AGV SYSTEM LOCALIZATION: MORE EFFICIENCY IN INTRALOGISTICS

HOW COMPANIES CAN OPTIMIZE INTERNAL TRANSPORTATION WITH SENSOR SOLUTIONS

SICK
Sensor Intelligence.

White paper

Automated guided vehicle systems (AGV systems) provide support in efficiency-driven intralogistics. The prerequisite is highly functional sensors for localization, which enable optimal navigation of the vehicles. There are many solutions – SICK is offering industrial vehicle designers and system integrators guidance with this white paper.

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MANAGEMENT SUMMARY

Efficient intralogistics make a significant contribution to the success of a company. Automated guided vehicle systems (AGV systems) are playing an increasingly important role. A prerequisite for profitable use of AGV systems is precise localization of the vehicles, which in turn forms the basis for optimal navigation. When building AGV systems, vehicle designers and system integrators are challenged to develop functional, economical solutions for their operation.

But which localization solution is the right one? First, designers must decide whether to use self-localization or external localization[1)] technologies, or a combination of both. Self-localization, in which the vehicle itself is equipped with sensors, is widely used. Synergies can often be exploited here: Laser scanners used for the safety concept of a vehicle, such as LiDAR sensors ("light detection and ranging"), can also be used in parallel for localization functions.

The following sensor technologies are particularly important in intralogistics:

- LiDAR: Environment perception using a suitable laser scanner
- Line-based guidance
- Cameras: 2D and 3D image processing
- RFID transponder and grid localization
- Ultra-wideband (UWB)

The decision in favor of a technology depends on the respective internal company requirements and deployment scenarios. SICK not only offers suitable sensors and application solutions for this purpose, but also supports you in the selection process.

1) In self-localization, the vehicle locates itself with the help of sensors. With infrastructure-based external localization, a vehicle is localized externally, for example via an overhead camera or UWB antenna.

1. Efficiency pressure in intralogistics

The relevance of intralogistics has increased enormously in recent years – and with it the pressure on original equipment manufacturers (OEMs) and system integrators, whose responsibilities include the construction of industrial vehicles for plant transport. The focus is shifting more and more to internal plant logistics and its key role for smooth processes in production, distribution, mounting and other areas: According to the “Trendreport Intralogistik und Werkstransport 2021” (EN: Trend Report Intralogistics and Plant Transport 2021) by industrial logistics company INFORM[2)], 76 percent of respondents from logistics and supply chain management rate internal transports with high or very high relevance for the overall success of the company. In an earlier survey from 2013, on the other hand, respondents still tended to describe internal logistics with words such as inadequately engineered, hardly optimized and even as “production brakes." But those days are over.

2) INFORM Institut für Operations Research und Management GmbH, Trendreport Intralogistik und Werkstransport 2021: ein Wirtschaftsbereich am Wendepunkt? (April 2021), URL: https://www.inform-software.de/informationsmaterial/infomaterial-details/information/trendreport-intralogistik-und-werkstransport-2021 (Status: 6/22/2022).

Challenges: Productivity, on-time delivery, predictability, etc.
Across industries, the demands on in-plant logistics are growing, which also affects the daily work of original equipment manufacturers (OEMs) and system integrators. Respondents to the INFORM Trend Report named the following as the biggest challenges facing internal transport:

- Increase in efficiency (80 percent)
- Adherence to deadlines (73 percent)
- Securing production supply (65 percent)

A look at the different industries shows that there are very different drivers of this development: In the automotive industry, the individualization trend up to batch size 1 is shaping events. Today, different individualized derivatives have to be produced on one production platform: After all, car buyers today have countless configuration options for their vehicle. Rigid sorting lines can hardly do justice to this. Plant logistics must operate ever more flexibly and efficiently.

The pressure is also high in e-commerce, where speed is paramount – an ever higher throughput of goods is required, and products have to reach their recipients ever faster. In addition, there is a shortage of skilled workers, which now affects all industries. According to a survey commissioned by ABB Robotics Germany (2022)[3)] among companies from the online and retail, pharmaceutical, logistics and shipping industries, the labor shortage (30.2 percent) actually represents the greatest challenge for intralogistics.

[3)] ABB Robotics Germany, Robotik im Mittelstand und in der Logistik: Civey-Umfrage im Auftrag von ABB zeigt geteiltes Bild (2/22/2022).
URL: https://new.abb.com/news/de/detail/88111/robotik-im-mittelstand-und-in-der-logistik-civey-umfrage-im-auftrag-von-abb-zeigt-geteiltes-bild (status: 6/23/2022).

