



Automated Guided Vehicles

Recap warehouse automation

With the rapid growth of digitalization and e-commerce, today's companies are fundamentally rethinking their warehouse operations. Warehouse automation is at the heart of this transformation, an essential driver for companies aiming to boost efficiency, lower costs and stay competitive in a fast-paced market. From automated guided vehicles (AGVs) and intelligent sorting systems to advanced warehouse management solutions, automation technologies are not just optimizing processes but paving the way for a new era of precision, speed and innovation in logistics.

AGVs stand out as a game-changing solution in this evolving landscape, which is redefining how products are stored, picked and moved within the warehouse. Alongside these advancements, SAP's Extended Warehouse Management (EWM) solution plays a crucial role by coordinating key tasks in fully automated environments and ensuring smooth operations.

This paper is the first in a series of publications exploring key facets of warehouse automation, starting with the transformative potential of AGVs. Future papers will delve into the integration of conveyor technology with SAP EWM and examine emerging innovations shaping the future of warehouse logistics.

Definition of warehouse automation/warehouse robotics

Warehouse automation is the process of automating the inventory movements in the warehouse and in the subsequent delivery to customers with minimal human intervention. Robotics is a key element of this type of automation and includes the design, construction and operation of robots used to automate a process or procedure. These robots are strategically designed to improve the efficiency, accuracy and overall productivity of warehouse and logistics operations.

Purpose of warehouse automation

efficiency and productivity of warehouse management. Key purposes include the automation of the storage, retrieval, sorting and packing of goods as well as other routine tasks. This increases productivity through continuous operations and makes inventory management and order fulfillment more accurate. Other key goals include space optimization, faster fulfillment and delivery times, lower labor costs, safer working conditions with robots taking on hazardous tasks, real-time inventory monitoring and data analysis, and the ability to scale operations in line with changing demands.

The integration of robots into warehouse operations allows for more streamlined, cost-effective and competitive warehouse management. This is particularly crucial at a time when e-commerce is booming and customer expectations in terms of delivery times and service quality are increasing.

Introduction to automated guided vehicles

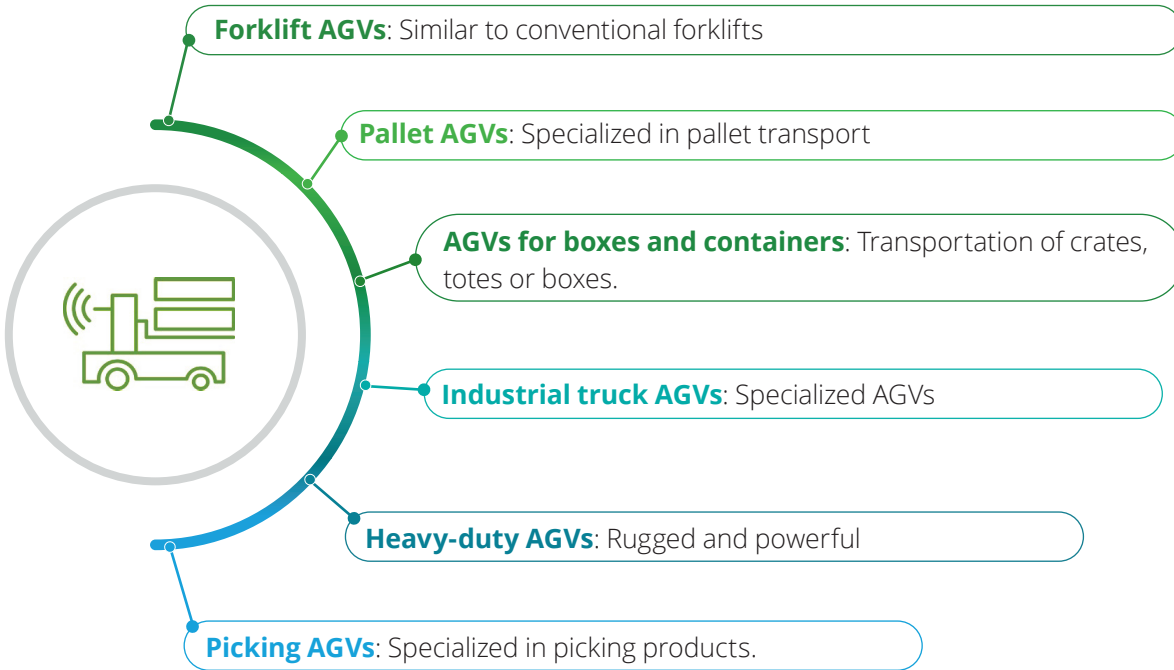
Automated guided vehicles (AGVs) operate without direct human control or driver assistance. These robots are used in a wide variety of industrial and logistical applications, where they are able to adapt to different environments, such as warehouses, manufacturing plants and distribution centers.

