TRENDS IN THE AUTOMATION OF MOBILE MACHINES

Strategies and technologies for increasing the productivity of agricultural machinery, construction machinery, and municipal vehicles





SICK

Sensor Intelligence

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INTRODUCTION

Automation with purpose: safe and productive.

Mobile machines face relentless challenges – from extreme weather and constant vibration to heavy contamination – especially during continuous operation. Every instance of unplanned downtime strains budgets, stretches limited skilled labor, and intensifies the pressure to meet rising productivity demands. Automation offers a powerful solution. By leveraging networked sensors, cameras, and controllers, organizations can build resilient systems that not only perform reliably but also integrate seamlessly into existing infrastructure.

This e-guide examines important selection criteria, presents successful applications, and provides checklists for developers and operating entities to use to make sound investment decisions.



AUTOMATION
IN TRANSITION

Increased productivity in the age of artificial intelligence (AI), robotics, and intelligent sensors

The environments mobile machines often operate in ranges from deep mud and hard gravel to glaring sunlight, thick dust, or fog. Traditional operation of agriculture, construction, and municipal vehicles are increasingly hitting both physical and economic limits. Manufacturers and operating entities are constantly faced with the challenge of increasing their productivity while also reducing costs. This places high demands not only on employees but also the technology. Automation is crucial. Early adoption of scalable and intelligent sensor solutions noticeably increases the productivity in repetitive processes.

→ From basic to intelligent
→ Trends and strategies



FROM BASIC TO INTELLIGENT

In the past, many machines were designed for extreme conditions and manual operability. However, with advancing digitalization, smart technologies are becoming a differentiator and, in the end, a competitive advantage. Investment pays off with **artificial intelligence (AI), robotics,** and **intelligent sensors**. These technologies can do more than just function in the ambient conditions but also actively interpret them.

The ongoing labor shortage is evident worldwide: In Japan, the number of construction jobs has decreased significantly since the 1990s (cf. research report on the Japanese construction industry, ResearchGate).
In the USA, the average age of farmers continues to rise – from 55.3 years in 2002 to 57.5 years in 2017 (cf. USDA Census of Agriculture 2002; Länderbericht USA, Agrarexportförderung 2020).

The shortage of workers is also very evident in Germany. Jobs in the construction industry remain unfilled for 274 days on average. According to the German Federal Statistical Office, a similar picture can also be seen in agriculture in Germany: The number of workers dropped by 7 % here between 2020 and 2023, in particular due to a decline in family and seasonal workers. As a result, larger, technologically equipped farms are more likely to dominate in future because they better utilize economies of scale, employ modern machinery more efficiently, and can address the shortage of skilled workers in a more targeted manner through automation.



! The automation of mobile machines has progressed from a visionary topic of the future to a specific field of action. Companies and municipalities that invest early in rugged, AI-supported systems not only secure efficiency advantages but also position themselves as a technology leader in a rapidly changing market.

SENSORS IN DEMANDING OUTDOOR APPLICATIONS

Whether it be agriculture, construction or municipal technology – the high performance of modern sensors and assistance systems is on display in numerous fields of application. Specific examples of machines show that automation not only increases safety and efficiency but also opens up new opportunities for sustainability and networking.

Sensor data fusion	**Robotics**	**Automation**	**Productivity increase**

Please select one of the following topics to obtain more information.





TRENDS AND STRATEGIES

Mobile machines need to combine safety, efficiency, and automation. The following developments are pointing the way forward:

→ **Functional safety in outdoor applications** – The international standard DIN EN ISO 13849-1 makes safety-oriented systems for mobile machines indispensable. It defines requirements on the safety-related parts of control systems and specifies how to determine and achieve the required performance level (PLr) for safety-relevant functions. Sensor-based safety systems such as Safe Brake Assist make it possible to safely stop machines in case of danger. Technologies such as LiDAR, ultrasonic, camera and radar detect hazards in real time and help ensure compliance with the functional safety requirements.

→ **Sensor fusion** – By combining LiDAR, camera, radar, and ultrasonic technologies, AI-supported systems are created that increase the availability and the detection capability of the sensor system.

→ **Autonomy level 4/5** – Fully autonomous mobile machines are already in use in clearly demarcated areas such as mines or large construction sites. SICK provides a scalable technology portfolio for this purpose.

→ **Productivity pressure** – Sensor technologies automate repetitive tasks such as leveling or compacting while at the same increasing the process quality.

