Comparison of five navigation technologies for AGVs

White Paper
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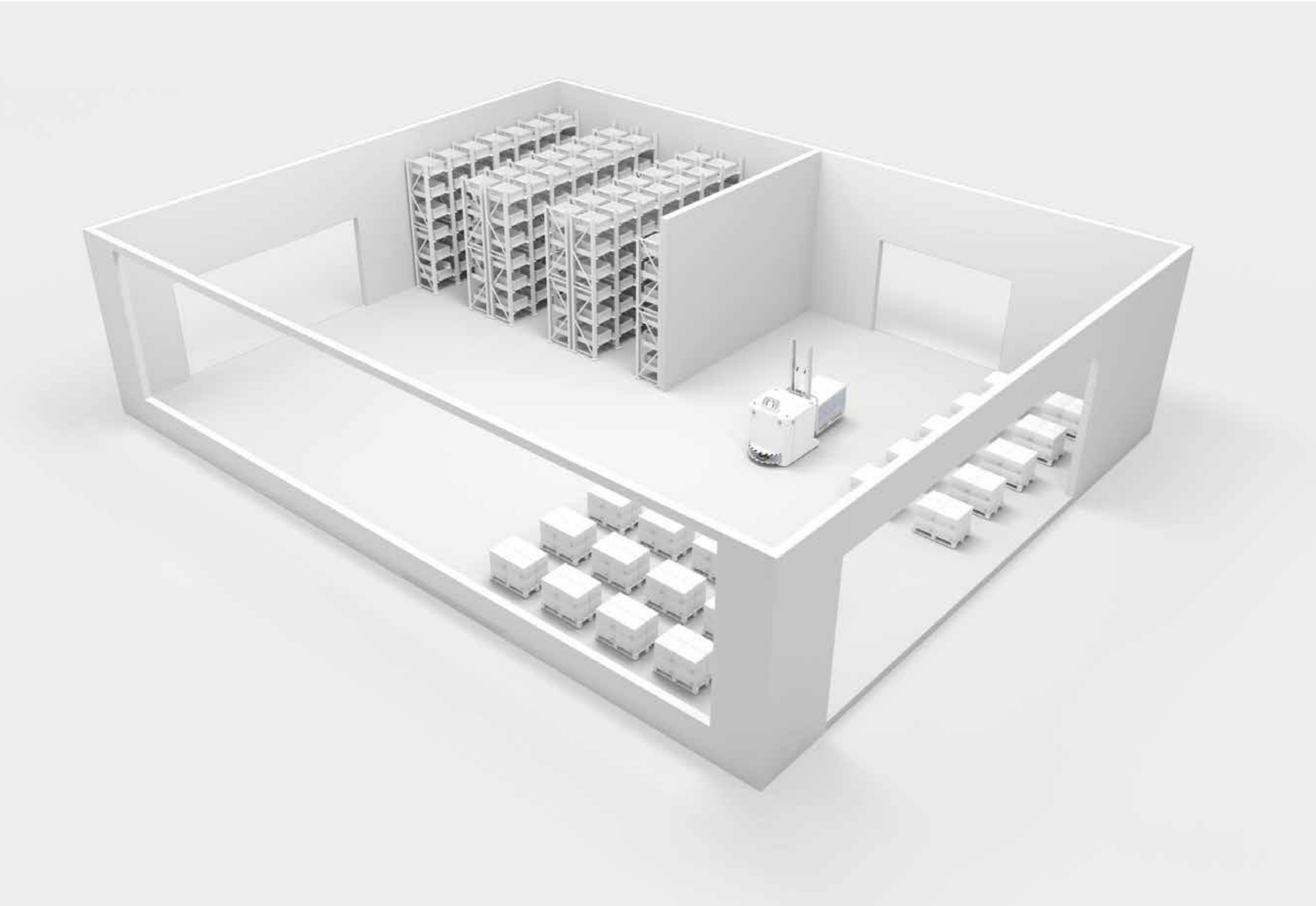


Navigation technology as success factor for efficient AGVs

Automated guided vehicles (AGVs) have significantly changed intralogistics in recent years by offering an efficient, automated solution for material transport and warehouse management. In modern companies, particularly in distribution centers and production sites, AGVs have become indispensable. These autonomously controlled vehicles perform a multitude of tasks, starting with the transport of materials through to automated manufacturing. Their application possibilities range from moving light products to transporting heavy loads, whereby they have proven to be a flexible solution in a wide variety of industries.