AGVs are extremely versatile, able to perform tasks from material transport to material picking and conveying. They offer users the flexibility to tailor these tools to the specific needs of different industries, making them valuable assets in optimizing material handling processes.

The term autonomous mobile robots (AMRs) is often used interchangeably with AGVs as they can both navigate and operate autonomously. This association underscores the broader significance of AGVs in the field of robotics and automation, where their ability to perform tasks independently contributes to the evolution of technological solutions in various sectors.

There are different types of AGVs for different applications and use cases. The graphic below provides an overview of the most common types of AGVs.

Types of automated guided vehicles



Methodology for selecting automation tools

In this section, we focus on methods for selecting warehouse automation tools, using the automated guided vehicles (AGVs) as an example. There are two methodologies we recommend for finding the right AGVs for a specific warehouse requirement: The first is a utility analysis designed to measure and compare the perceived benefits of different AGVs, while the second systematically evaluates potential uncertainty through a risk analysis.

Methodology for AGV selection

Utility analysis

A utility analysis assesses and compares the perceived utility or added value of different AGV options to help find the right AGV for a particular warehouse. The goal is to make an informed decision based on a comprehensive understanding of the benefits and costs of each AGV based on the relevant requirements.

The first step is to define the key criteria and objectives in the selection process, considering factors such as functionality, integration architecture or maintenance requirements.

The graphic below offers a detailed description of the evaluation criteria used in this process. We compare the software and hardware features, integration and network architecture, support and maintenance requirements as well as the price-performance ratio of the respective providers.

Our first criterion is software functionality as it pertains to integrating the AGVs with the current ERP software and internal communication systems. The example we use here is the live visualization of such parameters as location on a map, transported orders or battery levels.

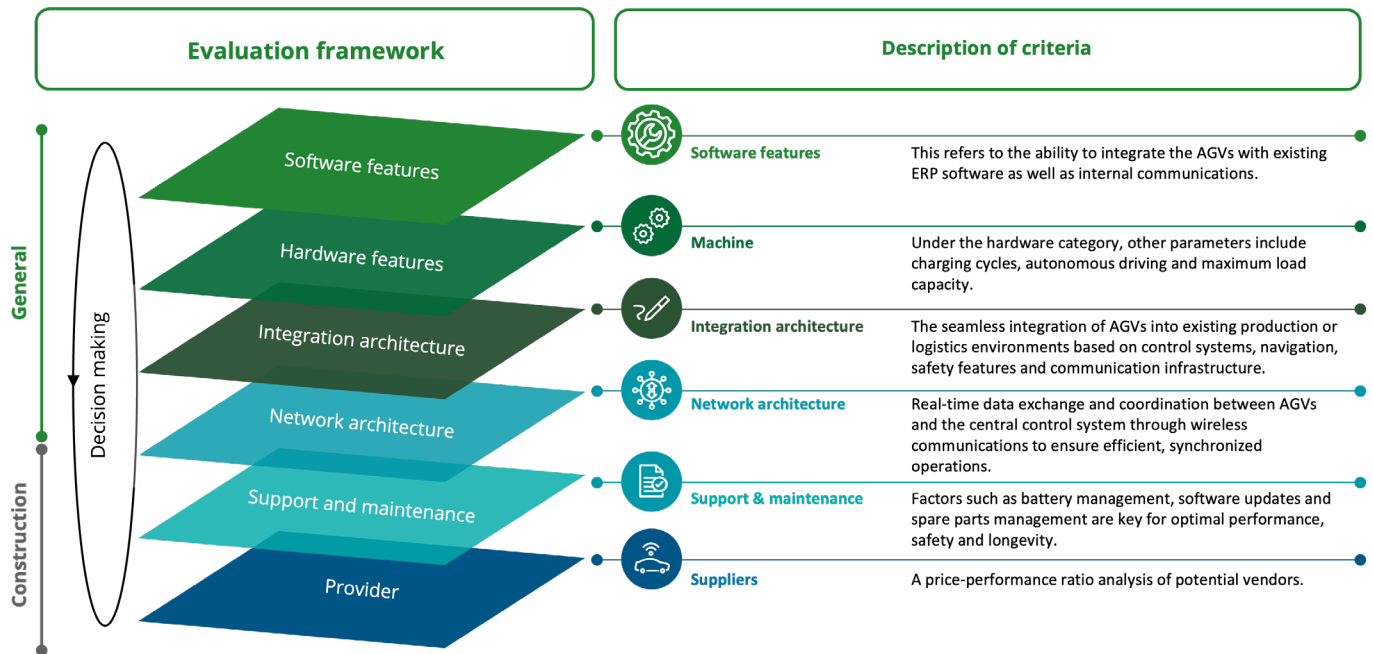
Several other parameters relate to hardware, including the charging cycle, autonomous driving, maximum load capacity, etc. When it comes to orientation within a building, the hardware components use lines or magnetic fields on the floor, reflectors and barcodes on walls or laser sensors.