TECHNOLOGY AS A SUCCESS FACTOR

The key to modern automation

Implementing autonomy requires choosing the right technology. Outdoor automation presents a complex challenge – dust, rain, vibrations, shifting light conditions, and rugged terrain demand sensors that are not only highly precise but also durable and adaptive. Equally important is ensuring that these solutions are easy to plan, integrate, and support in real-world applications. A well-designed system architecture, modular interfaces, and robust technical support can significantly shorten development cycles and reduce implementation risks.

→ Criteria for rugged sensors
→ Interactive graphic



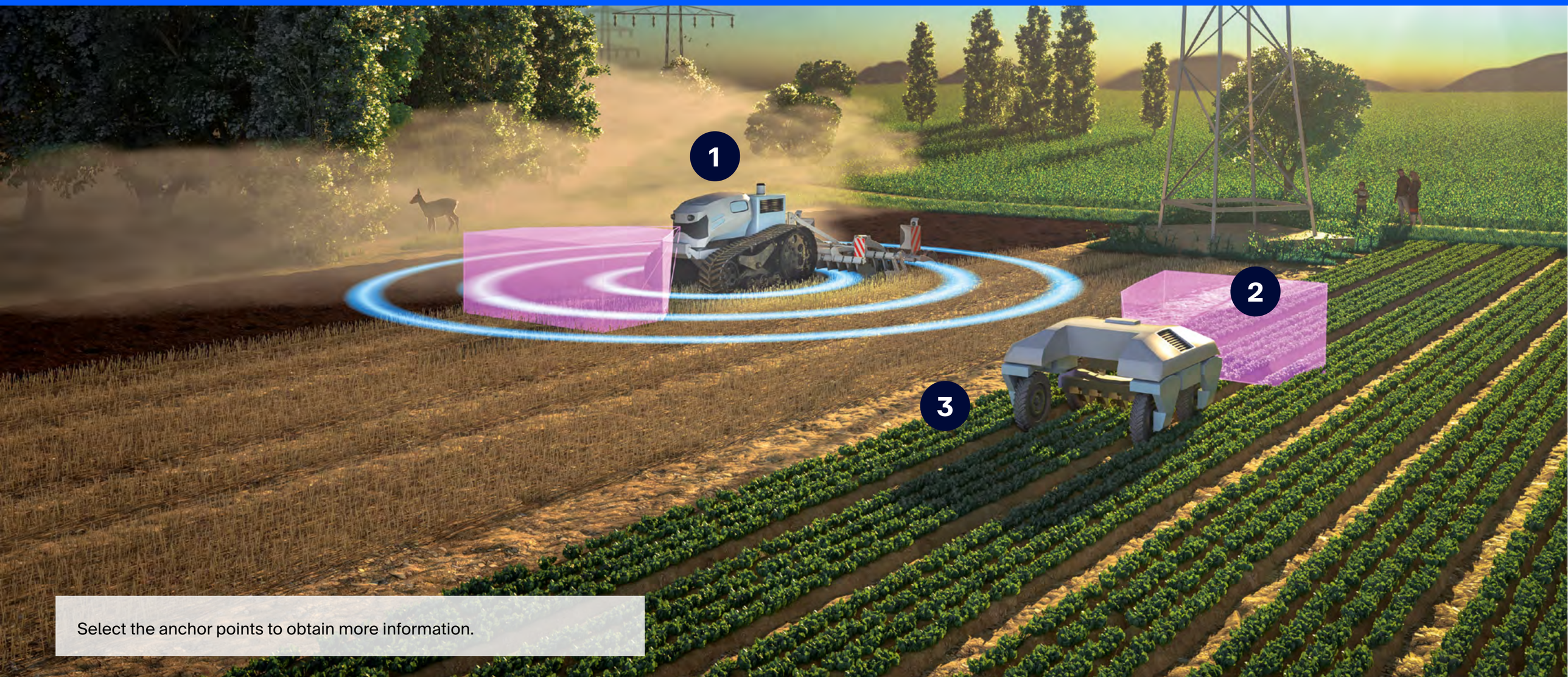


CRITERIA FOR RUGGED SENSORS

Modern machines utilize a multitude of sensors which, together, generate a comprehensive and reliable picture of the surroundings. **LiDAR sensors** precisely and in real-time detect different types of terrain and obstacles – even when moving. **Radar sensors** retain their performance even in dusty, foggy or snowy conditions. **Modern stereo cameras** capture not only visual data such as colors, textures or contrasts but also precise information on distances. **Ultrasonic sensors**, on the other hand, offer a cost-effective means of measuring distances in tight spaces.

