SICK AG WHITEPAPER

MODERN PRODUCTION LOGISTICS: CHALLENGES AND OPPORTUNITIES FOR MACHINE BUILDING

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Sensor Intelligence.

INDEX

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Summary

Production logistics in modern manufacturing companies are becoming intelligent. While the areas of production and intralogistics used to be different disciplines, they are currently merging and will continue to do so in the future. This is done with an eye to the associated goal, Industry 4.0, in which every sensor, every machine, and every human involved can communicate with and among one another at any time.

This kind of factory – also called a “Smart Factory” – is characterized by certain production logistics features:
- Optimal flexibility
- High degree of automation
- Extensive self-organization
- Broad transparency in production and logistics processes
- Strong networking of machines, products and processes
- Greatest possible elimination of manual operations
- Permanent optimizations through data evaluation

Different solutions from SICK are in demand in all areas of production logistics for these reasons: Intelligent sensors and sensor systems with hardware and software for protecting, detecting, identifying, localizing, measuring, and monitoring.

1. Markets in flux – in machine building as well

More and more manufacturing companies are facing changing consumer expectations shaped by accelerating digitalization. Among other things, this puts pressure on conventional systems in production logistics. Markets and consumer demands are becoming more fast-paced and diversified. Increased demand for customized (mass) production increasingly requires the manufacture of tailor-made products – and in very different quantities as well as at market-driven prices (see Figure 1).

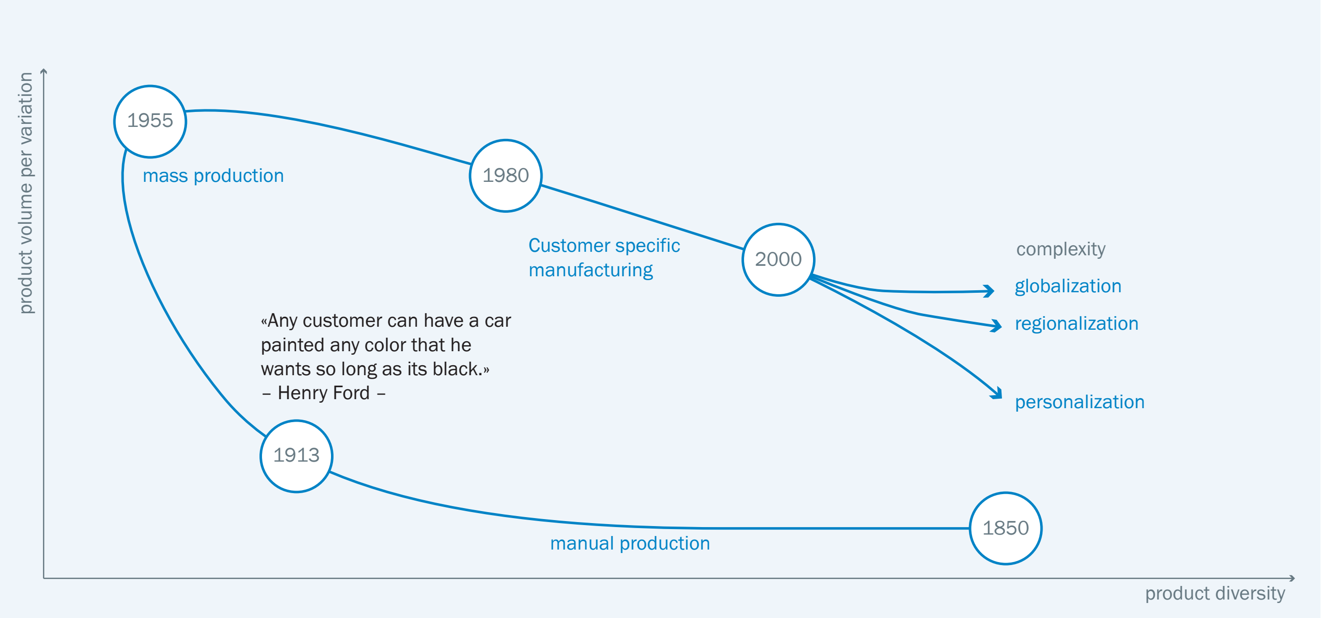


Fig. 1: Market and society requirements as drivers of new paradigms
(Source: Koren, Y. (2010): The Global Manufacturing Revolution: Product-Process-Business Integration and Reconfigurable Systems (English), Wiley; 1. Edition)

This means that companies are increasingly expected to shorten innovation cycles. Greater variant diversity, smaller batch sizes, fluctuating quantities and shorter product life cycles are the result. At the same time, the Internet gives consumers full price transparency across global markets, further increasing competition and cost pressure.

In line with these requirements, the demands of manufacturing companies on their suppliers are also changing. Machine and system manufacturers must therefore develop new machine concepts that enable their customers to manufacture much more flexibly and efficiently.

