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## Whitepaper

# High-performance automation for mobile robots: PC-based control

## AGVs and AMRs in production and intralogistics

The market for AGVs (automated guided vehicles) and AMRs (autonomous mobile robots) is rapidly expanding, propelled by the additional flexibility, efficiency, and safety that driverless transport systems bring to the world of intra- and production logistics. This is where Beckhoff's powerful, compact and flexible automation platform, PC-based control, is enabling users to unlock major technological advantages.

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► [www.beckhoff.com/agv](http://www.beckhoff.com/agv)

Even before the pandemic, all kinds of companies were taking a close look at industrial robots – and with good reason. Robots offer opportunities to mitigate the shortage of skilled workers, improve productivity, and maintain operational quality at a consistently high level. Robots often take on monotonous and strenuous tasks that employees don't want to do, such as heavy lifting.

The pandemic intensified staffing shortages further still, creating a surge of interest in robots for fulfillment and manufacturing environments. After all, end users want – and need – to respond flexibly to the changing requirements of their customers, which is why they are increasingly demanding innovative concepts that allow them to change the configuration of their systems quickly and easily.

### AGV

#### **Automated Guided Vehicle**

Vehicles that move on a specific, defined path. They are steered automatically but can only drive on a predefined route.

### AMR

#### **Autonomous Mobile Robot**

Vehicles that move independently through their environment. They can independently detect obstacles and avoid them.

The combination of these factors has been the catalyst for a growing trend in logistics and production operations for the use of AGVs and robots, notably of the autonomous mobile variety. Forbes Business Insights forecasts an average annual global growth of 23.7% for autonomous mobile robots from 2021 through 2028, ultimately reaching \$8.7 billion (€8.07 billion). With the dramatic increase in e-commerce sales, the warehouse and distribution center industry is expected to record the highest growth in mobile robots, followed by manufacturing applications.

In many cases, the capabilities of mobile robots can be limited by the underlying technologies, as most control platforms for autonomous mobile robots consist of different systems (PLC, motion control, navigation system, safety system, and battery system). Combining these separate components of an AGV control system has traditionally been a complex task, requiring meticulous integration and wiring within the compact frame of an AGV. This is where Beckhoff's PC-based control offers a critical advantage as one of the most compact control systems for mobile robots, combining all the necessary functions into a single compact machine control system. Even the navigation, which primarily takes the form of a separate black box, can be implemented with the open, PC-based control technology from Beckhoff – potentially on a separate processor core of the CPU or in a different operating system running in a virtual machine on the same CPU if required.

## A high-performance control platform for AGVs and AMRs

**Beckhoff implements open automation systems using tried-and-tested PC-based control technology. The main areas that the product range covers are industrial PCs, I/O and fieldbus components, drive technology, automation software, control cabinet-free automation, and hardware for machine vision. EtherCAT as a real-time Ethernet fieldbus ensures high-performance communication.**



The modular range of components from Beckhoff provides a clear competitive advantage in the automation of AGVs and AMRs.

Various product ranges that can be used as individual components or integrated into a complete and mutually compatible control system are available for all sectors – even for autonomous systems such as AGVs, AMRs, and shuttles for automated storage systems. With achievable update rates in the sub-millisecond range and jitter of less than 5 microseconds, PC-based control offers end users a deterministic control platform providing highly accurate control without performance limitations.

Another key advantage of PC-based control from Beckhoff is that the various control tasks of an AGV can be distributed across the individual cores of a multi-core CPU in order to optimize the CPU performance, even boosting a single core if required via TwinCAT's Core Boost. The result is a fully integrated system architecture based on a single embedded or industrial PC that performs all AGV functions: PLC, motion control, HMI, vision, robotics, analytics, machine learning, all relevant

safety functions, and even third-party software (for navigating the AGV, for example). PC-based control eliminates the need for separate hardware for each complex function, significantly enhancing the life cycle and integration of the system while also supporting the synchronous

execution of functions. The integration of all functions into a single, compact control hardware not only reduces costs, but also dramatically reduces the space required in the vehicle carrier – and installation space is always at a premium in an AGV.