As a result, the development of autonomous navigation technologies has greatly expanded the possibilities for companies looking for automated material transport solutions. A detailed comparison of various navigation technologies for AGVs highlights the diversity of these technologies as well as their benefits and drawbacks.

Overview: Navigation technologies for AGVs

- Laser navigation (natural navigation)
- Laser triangulation
- Optical or inductive guidance
- Grid navigation
- Camera-based navigation (vision guidance)

1. Laser navigation (natural navigation) for high precision

+ Precise and flexible navigation
+ High accuracy
+ Reliable detection of obstacles
+ Independent of ambient light
— More expensive in terms of hardware and software
— Sensitive to soiling
— Limited operating range of the laser beams

Laser navigation, also referred to as contour navigation or natural navigation, is a highly developed technology used in AGVs for precise navigation. The principle is based on the use of laser scanners or lidar (light detection and ranging). These devices use a rotating laser beam to scan their surroundings and pass on the measurement data to suitable navigation software. During this process, the AGV initially moves through its environment in "learn mode" and stores pillars, corners or stationary machinery as fixed points in its software. By doing so, the AGV creates a precise map of its surroundings and can use this map to orient itself autonomously on all subsequent journeys in the room.

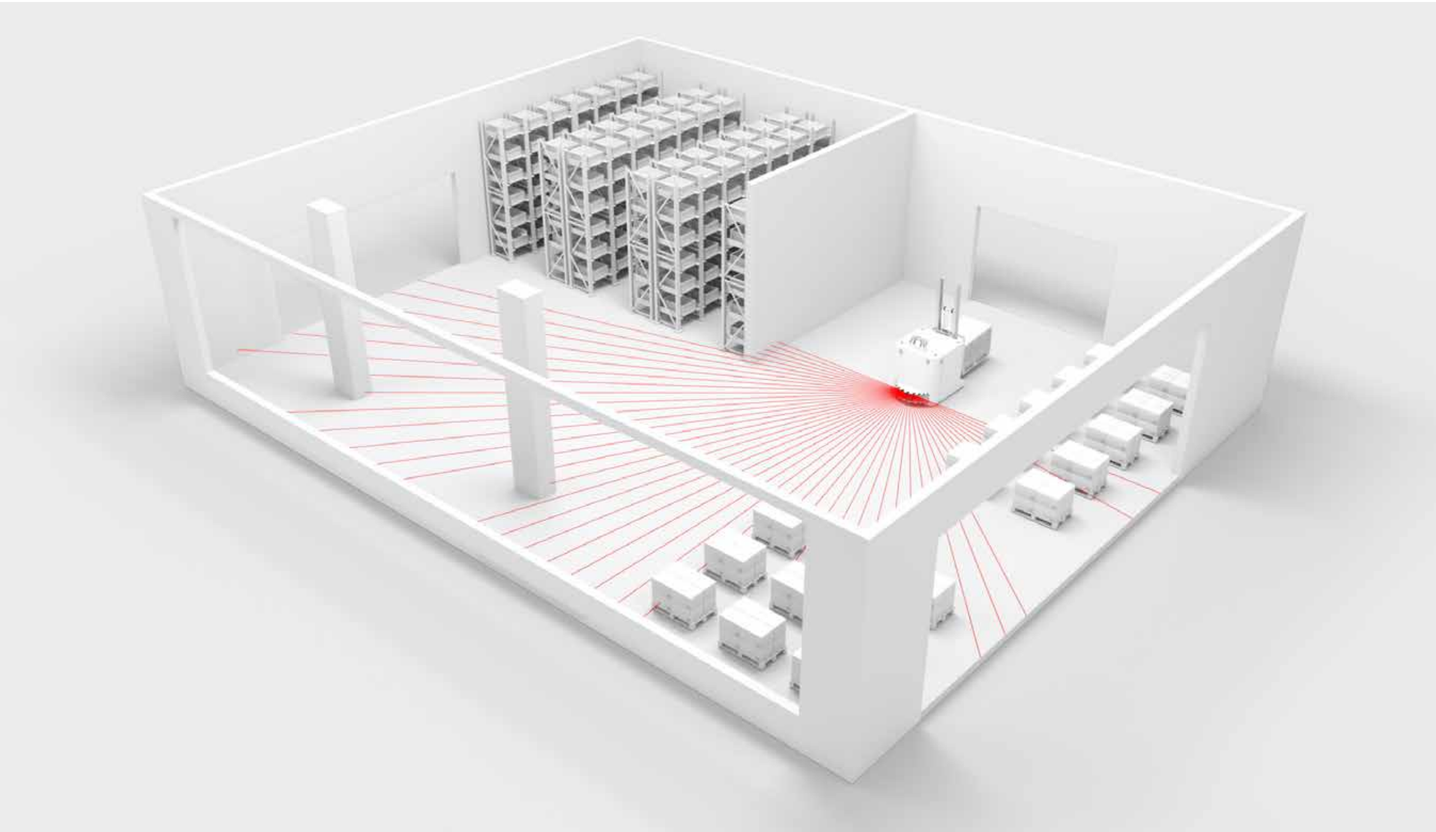
The main advantage of this technology is the precise and flexible navigation: Laser navigation offers a high degree of accuracy when determining the position of the AGV. This enables the AGV to bring the transport material precisely to its destination. Furthermore, this technology ensures the reliable detection of obstacles because laser beams are reflected in a precise way. As a result, obstacles can be driven around and collisions avoided.