The integration architecture is vital for the seamless integration of AGVs into existing production or logistics environments and mainly uses control systems, navigation, safety features and communication infrastructure.

We evaluate the network architecture on the basis of the wireless communication infrastructure for real-time data exchange and coordination between AGVs as well as the central control system to ensure operations are efficient and synchronized.

As AGVs require regular maintenance, we also need to consider support and maintenance factors in our utility analysis. This relates to battery management, software updates, spare parts management and other factors that not only optimize performance but also promote safety and longevity.

The price-performance ratio is the final criterion in our analysis. We evaluate suppliers based on key criteria such as references, market position, financial stability, scalability, reliability and location. The product roadmap for future implementations is also a key consideration in terms of the kind of products that are available in different regions.



In a second step, we give the different AGV types a numerical utility score for each criterion to reflect the level of desirability or satisfaction with each type.

We can also assign a weighting to the above-mentioned criteria, which allows us to consider how we rank the different criteria in the overall selection process. By designating certain criteria as more or less critical, decision-makers can account for their preferences and

priorities for AGVs in their warehouses.

To determine the final weighted score, we first multiply the numerical value assigned to each criterion by its corresponding weight and then add up all the weighted scores for each AGV type to produce the final score.

Risk analysis

Risk analysis is a structured and comprehensive approach designed to identify, evaluate and manage the uncertainties that could affect the efficiency and cost savings of AGVs in the warehouse.

There are many benefits to conducting a risk analysis. First, providing an in-depth understating of any potential challenges that may arise helps the AGV selection process. Users can identify uncertainty early on and manage it effectively with this proactive approach. The insights gained in risk analyses also ensure optimal implementation as well as continuous, sustainable operation of the AGVs. This is a critical element of the decision-making process that has a real impact on the future success and resilience of the AGV type selected.

We recommend structuring the potential risks into six different categories as described in the graphic below: business performance, technical performance, sustainability, change management, usability and implementation effort.

Business risk refers to the potential for negative outcomes impacting a company's financial performance and operational viability. These risks can come from a variety of sources, including market changes, financial difficulties, operational challenges, strategic uncertainties, compliance issues and technological disruptions. An AGV system may, for example, experience delays and logistical issues, which users can minimize by introducing a detailed maintenance plan.

Technical risks associated with uncertainties and challenges may arise during the development, implementation or integration phase of a new technology or technical solution in a project, product, or system. One way to mitigate the new security risks associated with new software systems and architectures is to introduce a well-designed security strategy.