Only through **sensor fusion** – the intelligent merging of these data sources – is a complete understanding of the surroundings created. This enables, for example, blind spots to be reduced, safety zones to be dynamically adjusted, and machines to be given the ability to navigate independently.

A further crucial field is the area of **Motion Control**, where **encoders**, **inertial sensors or proximity sensors** enable the precise positioning of vehicles and attachments – even on steep inclines or rough terrain. This is especially important for applications in agriculture and forestry where machines need to operate with precision, for example when sowing rows of plants or when loading logs.



Select the anchor points to obtain more information.

AUTOMATION SOLUTIONS FROM SICK

Practical application of intelligent sensors for mobile machines

SICK offers a comprehensive portfolio of automation solutions that have been developed and tested for the challenges of outdoor applications on mobile machines. In this section, you will find out, by way of concrete examples, how the technologies from SICK are solving real-life problems.

→ Overview: outdoor ready
→ Motion Control
→ Environmental perception
→ Safety



OVERVIEW: OUTDOOR READY

SICK's portfolio of sensors for outdoor applications ranges from environmental perception to Motion Control right through functional safety. These solutions intermesh with one another: sensor data for environmental perception flow into movement algorithms, safety functions also evaluate the ambient conditions at the same time and respond with lightning speed to hazards.

SICK subjects its sensor technologies to a multi-stage testing process that comprises not only internal laboratory tests but also endurance testing under real-life conditions:

→ **Outdoor Test Center (OTC)**
SICK operates in-house test fields that are active 365 days of the year. Here, sensors are tested under realistic ambient conditions.

→ **Corporate Test Center (CTC)**
In addition to field tests, SICK also performs standardized test methods in climate-controlled test laboratories. These include, among others, rain chambers, salt spray tests, shock and vibration test rigs as well as EMC resistance tests.

→ **Certified external testing facilities**
These are validated according to international standards (e.g. EN 60068, ISO 20653) by independent bodies.

→ **Field tests at the customer**
In the end, it's reality that counts. All solutions are integrated directly into construction vehicles, tractors or combine harvesters in collaboration with OEMs and tested over a period of weeks or months.





MAIN FIELDS OF APPLICATION OF INTELLIGENT SENSORS

The automation of mobile machines requires sensor solutions that are precise, rugged and versatile. SICK offers three perfectly matched technology areas for this:

→ **Motion Control**: Precise motion control – enabled by inclination sensors, encoders, and proximity sensors – ensures safe positioning and reliable operation, even under extreme conditions.

→ **Environmental perception**: Surrounding perception using LiDAR, radar, cameras, and ultrasonic sensors enables navigation, object detection, and collision avoidance – even in challenging weather and demanding environments.

→ **Safety**: Certified safety systems, combined with well-defined processes and trained personnel, ensure reliable protection for both people and machines – even in dynamic, complex environments.



MOTION CONTROL

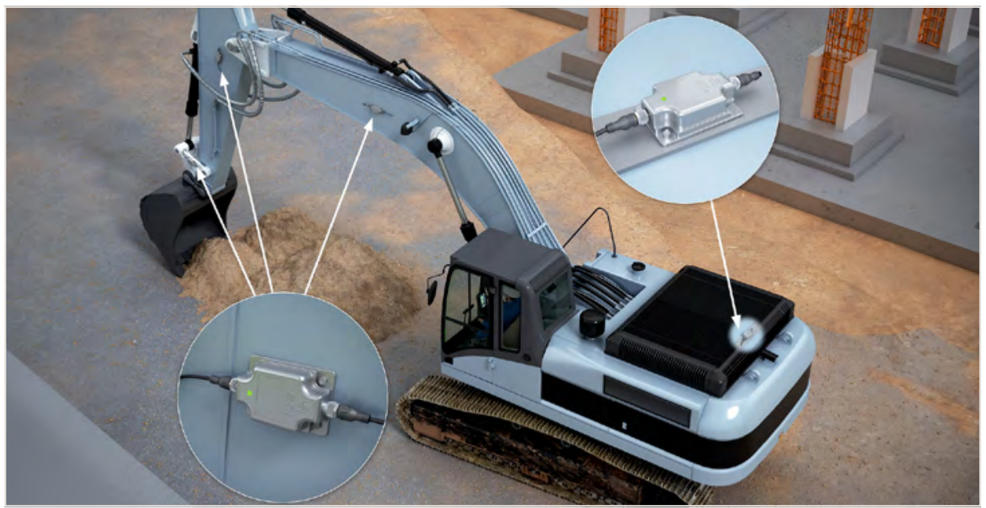
Precise movement data is essential for numerous applications. SICK offers a wide range of motion control solutions that are optimized for use in mobile machines:

→ **Inclination sensors (e.g. TMS/TMM88 Dynamic or TMS/TMM22)**
These inertial sensors measure changes in angle in one or two axes with a high resolution. They are ideal for leveling crane structures, aligning scissor lifts or controlling cutter bars.

→ **Absolute encoders (e.g. AHS/AHM36)**
They measure the rotational movement of booms, support feet or wheel drives. CANopen and SAE-J1939 interfaces allow seamless integration into existing vehicle control systems.

→ **Linear encoders (e.g. MAX48)**
The encoders contactlessly register the piston position in hydraulic cylinders with high measurement accuracy. This continuous position feedback allows precise control, reliable monitoring and automated processes in hydraulic machines.

→ **Inductive proximity sensors (e.g. IMG, IMB or IMS)**
These reliably and contactlessly detect metallic objects and are especially resistant to dirt, moisture and vibration. The solutions are designed for harsh ambient conditions, with vibration resistance, different enclosure ratings and uncomplicated mounting options.





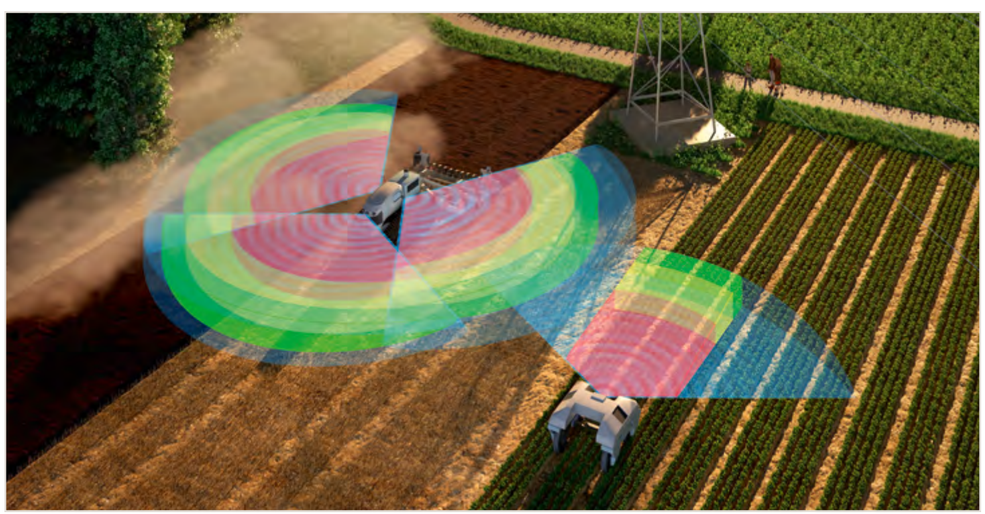
ENVIRONMENTAL PERCEPTION

Perceiving the environment almost like a human – this is the aim of modern sensor technology. SICK allows different sensor types to be combined to create a complete picture of the surroundings:

- → **2D LiDAR sensors (e.g. picoScan100)** are compact, cost-efficient and reliable. They are suitable for tasks such as contour guidance or quality control, for example to detect edges, outlines or deviations when processing agricultural or forestry products.
- → **3D LiDAR sensors (e.g. multiScan100, MRS1000)** record environments as point clouds in three dimensions – for navigation on uneven terrain, object detection and volume measurement.
- → **Radar sensors (e.g. RMS2000)** operate regardless of the visual conditions and are ideal for dusty, rainy or foggy environments – e.g. for reversing assistants or blind spot detection.
- → **3D cameras (e.g. Visionary-B Two)** capture visual data in 3D as well as depth information – for detecting people, machines or loads in a complex environment.
- → **Ultrasonic sensors (e.g. UM30, UC30)** are suitable for near-range applications, even with transparent or poorly reflective objects.