2. Automated guided vehicle systems: Tools for more efficient processes

One promising way for operators and vehicle manufacturers to meet these challenges is through the use of automated guided vehicle systems (AGV systems). According to the INFORM trend report, 25 percent of the companies participating in the survey were already using AGV systems in 2021 – for 47 percent of respondents, the introduction of automated guided vehicle systems was one of the most urgent concepts to be implemented in the short to medium term.

The advantages of AGV systems are manifold: Autonomous vehicles can support individualized production by making previously rigid sorting lines more flexible. The high degree of automation increases productivity and reduces errors. And last but not least, the effects of the shortage of skilled workers can at least be balanced out by automated guided vehicles – if internal transports are increasingly autonomous, workers can be deployed elsewhere.

3. Localization: Important building blocks for AGV system navigation

With the growing popularity of AGV systems in intralogistics, vehicle manufacturers are facing big challenges. After all, the vehicles should be versatile and work quickly, safely, and accurately. Goods, commodities and components have to be fed quickly and accurately in a short time, and in different environments, on different substrates, etc. The AGV systems should be able to adapt easily to changes within a very short time, for example in warehouse structures or on platform bases. Absolute reliability of individual vehicles and the fleet as a whole, as well as high availability – i.e. minimal downtime – are essential requirements for successful deployment.

Location determination as a basis

Speed, precision, adaptability, and reliability – all these requirements must be met in AGV system development. A key tool for achieving this is navigation that optimally combines localization, vector definition, engine control, route planning and fleet management. However, the navigation of an AGV system is only as good as its localization. Where are the automated guided vehicles at the moment? What routes are they on? Are the vehicles taking the best route? Localization solutions can help companies answer these core questions of AGV system navigation.

4. Overview: Localization options and technologies

Basically, companies can choose between external or self-localization solutions or approaches that combine both localization options. Within these options, they have various technologies at their disposal – which one is best suited for a company depends largely on the planned application scenario.

4.1 Self-localization, external localization – or both?
Self-localization: With self-localization, the vehicle determines its location using on-board equipment, such as sensors attached to the vehicle. These can be laser scanners as well as 3D vision cameras, for example. Self-localization is by far the most frequently used variant of localization in intralogistics. The reason is that an AGV system not only has to "know" where it is moving in space, but also has to meet certain safety requirements. For example, safety laser scanners can ensure that an AGV system safely detects people and can brake in time. That is why self-localization solutions are typically used wherever safety standards have to be observed.

External localization: With infrastructure-based external localization, there are usually no active elements installed on the vehicle itself; instead, it is localized externally. For example, it is possible to determine the location using an overhead camera that tracks a barcode on the vehicle. Or a UWB antenna that locates a tag on the vehicle.

Combined approaches: Combination solutions of technologies for external and self-localization are not particularly widespread, but they are conceivable in a wide variety of forms. They promise flexibility in cases where pure self-localization or external localization does not produce the desired results: A possible application scenario would be that vehicles in a large hall are easy to locate externally, but if they drive into aisles with a heavy shielding, self-localization functions can be a useful addition.

4.2 The most relevant technologies for localization

What localization technologies are there in the first place? How do they differ and which solutions are suitable for which requirements? These questions are answered by the following overview of various technologies that have particular relevance for intralogistics.

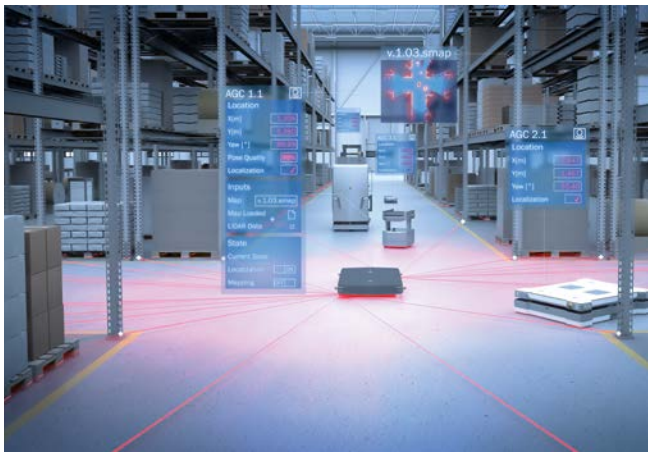
Technologies for self-localization:

For detailed information on the respective product, click on the product name in the information boxes.

LiDAR

LiDAR stands for “light detection and ranging”. The method for environment perception of natural contours is based on measurement data from probing laser scanners that detect points in the environment.