2. Production processes: From manual to fully-automated manufacturing

Figure 2 illustrates manufacturing concepts in a factory using four different production lines: If, for example, a product is to be manufactured in large quantities, modular production cells or fully interlinked production lines are good solutions. Manual manufacturing is suitable for the production of small quantities. Conventional machines can be loaded flexibly and automatically with robot support, combined with manual loading if required.

Logistics areas such as goods receiving and dispatch are located upstream and downstream of the production lines. Depending on the type of manufacturing, the degree of automation in material handling and other areas of production logistics varies greatly.

Selection of the appropriate manufacturing concept also depends on the volume and variance of the product to be manufactured. Fully linked production lines are generally preferred when manufacturing few variants and high quantities, while modular production cells are preferred when producing many variants.

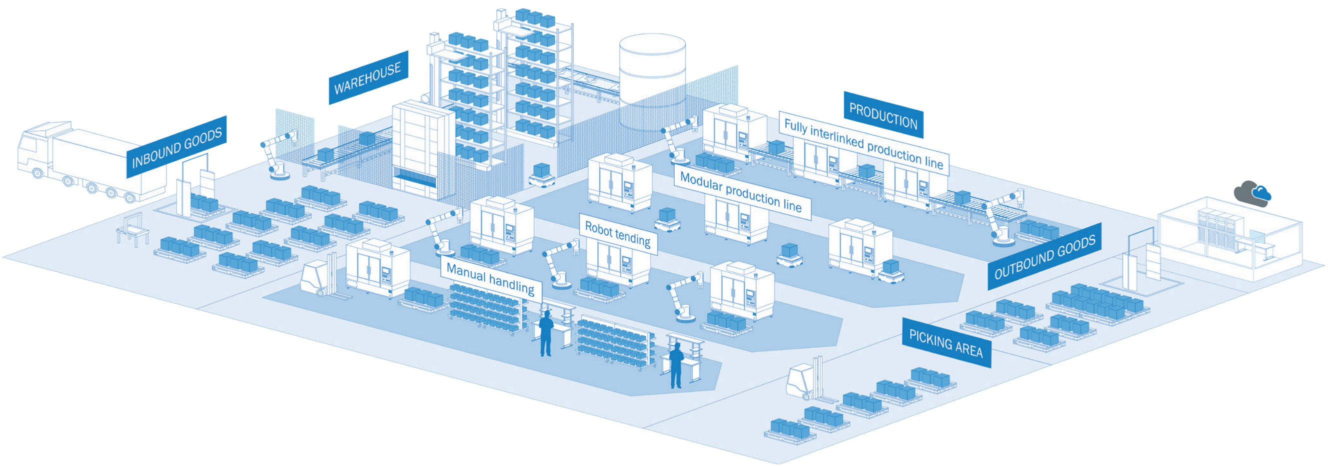


Fig. 2: Manufacturing concepts in a factory based on four different production lines

3. Production and intralogistics: Two disciplines merge

Production logistics encompasses all the processes between purchasing and distribution logistics that ensure that the machines and workstations are supplied with the right materials or products at the right time and in the right quantity and quality. The progressive automation and digitalization of manufacturing can help make the material flow from the delivery of materials to the shipping of the finished product fully transparent. This is where the sensor solutions from SICK come into play. The areas affected by this are shown in the following graphic and described below.