Compared to camera-based systems, laser navigation is almost independent of the ambient light. It functions both in daylight and also in dark environments or under difficult light conditions.

The advantages named above are offset by the relatively high acquisition and implementation costs. Laser navigation systems are usually more costly with respect to hardware and software than some other navigation methods. This can be a financial obstacle for small companies.

The precision of laser navigation systems can be impaired by the presence of dust or soiling in the environment. Regular maintenance and cleaning are therefore necessary to ensure that the systems continue to function reliably.

Furthermore, the operating range of laser beams is limited, which means that laser navigation systems are better suited to environments with clearly defined contours. In wide, contourless environments, additional technologies are required.



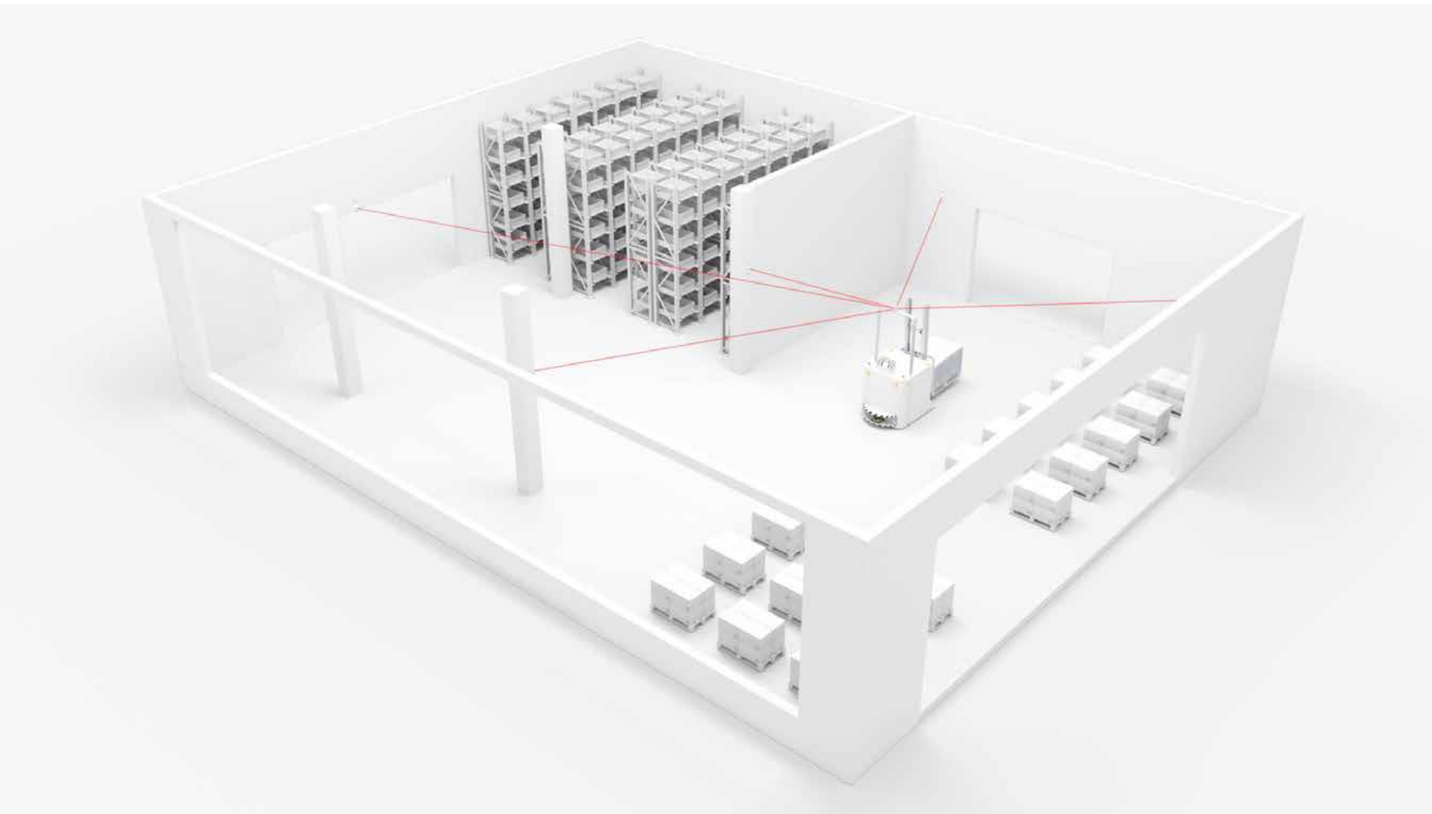
2. Laser triangulation
for dynamic environments

Laser triangulation is a navigation technology where reflectors are installed in the room so that the position of the AGV can then determined using a laser scanner. This method enables extremely precise navigation and movement of the AGV in its surroundings. To allow the position of the laser scanner to be determined, it must have clear visual contact with at least three reflectors positioned several meters above ground level.

The advantage of laser triangulation is the high accuracy of position determination, which is crucial for precise navigation. Furthermore, this navigation technology proves to be effective particularly in dynamic, frequently changing environments.

Despite these benefits, however, there are also disadvantages. The high cost is a significant aspect because not only the sensor has to be mounted laboriously at reflector height on the AGV, but reflectors also need to be installed in the room. The use of laser triangulation also requires the environment to fulfil certain conditions. The reflectors must be detectable to enable reliable position determination. Moreover, additional sensors must be installed for transportation path safeguarding.

+ High accuracy for position determination
+ Precise navigation
+ Effective in dynamic environments
— Installation expensive and laborious
— Environment must fulfill certain conditions
— Additional sensors necessary for transportation path safeguarding