With **LiDAR-LOC, SICK is offering** a localization solution for autonomously moving AGV systems. The modular software solution ensures accurate and reliable localization results based on natural contours. LiDAR sensor data is used for this purpose, which can be linked with information from other sensors if required. LiDAR-LOC can be easily integrated into existing infrastructures.



The microScan3 safety laser scanner, for example, which relies on the innovative safeHDDM® scanning technology, can be used here. It not only delivers highly precise measurement data, but is also resistant to dust and ambient light. This has a direct positive effect on the availability and productivity of the automated guided vehicle systems.

LiDAR-LOC runs on all commercially available controllers and common operating systems. This means the solution provides an optimal starting point for the development of vehicle navigation systems.

LIDAR-LOC –

These are the advantages offered by environment perception using a suitable laser scanner:

- **Quick and uncomplicated implementation:** No infrastructure changes required due to additional artificial landmarks
- **Accurate localization:** Even in environments with high dynamics and few contours
- **Modular design:** Easy integration of new functions
- **Scalable solution:** Suitable for the respective application, from individual vehicles to fleets
- **Optional individualization:** Additional sensor signals can be integrated for individual applications

Line-based guidance

During line guidance, AGV systems follow a line placed on the ground. In this process, a sensor orients itself to the line, which can consist of luminescent or magnetic bands, for example.

With the **OLS**, SICK is offering a sensor for optical line guidance based on luminescence technology. It detects all commercially available luminescent adhesive tapes regardless of substrate, contamination or surface defects. It reliably outputs deviations from the track center. Track can be laid flexibly and in small curve radii of up to 0.5 m thanks to the adhesive tapes. In addition, the OLS can read 1D codes when crossing and process route information or travel commands in this way.

OLS –
These are the advantages offered by localization with luminescence technology:

- **Rugged and accurate:** Insensitive to ambient light, contamination or surface defects
- **Easy track laying and route changes:** By attaching conventional adhesive tape
- **High flexibility when laying track:** Small curve radii up to 0.5 m possible; large reading field enables flexible track laying with branching, merging, etc.
- **Simple vehicle control:** Transmission of route information or driving commands by reading barcodes
- **Cost efficiency:** Low installation costs, cheaper than camera solutions

The **MLS** from SICK is a magnetic line guidance sensor for the navigation of automated guided vehicles. The sensor aligns itself towards the center of the magnetic tracks to help the vehicle navigate. It can reliably differentiate between up to three lanes – it handles branches and lane merges with ease. The wide latitude in the choice of magnetic tape and installation height means flexibility with design and retrofitting. Magnetic markers can be attached next to the track as an option for additional commands.

MLS –
These are the advantages offered by localization with magnetic line guidance:

- **Easy installation:** Rugged aluminum housing with slim shaft, different measuring range variants
- **Fast commissioning without setting:** Optional setting and visualization via user interface
- **Large ground clearance:** Installation with 10 to 70 mm clearance to the magnetic tape
- **Safe lane detection:** Differentiation of up to three lanes for intersections and merging; inertial measurement unit supports AGV system navigation
- **Reliable command detection:** Simple and reliable detection of command markers (STOP, MERGE, SPEED, CHANGE)

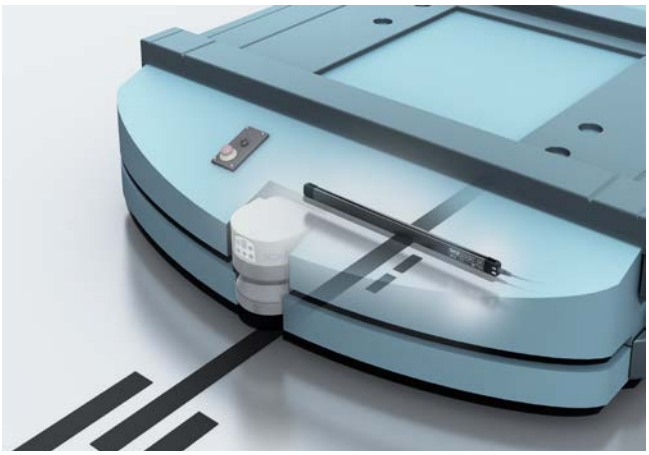
Cameras: 2D and 3D image processing

Image-based localization uses cameras on the vehicle to determine the location of an AGV system. The cameras generate a point cloud based on measurement data from the environment. This can be used to support localization.