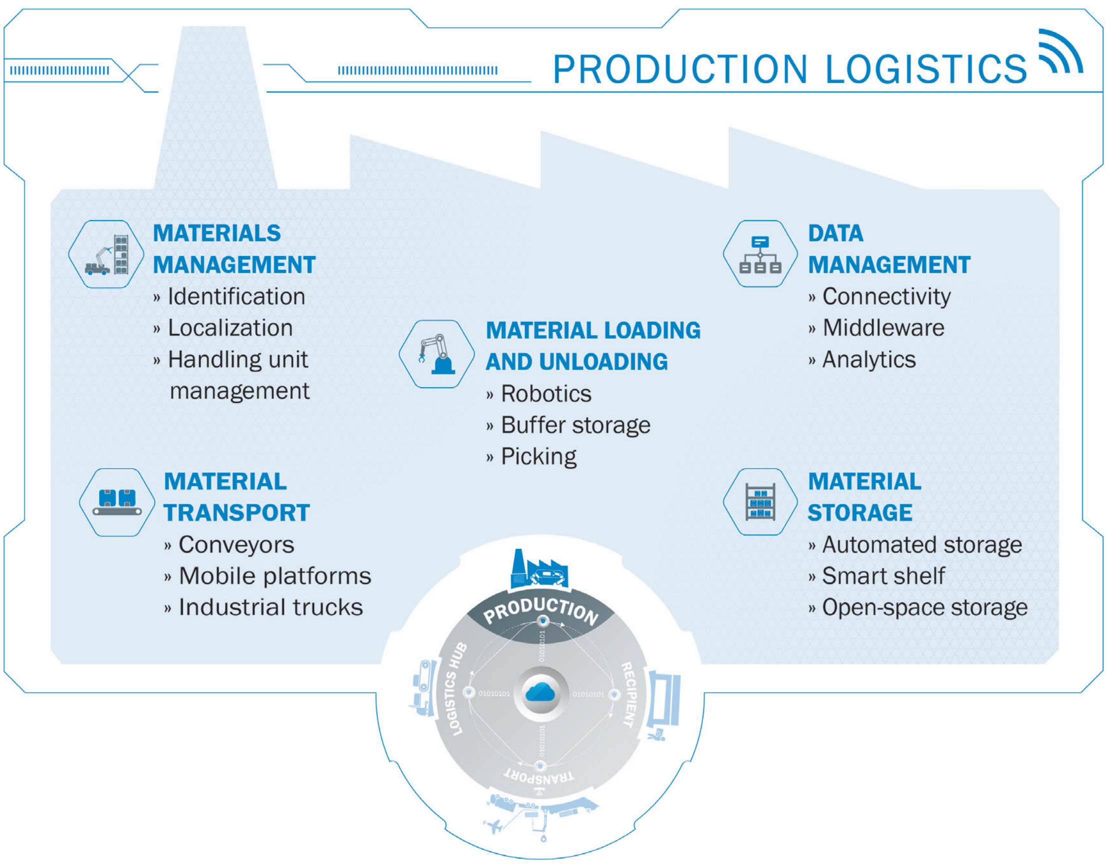


Fig. 3: Areas of production logistics

Material management
When is which part where? The issues of localization and identification of products and materials provide the foundation for better material handling in production. Container management also helps to ensure problem-free production processes and lower storage costs.

Material transport
Conveyor belts, mobile platforms, tugger trains and industrial trucks are used to achieve a highly efficient and flexible supply of new components to production and for returning empty containers.

Material loading and unloading
Current automation technologies not only master the tasks of supplying and returning materials, but are also finding application throughout the entire material flow in production, including in manual picking processes, robotics, and in buffer stores. This smooths out fluctuations in the production process, increases transparency, and reduces downtime.

Material storage
Modern storage concepts ensure automated replenishment and thereby actively support the production flow. For example in open-space storage with pallets, with intelligent rack systems, or in fully automated warehouses.

Data management
With the help of connectivity technologies and suitable middleware, data can be integrated into higher level systems such as ERP systems and MES. By bridging the boundaries between networks or software systems, production logistics can create a transparent material flow, provide the basis for the use of analysis software, and facilitate automated logistics processes.

4. Flexible manufacturing of batch size 1

If all possible production steps are mapped in a rigidly linked production line, the theoretical maximum capacity must be provided for each step, even if it is not required. In addition, a fault in a single step affects the entire production chain.

In the production of small batch sizes, the setup times must also be viewed critically. As non-productive times as well as potential sources of errors, they have a negative impact on overall equipment effectiveness and should therefore be optimized or even avoided if possible. In addition, mechanical setup equipment can wear out and thus impair product quality.

For more efficiency, the manufacturing concept should therefore be modular. Here, the individual production steps are mapped in a modular production cell structure in which each product variant passes through the production cells required for it. Frequently required process steps can be carried out in correspondingly powerful modules, and redundant modules alleviate bottlenecks.

In order for customers to be able to choose individual product variants from a large standard portfolio, production must serve a very broad product range on an as-needed basis. Ideally, investments in tools and fixtures are therefore also planned from the outset for successor products with a view to a long service life. If we think ahead – increasing the number of variants with sometimes very small quantities – it must ultimately be possible to produce a single copy: Batch size 1.

That is why production and its logistical processes need to be (re)designed to be as flexible as possible while maintaining a high degree of automation.

5. New challenges and solutions in modular manufacturing concepts

The implementation of a modular manufacturing concept also poses new challenges for the machine builder. The modules must often be able to react flexibly to the product variants to be manufactured. The product often controls the process. This means that the production cell automatically detects to which variant the intermediate product currently on hand corresponds and automatically starts the associated process. SICK offers the identification solutions required to do this. They can be adapted to a wide range of application requirements.