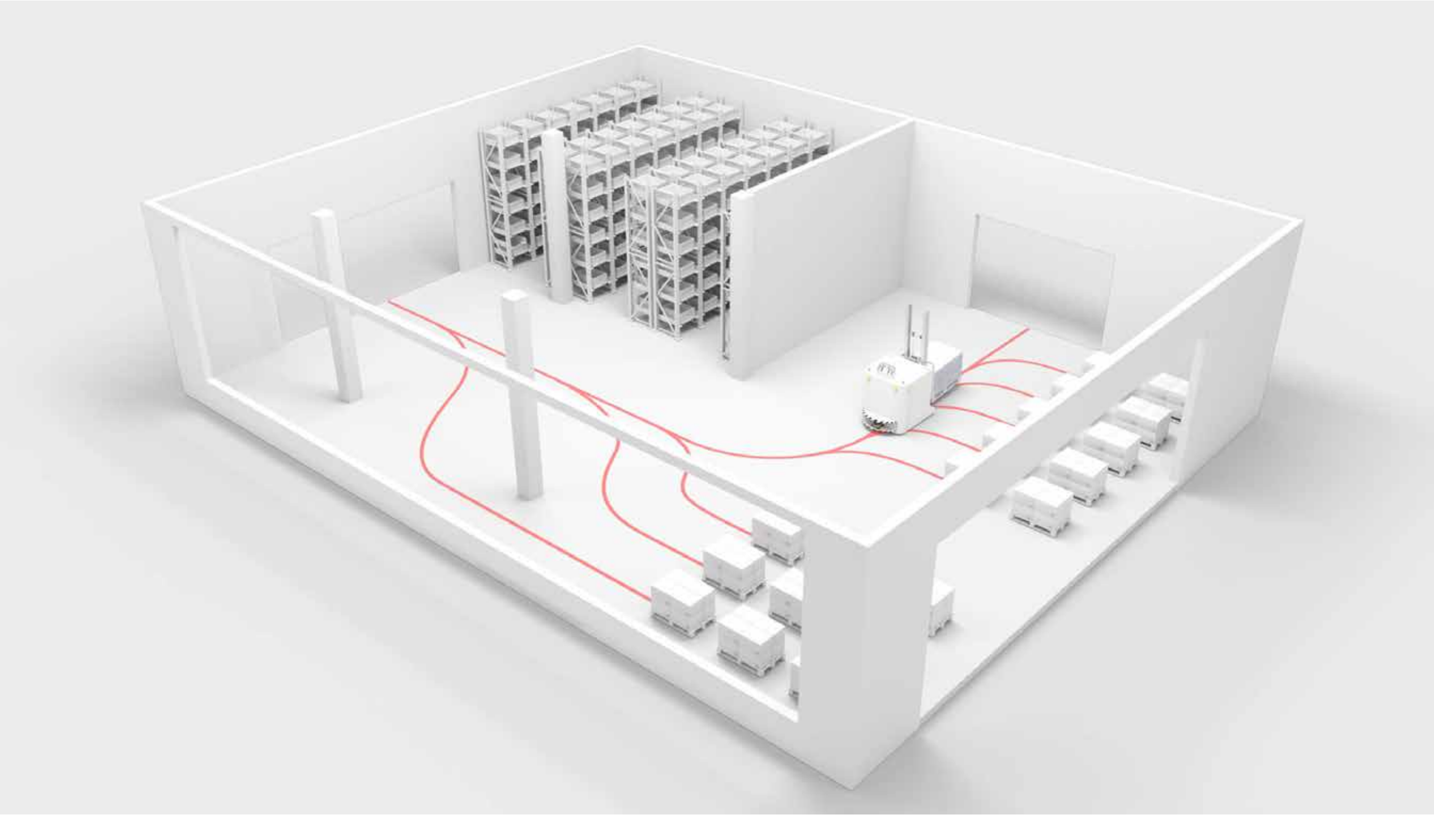


3. Optical or inductive guidance for environments with clear paths

The optical or inductive guidance of AGVs is based on a navigation technology where the vehicles follow magnetic tape or an induction cable installed in the floor. This tape or cable functions as a guide track for the AGVs. Sensors on the AGV detect the magnetic field of the tape or cable and thus enable the vehicle to precisely orientate itself and navigate along the predefined path.

