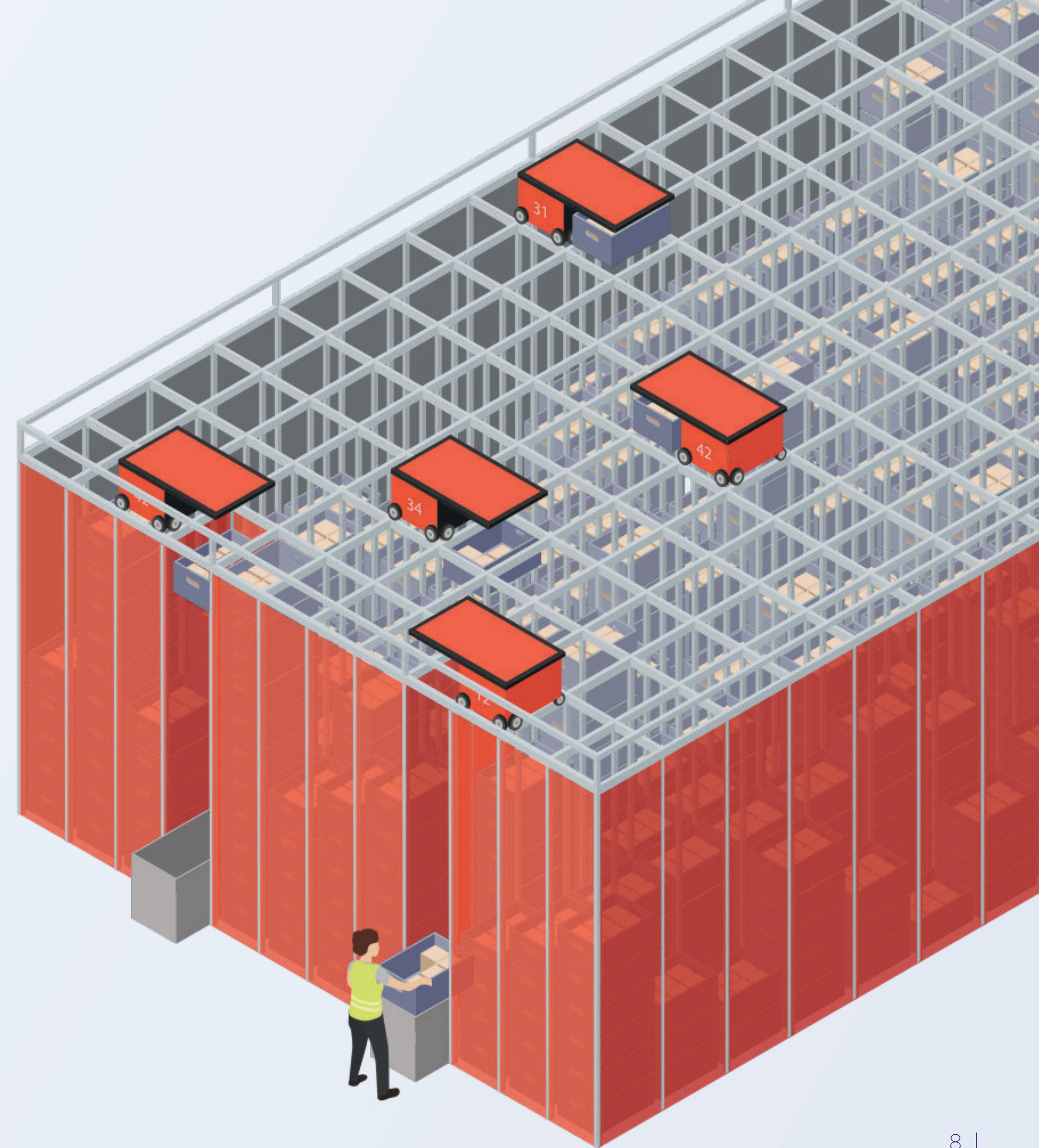


# Dynamic small parts storage

Dynamic small parts storage systems are automated systems with one or more lifts or shuttles. Storage lift systems, horizontal carousels and paternoster vertical carousels are common concepts in intralogistics. Large storage cabinets hold bins or totes containing goods on multiple trays. These trays are moved based on the paternoster principle, bringing the required goods directly to the access opening of the storage cabinet. Today's fast systems no longer work according to the paternoster principle. Instead, the trays are conveyed to the access opening by a shuttle inside the storage cabinet. Thanks to their compact design, dynamic small parts storage systems take up little floor space and also make optimal use of vertical space.