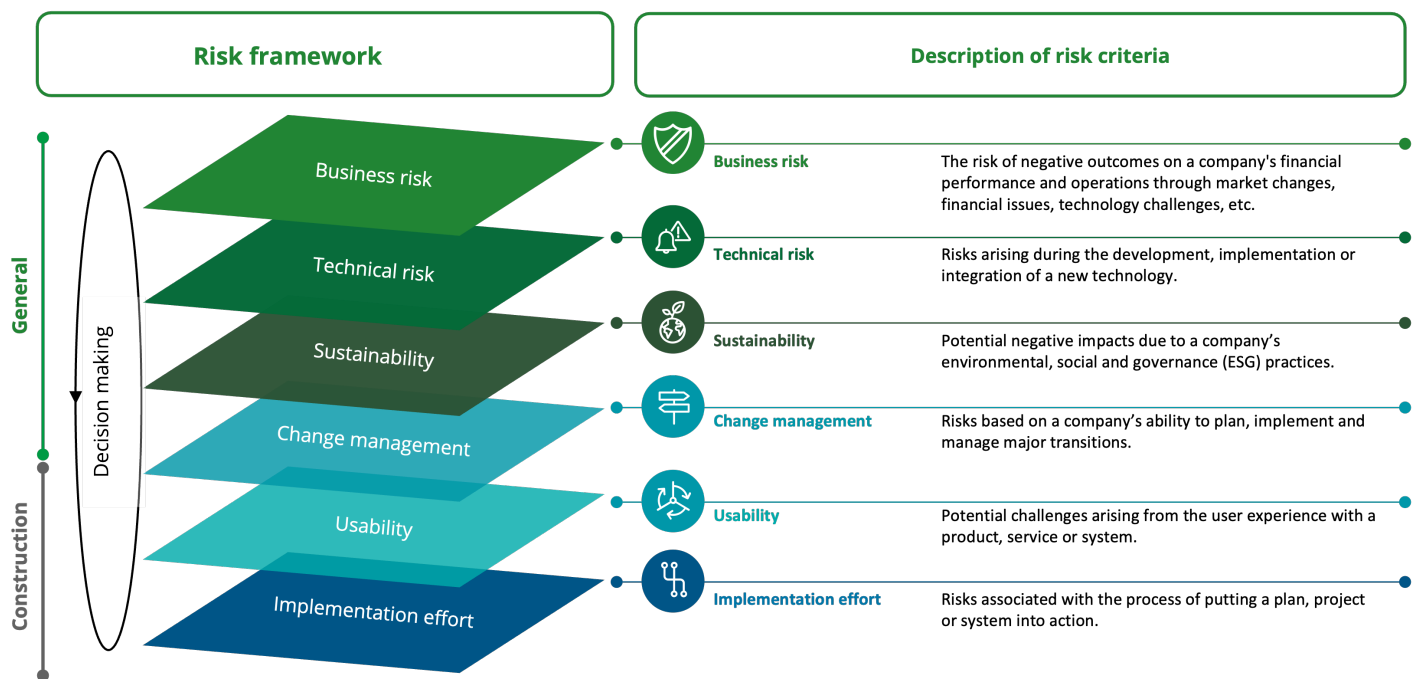
Sustainability risk refers to the potential negative impact associated with environmental, social and governance (ESG) practices, but it can also relate to Clean Core Approaches, release compatibility or other SAP sustainability issues. Working closely with SAP on the integration strategy can help minimize this risk.

The fourth risk criterion is change management, the structured approach to planning, implementing and managing transitions within organizations. Change

management risk arises from key business adaptations in areas such as maintenance and system knowledge, which may require targeted training.

Another critical aspect to consider is the potential challenges or problems that may arise from using a particular product, service or system. This risk criterion, known as usability risk, includes concerns about user-friendliness, navigation and the overall user experience. An overly complex system architecture can lead to additional technical and change management risks if users cannot quickly and efficiently identify bugs or errors. A well-defined training strategy and a reduction in the number of required interfaces can help prevent such risks.

Implementation effort risk refers to the potential challenges and uncertainties that arise during the execution phase of a plan, project or system. One example here is the level of effort required by external service providers to achieve successful implementation. Managing and mitigating this risk requires careful planning and alignment with all stakeholders involved.



Conclusion

Warehouse automation is a transformative step in logistics that is reshaping how companies store, pick and distribute goods. By integrating automated guided vehicles (AGVs) and other advanced technologies with intelligent management systems like SAP EWM, businesses can improve efficiency, accuracy and scalability while minimizing costs and risks. The methodologies outlined here, utility and risk analysis, offer a structured approach for selecting the right automation tools to align with your business goals and operational needs. As e-commerce continues to grow, warehouse automation is becoming a critical enabler in meeting the customer's increased expectations for faster delivery times and higher quality service. The use of AGVs demonstrates the potential of robotics to

revolutionize warehouse operations through optimized workflows and better adaptability to market demands. This paper is part of a series that explores not only the benefits of automation but also practical strategies for implementation, such as integrating conveyor systems with SAP EWM. By addressing both the opportunities and challenges of warehouse robotics, we hope these insights will help you and your company move toward a more competitive and sustainable future in logistics.

Contact us



Theofilos Kotzaeroglou
Partner

Tel: +49 1515 8072 314

Email: tkotzaeroglou@deloitte.de



Ann-Kathrin Birk
Senior Consultant

Tel: +49 1601 5299 17

Email: anbirk@deloitte.de



Frerik Jonas Voskors
Consultant

Tel: +49 1511 2683 432

Email: fvoskors@deloitte.de



Jia Cheng Liu
Consultant

Tel: +49 1711 2852 50

Email: jiacliu@deloitte.de

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