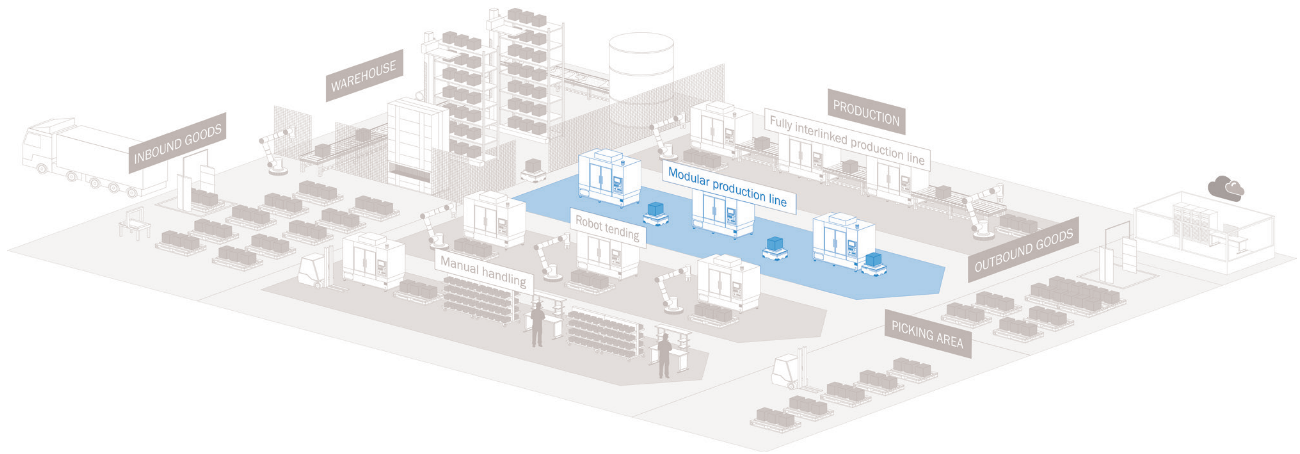


Fig. 4: Modular manufacturing concept

5.1. Identification solutions: Three solutions for efficient identification

The specifications of an application intended for object identification must be precisely defined in advance. Only in this way will it be possible to ensure that the application fulfills the requirements and is neither undersized nor oversized. The specifications must also take into account the desired degree of automation and the type and security of data storage.

After defining the specifications, a suitable identification technology can be selected. Figure 5 identifies the three most common identification technologies: RFID read/write devices, laser-based fixed mount bar code scanners, and image-based code readers. All three technologies can be combined in one system if required.

	RFID	Laser	Image line scan/matrix
1D bar code	–	✓	✓
2D code	–	–	✓
Transponders	✓	–	–
Line of sight	not required	required	required
Costs of a label	> 0.05 €	< 0.005 € (label)	< 0.005 € (label)
Procuring the label	Purchase	Purchase, label printing on standard printer	Purchase, label printing on standard printer
Maximum storage capacity of the label	high	low	medium
Maximum reading field width	very large	large	large | average
Depth of field*	N.A.	high	low | average
Omnidirectional reading	very well suited	min. 2 devices needed	well suited
Maximum object speed	2 m/s to 20 m/s, depending on application	5 m/s	6 m/s
Sensitivity to external light	no influence	very low	low
Impairment due to dirt and wear	low	medium	medium
Metals / liquids in the surroundings	have an influence	no influence	no influence

Fig 5: Overview of the features of the different identification technologies in industrial use

* Parameter of optical systems

The advantages of RFID read/write devices:
- Identification of even hidden or dirty objects
- Suitable for large objects with imprecise transponder position
- Reading and writing of data
- High level of protection against falsification
- Strong data protection

The advantages of image-based code readers:
- Reading of different code types possible
- Independent of code alignment
- Monitoring of code qualities for process optimization
- Subsequent image analysis possible
- Also suitable for heavily damaged codes

The advantages of fixed mount bar code scanners:
- Also suitable for different distances and object sizes
- Coverage of large reading areas with only one device
- High read stability, even in varying ambient light
- Low commissioning costs

5.2 Robot vision and robot guidance systems: Image-based sensors for “seeing” robots

A flexible production cell with integrated robot gripper “recognizes” different products and assigns each of them to the correct process. The production cell is thus able to perform the process step with the appropriate product variant. In the manufacturing process, the robot servo gripper ensures correct handling of the intermediate products or assemblies and their correct positioning. The positioning differs depending on the product variant or assembly. The robots allow a high degree of flexibility while maintaining high productivity. However, robots are only as flexible as their programming. In addition, the accuracy of a robot-guided machining operation depends heavily on the exact pickup of the parts by the servo grippers.

If the products are to be fed in without mechanical stops for reasons of flexibility, or if parts are to be removed directly from a container, a vision-based robot guidance system is often used.

Image-based solutions increase the robot field of vision: Thanks to SICK technology for industrial image processing, the robot localizes and identifies previously defined objects and decides for itself how to grip the respective object. This does away with the need for mechanical attachments. Even measurements and quality inspections can be carried out. For example, optical monitoring systems can monitor the position and quality of products, and harmonize the sequence, during joining processes. For example, SICK offers the following vision-based solutions:

2D part localization with the PLOC2D robot guidance system:
Easy-to-use sensor system for 2D part localization that requires no vision expertise and is ready for operation right away.

A 3D vision system with 3D Belt Pick for robot guidance:
The easy-to-integrate 3D vision solution for robot guidance applications avoids collisions and product damage in picking processes. The robot guidance system with specialized 3D SensorApp locates objects on a conveyor belt and orients itself to the shape of each individual product.

Bin picking with the PLB robot guidance system:
The flexible robot guidance system for bin picking is used to precisely determine the position of components in boxes or on pallets, regardless of the shape and alignment of the parts. The robot guidance system is available with different 3D cameras.

Position detection with 2D machine vision:
When a workpiece is processed by a robot, it may be necessary to once again detect the exact position of the workpiece in the robot gripper and adjust the robot movements accordingly. 2D camera solutions are particularly well-suited for this purpose, as they quickly and precisely record the position of the workpiece and transmit 4deviations from the setpoint to the robot control.