The automatic small parts storage system by AutoStore® is an innovative system for automatic storage and picking of small parts. It is one of the newest small parts solutions on the market and provides ultra-high-density storage, allowing bins to be stacked on the floor one above the other. High-speed robots move on a rail system mounted above the stacks, continuously picking up bins, sorting them and delivering them to the connected ports for incoming goods and picking.

Static small parts storage solutions are the counterpart to dynamic small parts systems. Static systems generally consist of multiple racking systems or aisles, storage and retrieval machines or shuttles as well as several picking stations. Automated small parts storage systems do not therefore represent a technology in their own right, but consist of the components described above.





# PLC

The term 'programmable logic controller' (PLC) is defined as follows by IEC standard 61131-1: "A digitally operating electronic system, designed for use in an industrial environment, which uses a programmable memory for the internal storage of user-oriented instructions to implement specific functions (...) to control, through digital or analogue inputs and outputs, various types of machines or processes (...)." <sup>4</sup> PLCs are the basis for the components and technologies described in the following since they are designed so that they can be easily integrated into machines or industrial control systems and used in all their intended functions. The PLC is therefore subordinate to the material flow controller, which not only is responsible for controlling individual machines but also optimising the way in which they interact.

# Material flow controller

A material flow controller (MFC) controls the interaction of different machines and components of automatic system parts, such as conveyor systems or shuttles or storage and retrieval machines, and is responsible for controlling material and data flows. It comes above the PLC in the hierarchy but below the warehouse management software. The material flow controller provides users with an overview through visualisation and shows them any faults which have occurred. The latest generation of material flow controllers also features user-friendly material flow visualisations and diagnostic functions and provides support in rectifying faults.<sup>5</sup>

<sup>4</sup> EN 61131 or IEC 61131

<sup>5</sup> Cf. <https://www.cim.de/logistiklexikon-deutsch/m/materialflussrechner>





# Warehouse Management System (WMS)

A warehouse management system (WMS) is application software designed to manage and optimise the processes in a warehouse. Since 2015, VDI standard 3601 has defined the scope and performance areas of an IT system for WMS management (VDI = The Association of German Engineers). The software includes basic functionalities for goods receipt, order picking and goods issue:<sup>6</sup>

**Goods receipt:** Article-specific entry of incoming goods against the purchase order, and assignment of these goods to free or fixed storage locations.

**Order picking:** IT support for picking, or more specifically finding and extracting specific articles based on a fixed order list, with feedback to the system on completion of a collective tour.

**Goods issue:** Based on specific order data from the higher-level ERP, materials management or inventory management system, individual orders are processed and prepared for shipping in accordance with the selected stock retrieval strategies.<sup>7</sup>