Compared to other navigation methods, the acquisition and installation costs for the sensor system are manageable. Furthermore, this technology has over the years proven reliable and robust, particularly in environments with clear and predictable paths. Because the sensor on the AGV is mounted only a short distance from the floor, such a form of navigation is independent of the selected vehicle type. This technology does, however, involve a certain amount of preliminary construction work, i.e. laying of the magnetic tape or induction cable. As the vehicles are reliant on the previously defined track, their flexibility in the case of changing layouts or new routes is severely limited. Installation of the magnetic tape then requires physical modifications to the floor, which is not always practical or desirable – particularly in environments that are subject to frequent rearranging. In complex environments with a large number of curves or narrow passages, the accuracy of navigation may be limited compared to state-of-the-art systems such as lidar or camera technologies.

+ Manageable costs
+ Reliable and robust technology
+ Ideal for environments with clear paths
— Preliminary construction work required
— Limited flexibility at locations subject to frequent rearrangement
— Limited accuracy in the case of paths with many curves



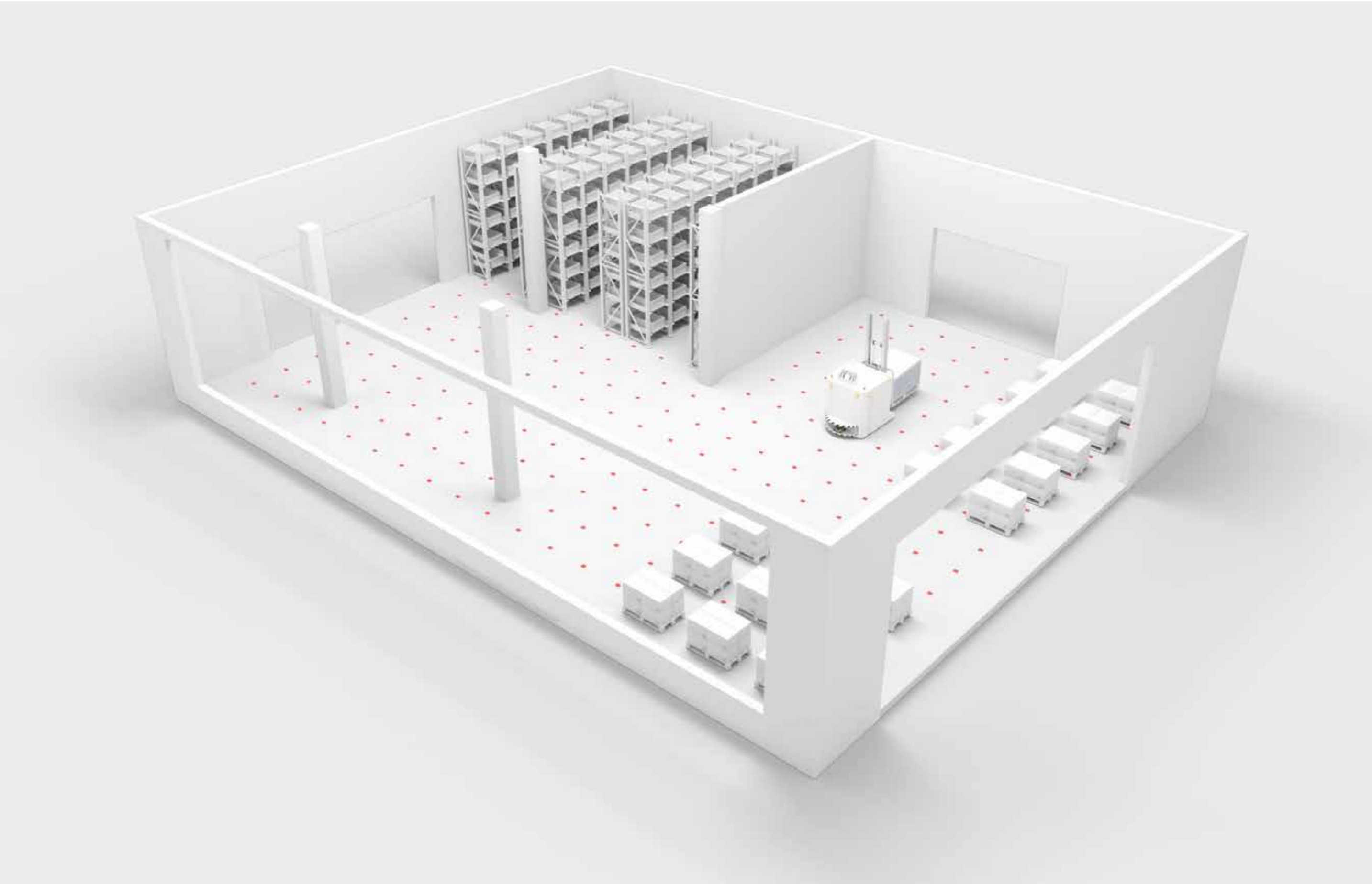
4. Grid navigation
for environments with clearly organized paths