5.3 Smart Sensors: Intelligent data collectors

Product characteristics can vary so much that reliable detection is difficult: For example, the reflectance of individual products can vary greatly if a sensor is to detect many different product variants.

SICK has developed Smart Sensors for this purpose that use the globally standardized IO-Link communication protocol. In this way, the sensors collect data far beyond classic switching signals or measured process variables. The speed at which Smart Sensors receive new parameter sets is a great advantage, especially for flexible batch sizes up to batch size 1. The parameters used can be automatically transmitted to a replacement sensor should a device fail. Smart Sensors automatically detect faults during operation and actively troubleshoot problems that may arise, which ensures smooth processes. To prevent unplanned system downtime, the sensors are equipped with diagnostic functions, thereby enabling predictive maintenance. And last but not least, smart sensors increase process efficiency by providing system processes with the right information at the right time.

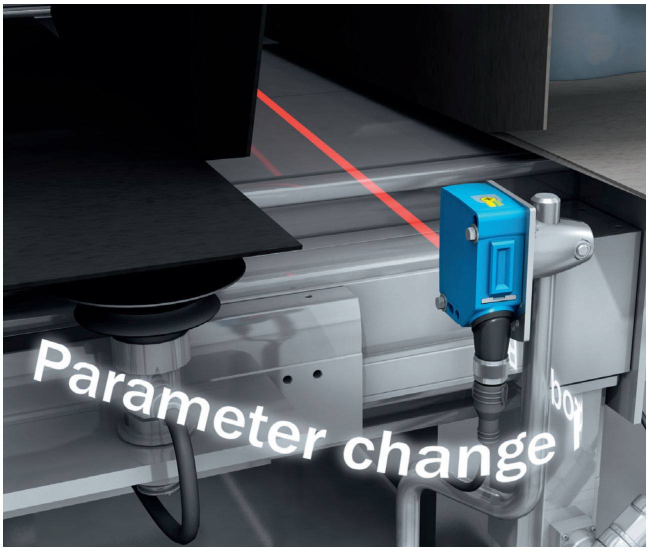


Fig. 6: Smart Sensors as intelligent data collectors

For example, when using the WTT12LC Smart Sensor in the PowerProx product family, different sensor parameter sets for specific formats can be created and stored in the control. This enables packaging formats to be switched during operation in a fast, reproducible manner and with no manual intervention.

6. Automated material transport through mobile platforms

One challenge in implementing a modular concept for production cells is their loading. Mobile platforms are often used here: Industrial automated guided vehicles (AGVs), service robots and automated guided vehicle systems (AGV systems).