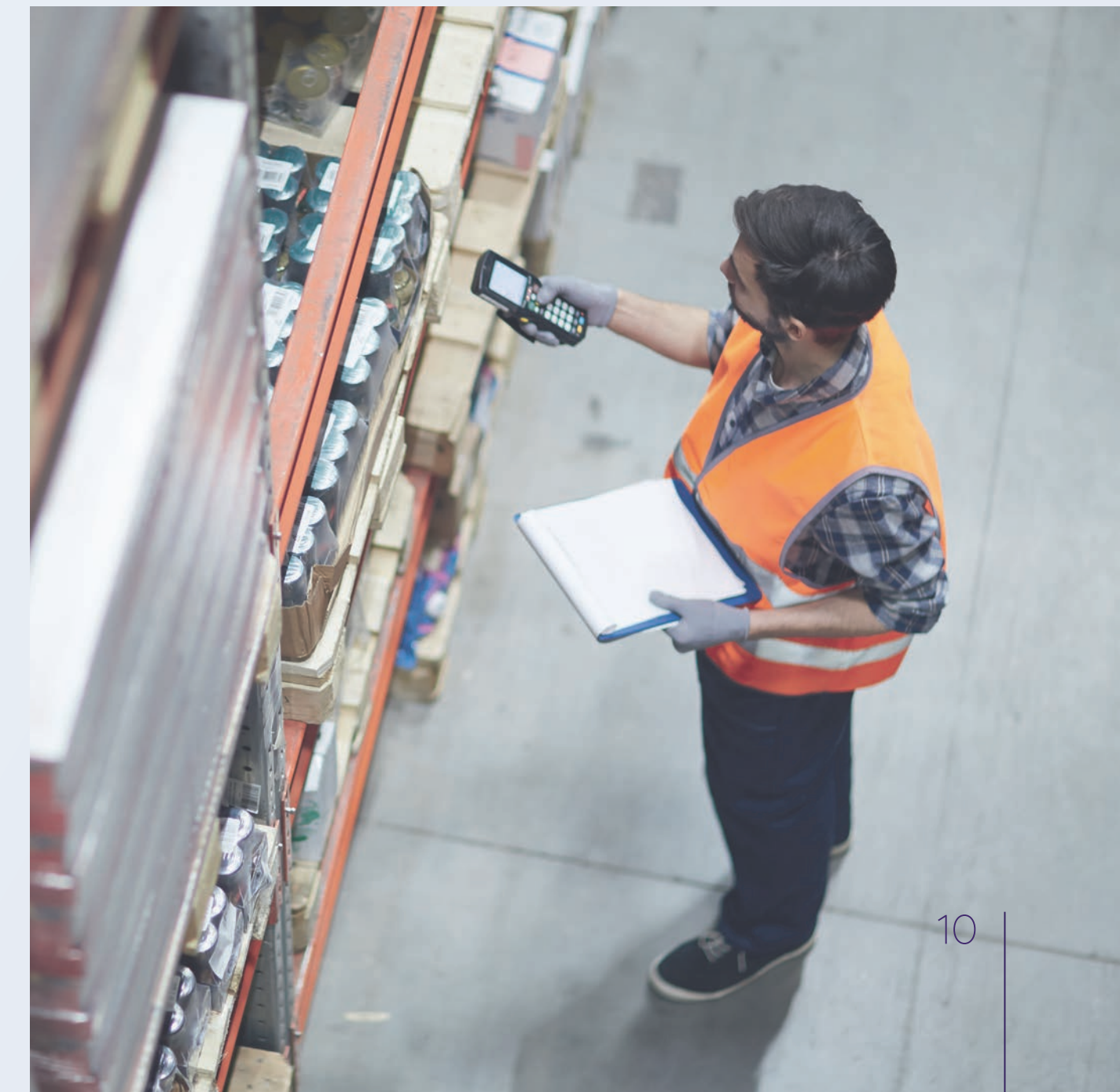
A warehouse management system is a key component of every automated warehouse. It ensures balanced control of the components, monitors and analyses process data, reports any failures and provides support in rectifying them, distributes articles optimally and thereby ensures a smooth material flow along the entire process chain.

Modern warehouse management systems are designed to enable order-independent and scalable processes in the warehouse. This means that they have standardised interfaces to flexibly connect third-party systems, such as a subordinate material flow controller.

Add-ons such as an integrated material flow controller bring even greater benefits for the user, with a unified IT landscape, less need for interfaces and a lower rate of errors.

<sup>6</sup> Cf. <https://www.cim.de/logistiklexikon-deutsch/l/lagerverwaltungssoftware>

<sup>7</sup> Cf. <https://wirtschaftslexikon.gabler.de/definition/lagerverwaltungssystem-lvs-38190/version-261616>