Functions such as **Contamination Indication** detect contamination early and report the need for cleaning – an important feature for low-maintenance autonomous machines.





SAFETY

SICK is a manufacturer of certified sensor solutions for mobile outdoor applications. The core offering is rugged solutions that perform their protective functions reliably even under extreme ambient conditions.





1. FUNCTIONALLY SAFE SENSORS

→ multiScan100-S: 3D LiDAR with functional safety according to Performance Level b for large monitored spaces.

→ safeRS3: Radar-based sensor technology, ideal for dust, fog or darkness.

→ outdoorScan3: The world's first 2D safety laser scanner with SIL2/PL d certification for outdoor applications.

→ Safety switches and safety controllers such as Flexi Soft or Flexi Mobile that process the signals from safety-relevant sensors and initiate targeted measures.

2. SAFETY SYSTEMS

With the Safe Brake Assist, SICK offers an ISO 13849-certified braking assistance system that prevents collisions with people and infrastructure in outdoor areas. It does so using 3D LiDAR sensors that continuously measure the distance between the vehicle and potential obstacles along the vehicle's path based on vehicle movement data. This ensures a safe and smooth operation even under demanding ambient conditions such as steam, heat or rain.

3. SAFETY CONSULTING AND ENGINEERING SUPPORT

Besides hardware, SICK also offers comprehensive consulting services in the area of functional safety, including risk analyses, feasibility studies and assistance with the standards-compliant implementation of safety-critical applications. OEMs and operating entities thus obtain single source solutions – from concept to validation.

FROM THE IDEA TO SERIES PRODUCTION

A partnership with SICK

Innovation doesn't occur in a vacuum. It is the result of strong partnerships. OEMs and system integrators that want to make their mobile machines smarter, safer and more efficient will find in SICK more than just a sensor supplier – they will find a **development partnership of equals**. From the first idea to successful series integration, SICK accompanies you with technological know-how, high industry knowledge and a clear goal orientation.

SICK is not only a technology leader but also an experienced development partner who focuses on long-term collaboration. With over 75 years of sensor knowledge and a modular portfolio of LiDAR, radar, camera, motion control and safety products, SICK provides cross-industry support – from farming to construction through to municipal technology. Global presence meets local proximity: application centers around the globe, support in the local language, and fast project assistance are par for the course. Even custom solutions can be implemented flexibly – from plug modifications right through to integrated algorithms.

SICK stands for partnership, not just product delivery: transparent communication, support beyond the conclusion of a project, and sustainable development are all provided as standard. Whether it be new vehicle platforms or retrofit projects, true innovation begins with the first discussion. You know your machines – SICK delivers the right sensor foundation.

Would you like to find out more? Then take advantage of the possibility of a no-obligation personalized consultation – tailored to your specific requirements.

Contact us now





CONCLUSION

Outdoor ready and safe:
Your ticket to autonomous machines

Rugged, intelligent sensor technology is a key driver for safer, more productive, and cost-efficient operation of mobile machines. Solutions from SICK – including LiDAR, radar, camera, and motion control systems – deliver reliable data even in rain, dust, vibration, and extreme temperatures. Through sensor fusion, these technologies create a comprehensive environmental view that enables both advanced assistance systems and fully autonomous workflows. Early investment in these solutions helps reduce downtime, mitigate the impact of skilled labor shortages, and unlock economies of scale.

Analyze your core processes and identify recurring and safety-critical tasks. Then define a stepwise automation concept: (1) Selection of an outdoor-capable sensor technology based on industry-typical environment requirements, (2) Modular integration via CAN, Ethernet or ROS and (3) Pilot operation with SICK support until series-production readiness.

By acting now, you will position yourself as a technology leader in a market where automation is the driving force of change.

SICK AT A GLANCE

SICK is a leading international manufacturer of intelligent sensors and sensor solutions. With over 10,000 employees and more than 60 subsidiaries and affiliates as well as numerous agencies worldwide, SICK is always close to its customers.

With a unique range of products and services for factory and logistics automation, SICK is adding value along the entire value chain of its customers. SICK also offers its customers extensive industry and application experience and a deep understanding of their processes and requirements.

SICK stands for partnership-based collaboration, improved productivity, high quality, and safety and the protection of health.

THAT'S "SENSOR INTELLIGENCE".

Find out more at www.sick.com/mobile-machines