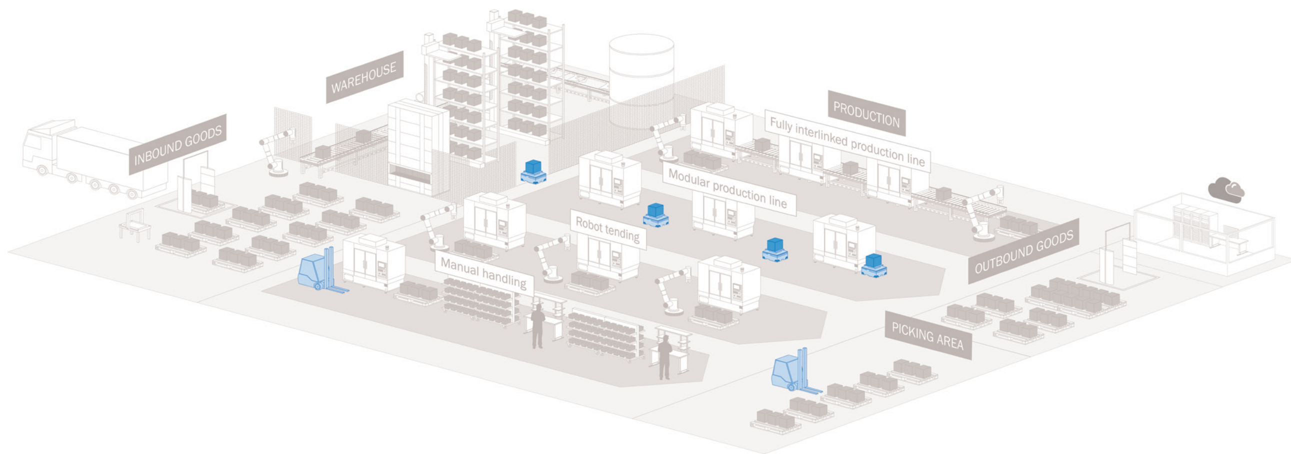


Fig. 7: Mobile platforms in a manufacturing facility

6.1 Navigation for dynamically adaptable logistics and production processes

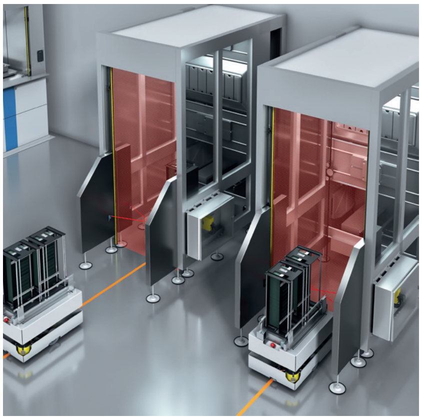
Various laser scanners from SICK support automated guided vehicles (AGVs) and AGCs in their autonomous transport operations. The vehicles also provide data for their own software to respond to ever-changing industrial environments. For example, AGVs and AGCs constantly synchronize the floor plan of a room to their route environment. This allows the vehicles to recognize their position at all times and find the route to their destination. With the help of a visual display of relevant measuring points, the routes of the AGV systems can be traced and controlled.

LiDAR-LOC localization solution:

The LiDAR-LOC modular localization solution precisely determines vehicle positions. The localization is based on natural surrounding contours: LiDAR sensors mounted on a vehicle scan the surroundings and the LiDAR-LOC software creates a digital map of the surroundings from the measurement data obtained. The LiDAR-LOC masters changes in the vehicle environment and the processing of measurement data from multiple LiDAR sensors. Additional artificial landmarks and external odometry are not required for vehicle navigation. The LiDAR-LOC is therefore ideally suited for its development.

6.2 Docking of AGVs and AGCs: Safety for man, material and machine

The area where a mobile platform docks and undocks from a machine is a hazardous point. There are three ways to secure these areas while distinguishing humans from materials. The first is a combination of light grid and muting sensors: The light grid reliably protects the hazardous point, but allows an AGV or AGC to pass with the help of the muting sensors. (Figure 8, left).



Hazardous area protection during AGV docking with safety light curtains

Hazardous area protection during AGV docking with the Safe Entry Exit safety system

Hazardous area protection during AGV docking with the Safe Portal safety system

Figure 8: Three ways to protect an area where a mobile platform docks or undocks from a machine

The second option for human-material differentiation and protection of the hazardous point is the implementation of a muting function with the Safe Entry Exit function. Any type 4 electro-sensitive protective device from SICK can be used here. Depending on requirements, this protection is combined with the Flexi Soft safety controller from SICK or a Siemens S7 control. Muting arms as signal generators are therefore not necessary. This reduces sources of error and increases machine availability (Figure 8, center).

The third option for hazardous point protection is a combination of safety laser scanner and safety software. This solution is based on one or more intelligent safety laser scanners. They ensure humans are distinguished from materials. Safe Portal Solutions makes it possible to connect safety laser scanners such as microScan3 to both the Flexi Soft safety controller and third-party controllers such as those from Siemens or Allen-Bradley. Through intelligent protective field programming, the safety laser scanner detects predefined objects, such as AGVs, and lets them pass. External muting sensors are not needed. Safe Portal Solutions unite very high availability with a particularly small footprint, ensuring maximum safety thanks to the permanently active protective fields (Figure 8, right).

7. Digitalization for more transparency and efficiency

Modular manufacturing - under certain circumstances with mobile platforms - requires not only technical implementation at machine level, but also a complex planning process for the individual systems and subsystems. For flexible and dynamic planning and control of manufacturing, the systems and subsystems need feedback as well as information from the field as directly as possible.

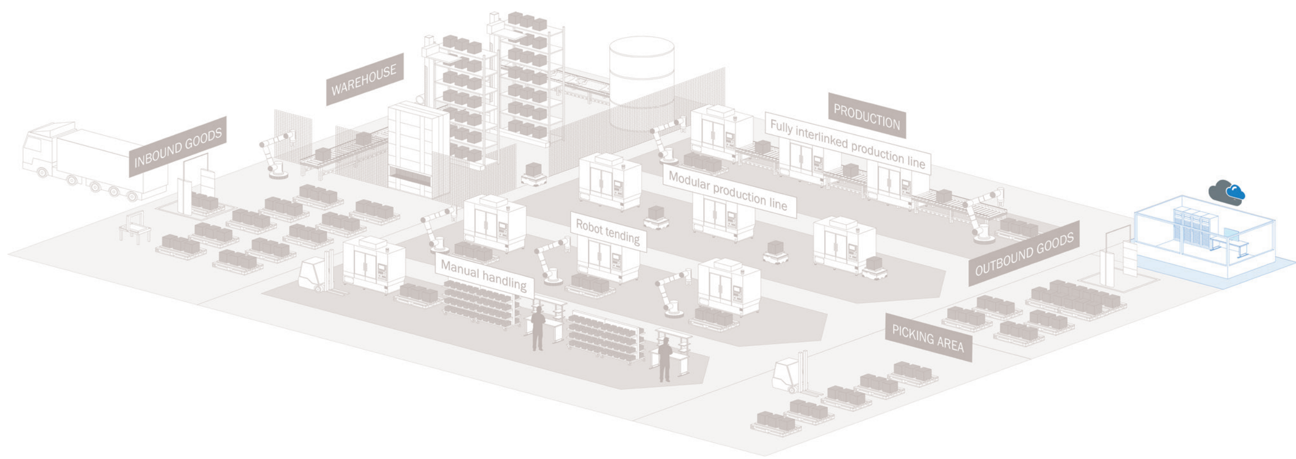


Fig. 9: The role of data in manufacturing

With the following Figure 10, the German National Academy of Science and Engineering (acatech) simplifies a maturity model that allows for a generally valid assessment of the stages of a company's development toward Industry 4.0. Computerization and connectivity are therefore also the first stages in manufacturing.