# Warehouse Management System (WMS)

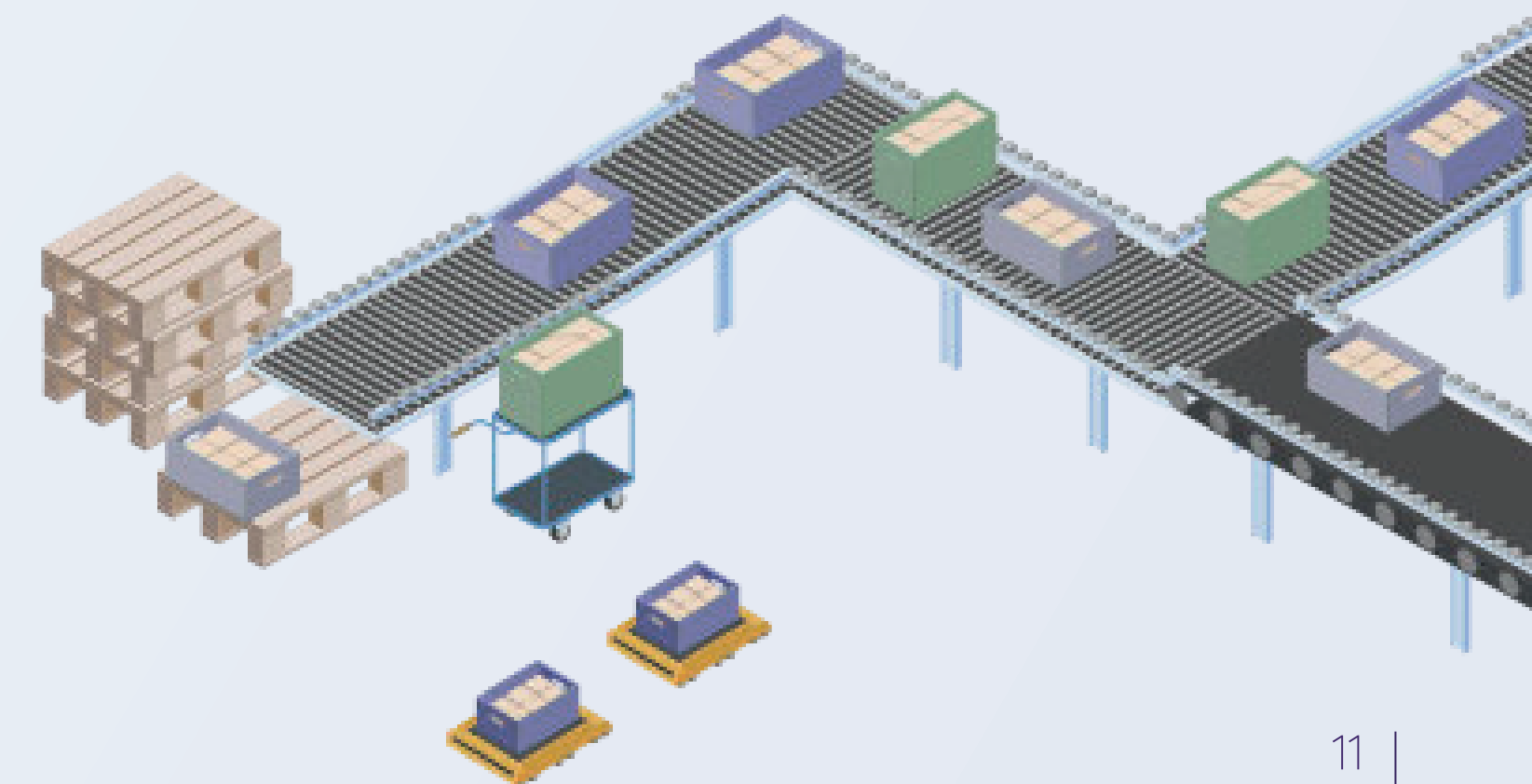
**Host** (Enterprise resource planning system/ERP)  
Master data, Articles, Customers, Orders

**Warehouse management system**  
Storage data, Storage places, Stock volumes

**Material flow calculator**  
Loading units

**Programmable logic controller (PLC)**  
Scanner, Light barriers

**Automatic components**





# Analysis

## Identifying success factors

Before rushing into automation, the first step is to analyse your warehouse and storage processes. It is important to identify potential in order to weigh up whether it actually makes sense to automate your logistics and to what extent. Below are a few ideas regarding when automation is worthwhile and the factors you need to consider.



# Standardising your warehouse

The golden rule is to standardise before you automate. The higher the degree of standardisation in your warehouse processes, the easier it is to automate them. This is true at all levels: Standardised warehouse software – an enterprise resource planning system (ERP) or warehouse management system (WMS) – makes it easier to connect automated control components over standardised interfaces. It is particularly beneficial if the warehouse software already has an automated storage or material flow control system as part of the standard version. Standardised, integrated IT processes create transparency and optimise your intralogistics management in the long term. Standardised load carriers such as Euro pallets, industrial pallets, wire mesh pallets or boxes with conveyor flooring can be easily transported on automated components. If you use highly individualised load carriers with special formats, this tends to involve costs for adapting the storage technology. The processes themselves are another key factor: Are there recurring tasks in your warehouse that are currently performed manually? This type of standardisation is a sure sign that automation may be the solution you are looking for.

## Complexity of your product range

The more diverse and complex your range of goods, the higher the likelihood of errors in manual processes. This can lead to a slowing down of production processes due to the need for frequent checks, for example, or to an increase in return rates. Automating your processes helps prevent picking and production errors and avoid high return rates, and is therefore strongly advisable if you have a particularly extensive product range. Based on over 35 years of experience, we recommend taking a close look at your processes right across the board. Depending on the process design, partial or full automation may be the correct measure to eliminate sources of error in your warehouse and optimise material flows.