Grid navigation is based on a grid-like coordinate system, which consists of either 2D codes on the floor or transponders embedded in the floor. These codes or transponders serve as reference points that the AGV uses to determine its precise position. The vehicle then moves along the predefined gridways, which enables precise navigation.

Installation and implementation of grid navigation is comparatively simple because it is based on clear, predefined codes or transponders. Use of a grid-like coordinate system allows precise position determination, which results in high navigation accuracy. Grid navigation is particularly well suited to environments in which the routes are predictable and organized, e.g. in warehouses or production plants with clear vehicle lanes.

Grid navigation is, however, less flexible if the environment frequently changes or new routes are required. The installation of codes or transponders requires physical modification of the floor, which means additional infrastructure changes. This can impede implementation in existing environments.

+ Easy implementation
+ High navigation accuracy
+ Ideal in the case of clear vehicle lanes
– Less flexible in the case of frequent changes to the environment
– Physical modification of the floor in order to install transponders
– Navigation along predefined routes only



5. Camera-based navigation (vision guidance) for high flexibility

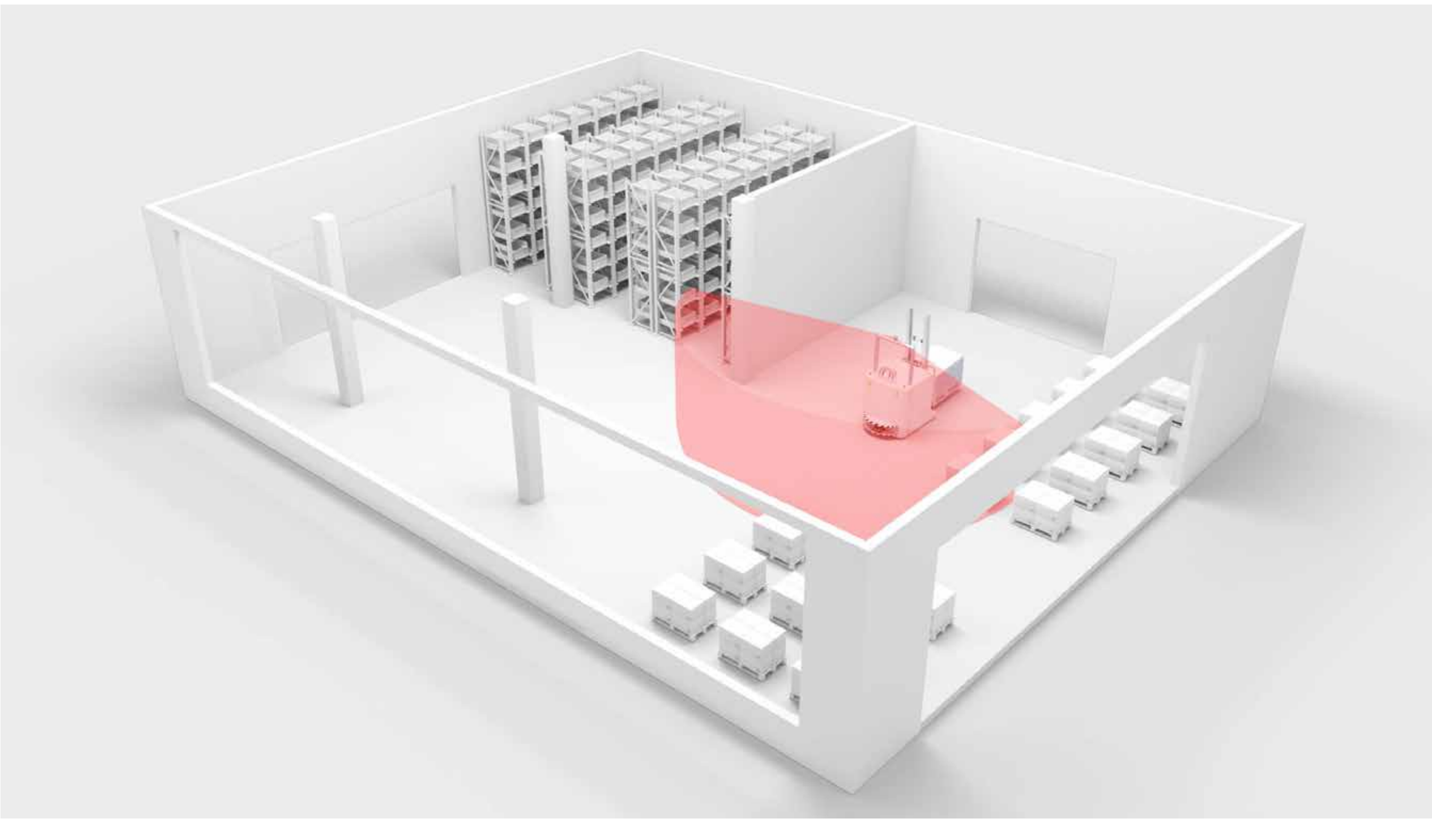
The principle of vision guidance is based on cameras which detect markings or patterns on the floor or in the surrounding area. The AGV then orients itself by means of these markings and patterns. They can be, for example, colored lines, QR codes or other visual markings. The camera continuously captures the area surrounding the AGV and interprets the visual information to enable precise position determination and navigation.