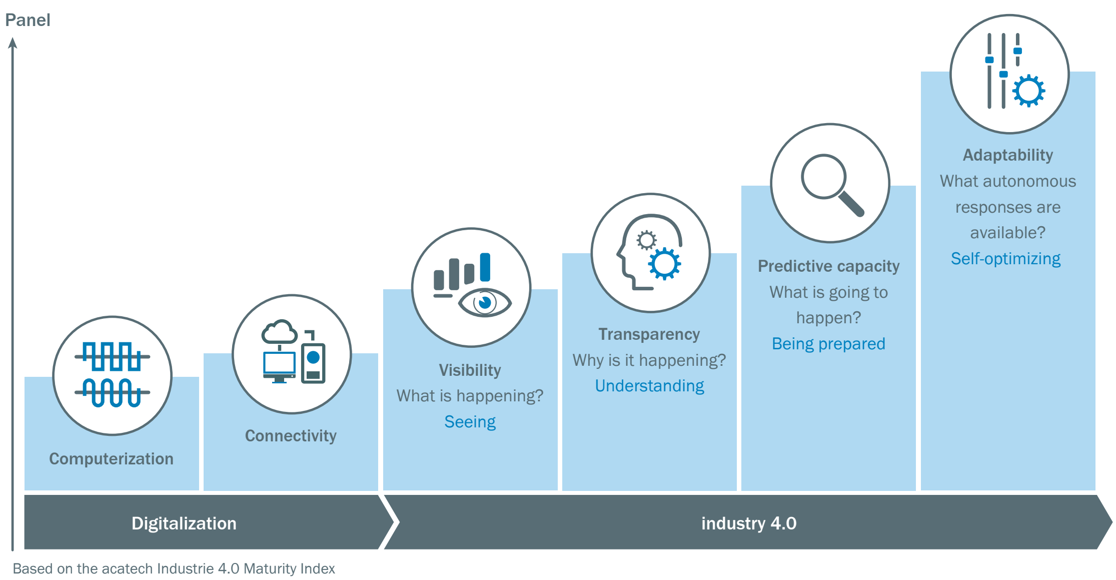


Fig. 10: “acatech Industry 4.0 Maturity Index” maturity model, German National Academy of Science and Engineering (acatech)

7.1 Smart gateways and middleware: The vertical integration of sensor data

Classic information of the first stage – computerization – is the current assignment of the production cells and the processing statuses of the orders. Identification solutions at the machine or processing station often record this information. However, the data is not processed in the machine, but in an IT system on an on-site server or in a cloud.

Access to sensor data is usually only possible from the control, meaning via the existing automation infrastructure, also known as operational technology (OT). Company-level computers, on the other hand, are usually located at higher levels of the automation pyramid. These computers work with other operating systems and protocols. If the data cannot be pre-processed directly where it originates, a gap is created: The IT-OT gap.

Accordingly, the second stage – connectivity, or making the data available – is a crucial but surmountable hurdle.