# Transparency and understanding of your processes

The prerequisite for a successful automation project is a comprehensive understanding of internal processes – this is the only way to regulate and stabilise your processes.<sup>8</sup> Transparent and stable processes are essential, since they are less susceptible to disruption and can therefore be easily mapped by an automated storage system. But which control software is best for you? A good warehouse management system guarantees transparency and process stability throughout the warehouse: Data and processes can be tracked using analytics functions such as business intelligence tools or dashboards, allowing for continuous optimisation.

Transparency in the warehouse is a must since non-transparent processes often go unnoticed until there is a problem and costs start to increase. Early intervention is crucial to stop the downward spiral before it starts: A lack of transparency often means that resources are not being optimally allocated or delivered to the right place at the right time. If picking in a manual warehouse is not guided and route-optimised, the throughput times are much higher than with a clearly structured, automated process. Automation in the warehouse, combined with the appropriate software for visualisation and material flow control, can therefore help bring transparency and efficiency to your processes.

<sup>8</sup> Cf. "Erfolgreich Automatisieren im Werkzeugbau", page 16ff.

## Flexibility in logistics management

Seasonal peaks or strong growth phases often push warehouse performance to its limits. Warehouse automation supports you in reacting to fluctuating utilisation rates flexibly and in a timely manner. What's more, an automated warehouse can secure rapid and sustainable growth. Automated systems allow you to get the most out of your warehouse – both in terms of structural factors, such as warehouse size, and processes. Plus, you stay ahead of the competition with enhanced operational flexibility and efficiency. Since an automation project cannot be implemented overnight, you should have a constant eye on your logistics and your competitors. This ensures economic success for your company through continuous productivity and delivery.



## Labour shortage in the warehouse

Even nowadays it is a challenge for companies to find suitable staff for their warehouses. Demographic changes mean that the workforce is set to shrink by 35 percent by 2035. In addition, employee expectations in terms of workplace ergonomics are increasing and the average age of the workforce is rising.<sup>9</sup> Seasonal fluctuations and other external factors such as pandemics or economic crises require a scalable workforce so that the right number of employees is available at the right time. One good solution to equip you for future trends and ease the burden on your staff is to automate your logistics, at least partially. To reiterate some of the points made above, automatic components are extremely flexible and scalable and allow versatile multiple-shift operation – a cost-effective way of enhancing the performance of your warehouse and compensating for personnel fluctuations.



<sup>9</sup> Cf. "Erfolgreich Automatisieren im Werkzeugbau", page 8



# Result

## Exploiting benefits and opportunities

Provided that they are optimally integrated into your warehouse logistics, automated storage and distribution systems bring considerable benefits: increased productivity, lower costs and improved warehouse utilisation. The following section illustrates the benefits of automation in more detail.





# Increased productivity and shorter throughput times

Automation in the warehouse enables you to improve your article quality and order picking productivity while simultaneously enhancing process reliability and production efficiency. As a result, throughput time is maximised and customers benefit from shorter delivery times. A study by the Fraunhofer Institute for Production Technology and the Aachener Werkzeugbau Akademie GmbH (Tooling Academy Aachen) also concludes that the greatest benefits of automation are the increase in productivity and the reduction in throughput times. The reasons behind this are relatively simple: Unmanned production can be expanded using automatic components, leaving employees to concentrate on planning tasks. And previously unproductive periods such as night shifts or weekends can be utilised effectively and productively thanks to automation.<sup>10</sup>

However, there is one essential prerequisite for shortening throughput times: Lengthy downtimes in automated systems are not sustainable. You should therefore make sure to choose a reliable provider with multiple years of market experience. Another important tip in terms of how warehouse software can support you: Modern, high-performance software solutions provide informative analyses to identify and eliminate malfunctions in a timely manner. Automated storage or warehouse management systems can distribute articles such that stock putaway and retrieval operations can continue even if individual components have failed. This strategy is known as cross-aisle distribution.

<sup>10</sup> Cf. Studie „Erfolgreich Automatisieren im Werkzeugbau“, page 12

## Tips on how to keep your automated components running smoothly

- › Stick to tried and tested systems and experienced providers when implementing new components. It's reassuring to know you have the experts behind you to help if there's a problem.
- › Let the provider advise you and be open to new approaches that don't necessarily correspond to your initial vision.
- › When it comes to managing hardware components, go with proven software solutions that offer data analytics as well as control components. This enables smooth operation and continuous optimisation.
- › In terms of software solutions, look out for intelligent add-ons such as cross-aisle distribution to ensure that putaway and retrieval operations can continue even if individual components have failed.