The main advantage of camera-based navigation is the high level of flexibility because it does not require any special floor infrastructure. This makes it ideal for environments in which the routes frequently change.

Vision guidance is, however, prone to difficult light conditions: The efficacy of camera-based systems may be limited in environments with poor light conditions or low contrast because these systems rely on clear, visible information. The quality of navigation depends on the clarity of the markings or patterns on the floor. Soiling or damage can have a detrimental effect on accuracy. Furthermore, the operating range of cameras is limited, which means that camera-based AGVs may have difficulty in precisely detecting objects at a greater distance. Compared to other navigation methods, the implementation of camera-based systems may necessitate a more complex integration into the overall system.

Although the pure installation costs are generally low, the acquisition costs for high-quality cameras and the necessary image processing technology can be correspondingly high.

+ Precise position determination
+ Extremely flexible in the case of frequently changing routes
+ No special floor infrastructure required
— Prone to difficult light conditions
— Limited operating range of cameras
— High acquisition costs for hardware and software



Summary: Careful selection and integration of the navigation technology

The use of AGVs enables a significant increase in efficiency in industry because they minimize manual work processes and ensure precise, automated control of the material flow.

Selection of the best navigation technology for AGVs plays a decisive role for the success of logistical processes in companies. The individual requirements of and factors at each company must be carefully analyzed to ensure that the most suitable technology is selected.

Crucial when selecting is the consideration of costs and benefits, whereby companies must ensure that investment in the navigation technology has a measurable added value for their specific operating processes. Here, selection of the appropriate sensor system also plays a key role because the accuracy of the data is essential for precise navigation. The surrounding conditions, whether continuously changing or static, also significantly influence selection of the optimum technology.

Flexibility is another decisive factor, particularly if the operational requirements and routes change regularly. Well thought-out and tailored navigation technology can help AGVs navigate smoothly through complex surroundings, while at the same time ensure efficiency and safety.

AGVs with the appropriate navigation technology are a key element for companies that rely on optimized, automated solutions for material transport in intralogistics.

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