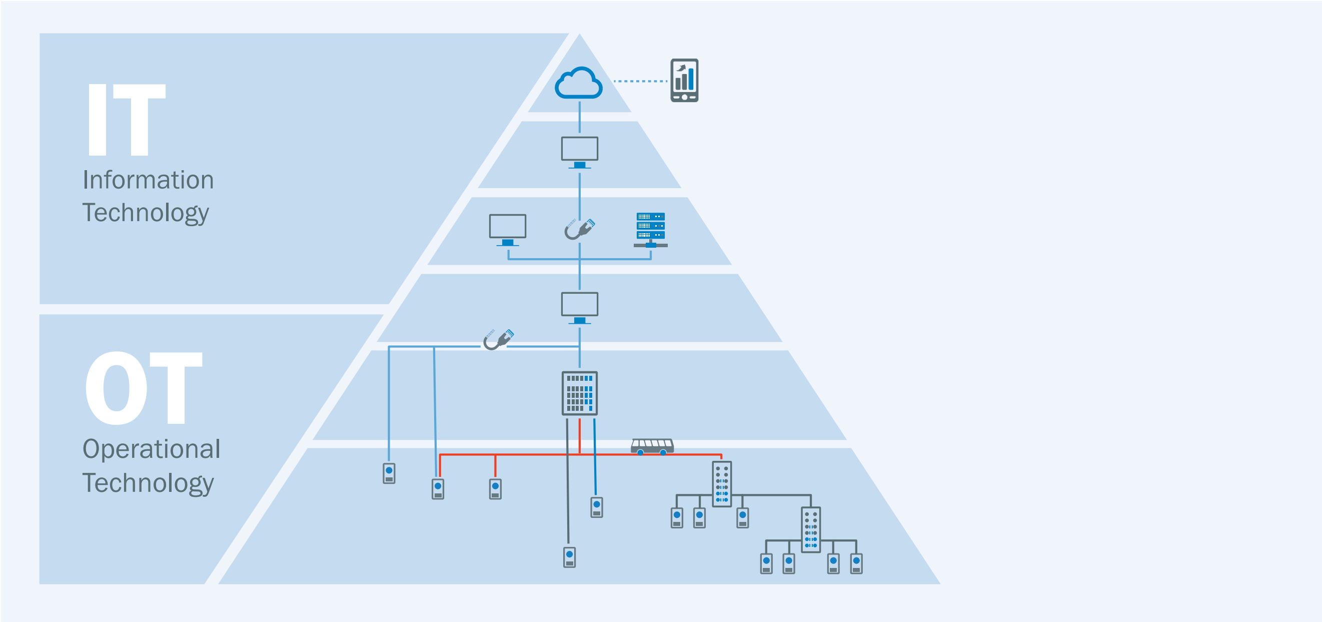


Fig. 11: The vertical integration of sensor data

Sensor Integration Gateways:
The point is to transmit sensor networks to the Internet. Dual-talk gateways are available to bridge the gap from the sensor to the PLC system, for example the SIG200 Sensor Integration Gateway from SICK for integrating sensor data into common PLC environments and enterprise-level systems. The SIG200 acts as an IO-Link master: It can be used to acquire, combine, evaluate and transmit digital input signals, digital output signals or IO-Link data from several devices via various fieldbus protocols. A REST-API provides a second data channel for higher-level processing. Due to its prioritization, this type of fieldbus communication is also called fast loop.

Sensor Integration Machines:
Sensor Integration Machines (SIMs) offer particularly flexible and intelligent paths to application solutions. Sensor and camera data can thereby be merged, evaluated, archived and transmitted. Only relevant data is then sent to the higher-level systems via an interface. Especially for complex sensor tasks such as machine vision, this is the appropriate approach. SIMs are available in a scalable portfolio and are based on the SICK AppSpace eco-system.

7.2 Automated processes through localization: Order location every second

For production planning, it is often crucial to know which machine is currently processing which order and where certain objects are located at the moment. This is because this enables automated analyses of the material flow and avoids unnecessary searches for orders.

UWB systems:
A relatively new key technology for order location is based on ultra-wideband (UWB). UWB transmits the exact position of an object several times a second, providing a high level of transparency and understanding of all production-related assets, load carriers and loading equipment. Tag-based localization in indoor areas uses the LOCU1xx and LOCU2xx localization solutions from SICK, UWB radio systems in the frequency band of short-range communication. These solutions consist of UWB tags and antennas based on ultra-wideband technology for receiving and analyzing telemetry data. The LOCU1xx and LOCU2xx achieve localization accuracy of less than a meter here. A time stamp for each position value makes position, object type and time completely transparent.

Data fusion:
However, for high-volume goods, direct localization using UWB technology is not profitable. The solution here is data fusion. This means that in an IT system, the data from identification technologies (e.g. RFID read/write devices or fixed mount bar code scanners) are linked with the position data from a container or industrial truck obtained via UWB. In this way, it is possible to deduce the position of the container from the position of the industrial truck.

Fig. 12: Data fusion

A localization solution can also store defined actions. For example, if an object enters a previously defined geozone, it triggers a command in a connected IT system. For example, a shipping order can be triggered automatically for the products on a located pallet as soon as the pallet is in goods receiving. Other possible applications include automated completeness checks of intermediate products for an order before the machine is set up, or monitoring of whether the right tools are in front of the right machine.

8. Summary

The Smart Factory as an answer to short innovation intervals, high degrees of individualization and strongly fluctuating quantities is a topic increasingly under discussion in machine building. In order to be able to offer their customers up-to-date solutions, machine builders are turning to new concepts in production logistics, and are thus participating in the development of manufacturing in the direction of Industry 4.0. Intelligent sensor solutions for the complete automation of manufacturing and logistics support machine builders in doing so. Such sensor solutions enable low production costs, end-to-end transparency and high flexibility. The networking and control of machines and sequences significantly increase time and cost efficiency in production and logistics processes.

FURTHER INFORMATION

1. Production logistics gets smart:
→ www.sick.com/production-logistics

2. Sensor solutions for machine tools:
→ www.sick.com/c/g291159

3. Solutions for identification:
→ www.sick.com/c/g77989

4. Sensor solutions for robotics:
→ www.sick.com/robotics

5. Smart Sensors:
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6. Industrial communication and sensor integration:
→ www.sick.com/gmt-integration-connectivity-mainpage

7. Mobile platforms:
→ www.sick.com/mobile-platforms

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