## Lower costs

The study also found that automation makes a significant contribution towards cutting logistics costs. Peak productivity hours and non-productive periods, order picking times, search times in the warehouse and ancillary activities have a significant influence on costs. These times can be reduced through full or partial automation, as can unit labour costs. Your staff are then free to concentrate on important and demanding activities such as operating and maintaining systems and machinery, while jobs such as picking and individual parts assembly can be performed more efficiently by machines. Resources are optimised and the potential of your employees is maximised. The knock-on benefits are a reduction in costs and an increase in productivity.

## Personnel support

Experience shows that personnel costs account for up to 50 percent of the running costs in a manual warehouse. In automated warehouses, the majority of the tasks are performed by robots, storage and retrieval machines, and so on. This is especially beneficial for monotonous, repetitive activities involving heavy items and awkward postures. It lets older employees for example – soon set to become the dominant group in the workforce – concentrate on more effective work such as machine maintenance or order picking in semi-automated warehouses. The major advantage: you reduce the burden on your staff and can increase productivity without hiring any additional employees.

## Improved carbon footprint

Automation in the warehouse can also improve the impact on the environment and reduce CO<sub>2</sub> emissions. There are two essential aspects in this context. In a manual warehouse where employees are moving around all day, it goes without saying that working conditions need to be as safe and pleasant as possible. This includes adequate lighting, heating and air conditioning, but also appropriate hardware such as printers. The various components in an automated warehouse clearly require electricity but there is still plenty of scope in terms of enhancing eco-friendliness, the extreme example being dark warehouses which do not require the use of lighting for normal operation. With customised energy-saving concepts, potential savings can be exploited and overall consumption significantly reduced. What's more, automatic components are optimised in terms of shortest routes or paths. In contrast to manual warehouses, empty runs are rare and routing errors are practically unheard of. All these factors combine to reduce energy consumption, improving your carbon footprint and cutting energy costs.

## Increased flexibility

Steered by a modern and efficient warehouse management system, automatic components greatly increase the flexibility of your warehouse. Ideally, the software should feature an integrated material flow controller (MFC). The MFC manages the automated storage systems, distributes resources evenly and ensures that the right product is delivered to the right place at the right time. Additional functions such as pre-sorting and preparing of orders during the night or cross-aisle distribution ensure that goods are delivered quickly and reliably. And automated warehouses can operate round the clock if necessary. All this helps to reduce bottlenecks, supply problems and idle time caused by seasonal fluctuations, for instance.



## Greater delivery reliability and fewer returns

Putaway, relocation and retrieval: all stock movements in an automated warehouse are performed automatically and are controlled by a superordinate warehouse management system. The type of human error that can occur in manual order picking, for example, is eliminated. A further benefit is that the precise handling of goods by the automated components reduces the likelihood of damage. Fewer errors and less breakage mean lower costs and improved delivery quality, resulting in a lower return rate.

## Inventory reliability and transparency

Users in an automated warehouse have an accurate picture at all times of how many items are in storage and exactly where they are located. Since the process flows can be seamlessly traced, the risk of shrinkage is significantly lower. Even with a complex product range, inventory reliability and transparency are guaranteed. There is an optimal level of warehouse utilisation, and a reduction in surplus stock and tied capital.

## Optimal use of space

Compared to manual warehouses, automated warehouses generally allow a much more efficient use of space: Multi-deep storage, narrower aisles and vertical maximisation are just a few of the techniques that can help you make the most of your warehouse space. Capacities can be increased in existing storage facilities without having to extend or even build a new warehouse. Not only that, but construction costs decrease if building space is optimised.

## Low workplace accident rate

Humans have no access to fully automated areas of the warehouse. As soon as someone enters, an emergency shutdown takes place. The type of accident and injury that can occur in manual warehouses involving forklift trucks or heavy, sharp-edged items is eliminated. Workplace safety is improved and the accident rate is reduced.

# Conclusion



## Holistic automation as the key to success

Automation is undoubtedly the future of warehousing, however it is still important to give careful consideration to the question of when it makes sense and why. Automation clearly has enormous potential in terms of production and assembly processes. But other areas such as trade and retail, healthcare and the hazardous goods sector can also benefit from the advantages of automation. Increased productivity, throughput and delivery quality are likely to be just as relevant in the future as easing the burden on staff and creating greater transparency and flexibility in the warehouse. In order to exploit this potential, it is essential not to consider software and hardware separately but to see the two as integrally linked. Only if the automatic components operate faultlessly and are optimally managed by the warehouse software can an automated warehouse make a sustainable contribution to successful and optimal warehouse operation.