SICK offers simple operation and very high data quality with the compact Visionary-T Mini 3D vision cameras, which are suitable for almost all industrial 3D image processing requirements. Thanks to 3D runtime technology, the cameras generate detailed depth and intensity data. Even with strong light-dark contrasts and long distances, the devices reliably detect their surroundings and deliver precise data, even with moving objects, due to the very short image acquisition time. A clear configuration tool makes it easy to parameterize the cameras and flexibly adapt the data to the respective application.

Visionary-T Mini –
These are the advantages offered by localization with cameras:

- **Cost efficiency:** Reliable camera for continuous use in industrial environment; cost-efficient solution in compact design for a wide range of applications
- **Precision:** Very accurate 3D and 2D data with high pixel density for detailed and reliable environment perception
- **High data quality:** Large dynamic range and particularly large contrast range
- **Fast data availability:** Versatile programming interface for external data evaluation
- **Customized configuration:** User-friendly tool for individual visualization and configuration



RFID transponder and grid localization

This form of localization uses either RFID tags or barcodes (1D or 2D) to create a grid structure on the floor. The vehicle follows this raster with the help of a sensor.

Image-based code readers from SICK can read a wide variety of code types, regardless of their alignment. Typically, Data Matrix codes and QR codes are used for the application described, often in the form of so-called multicode labels. With the help of code analysis, code qualities can be monitored and processes can be optimized more and more on this basis. The code readers can also read badly damaged codes because they have corrective image processing algorithms.

RFID (radio-frequency identification) uses radio waves for localization. With its RFID solutions, SICK enables particularly reliable identification of even concealed or dirty objects, since no line of sight to the RFID transponder is required. Thanks to large reading distances and reading field widths, even large objects with imprecise transponder positions can be easily localized. Encrypted data transmission ensures a high level of protection against forgery and the necessary data protection.

Image-based code readers and RFID –
These are the advantages of localization with RFID transponders and grid localization:

- **Cost-efficiency:** You only need RFID transponders and code labels and a camera sensor or RFID antenna
- **Simplicity:** AGV system drives using rasters, meaning no complex map is needed for navigation; time-consuming maintenance of maps is also unnecessary
- **Flexibility:** Information in the RFID transponder action catalog can be changed as needed
- **Accuracy:** Very precise localization possible

Technology for external localization

UWB

UWB (ultra-wideband) is a digital radio system for short-range communication. For localization, UWB antennas locate UWB tags attached to the AGV systems.

With the **LOCU** UWB system for tag-based localization, SICK offers a radio system with a very wide frequency range that makes a very high transmission rate possible. Here, AGV systems are equipped with a UWB tag that assigns them each an individual identity. If the AGV system moves between different antennas (also called anchors), they determine the exact position of the tagged AGV system by calculating the distance values between them. The locating accuracy of the LOCU is less than one meter.

LOCU –
These are the advantages offered by localization with UWB technology:

- **Precise localization:** Locating accuracy of less than one meter
- **Very well suited for indoor localization:** Sensing range from 20 to 50 meters; low transmitting power of the antennas in continuous operation
- **Data acquisition:** Each position value receives a time stamp – valuable source of information for optimizing logistics processes

5. SICK – sensors and solutions for AGV system design

Speed, precision, adaptivity, reliability and much more – this is what matters in the design of automated guided vehicle systems. And this is precisely where SICK supports designers and OEMs. With its portfolio for factory, logistics, and process automation, SICK combines sensor intelligence and application solutions: The combination of sensors and suitable software reduces complexity enormously. As a full-range supplier, SICK offers customized localization solutions that meet your individual requirements precisely.

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SICK AT A GLANCE

SICK is a leading manufacturer of intelligent sensors and sensor solutions for industrial applications. With more than 11,000 employees and over 50 subsidiaries and equity investments as well as numerous agencies worldwide, SICK is always close to its customers. A unique range of products and services creates the perfect basis for controlling processes securely and efficiently, protecting individuals from accidents, and preventing damage to the environment.

SICK has extensive experience in various industries and understands their processes and requirements. With intelligent sensors, SICK delivers exactly what the customers need. In application centers in Europe, Asia, and North America, system solutions are tested and optimized in accordance with customer specifications. All this makes SICK a reliable supplier and development partner.

Comprehensive services round out the offering: SICK LifeTime Services provide support throughout the machine life cycle and ensure safety and productivity.

That is "Sensor Intelligence."

Worldwide presence:

Australia, Austria, Belgium, Brazil, Canada, Chile, China, Czech Republic, Denmark, Finland, France, Germany, Great Britain, Hungary, Hong Kong, India, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Poland, Romania, Russia, Singapore, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Arab Emirates, USA, Vietnam.

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