### The essentials at a glance

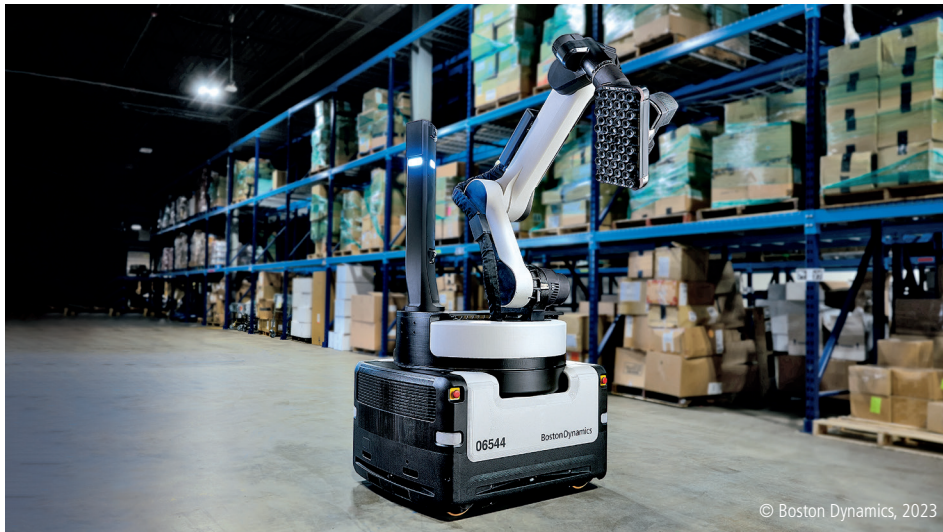
- + Beckhoff provides compact components for the automation of AGVs and AMRs
- + different form factors, designs, and connection concepts for control and I/Os save space in the vehicle frame and installation costs
- + PC-based control facilitates the integration of previously separate tasks (motion, navigation, safety, robotics) into a scalable platform
- + simple combination with existing drive concepts, sensors, and safety sensors



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Oceaneering Mobile Robotics (OMR) has the powerful, space-saving automation technologies from Beckhoff to thank for automating its highly compact, maneuverable material handling robot for manufacturing and medical facilities.





Stretch™ combines Boston Dynamics' three decades of R&D with automation and integrated safety technologies from Beckhoff.

## EtherCAT eliminates communication problems

Communication protocols are also critical for controlling mobile robots. This is where EtherCAT as a real-time Ethernet fieldbus offers considerable advantages. EtherCAT was introduced by Beckhoff in 2003 and made available to all device manufacturers right from the start via EtherCAT Technology Group (ETG). The broad acceptance of the communication standard by over 7,500 ETG members highlights the sheer abundance of available components. EtherCAT also facilitates the integration of peripheral devices without an EtherCAT connection via a wide range of communication interfaces, such as for CANopen. The TwinCAT automation platform also supports over 30 different communication protocols, which makes it easy to integrate battery systems and other peripheral devices, while also offering straightforward communication to local or public cloud services.

A wide range of EtherCAT Terminals, EtherCAT Box modules, and EtherCAT plug-in modules provide different I/O signals and ensure that practically all AGV components can be connected to the controller with minimal effort. One of the EtherCAT Box modules, for example, offers an integrated acceleration sensor and gyroscope that can measure the swaying of the load and transmit this directly to the controller via EtherCAT.

EtherCAT plug-in modules are a particularly compelling option for the series production of AGVs and AMRs. When combined with a customer-specific circuit board, they eliminate the need for point-to-point wiring, which not only reduces wiring work and wiring errors, but also generates significant cost advantages for larger production runs. EtherCAT P combines communication and power on a 4-wire standard Ethernet cable to offer even further potential savings during installation.

As a state-of-the-art communication system, EtherCAT not only ensures deterministic transmission of control data, but also enables the transmission of safety-critical control data according to the black channel principle over the

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“Communication protocols are critical for controlling mobile robots. As a real-time fieldbus, EtherCAT offers considerable advantages.”

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Global Intralogistics Industry Manager,  
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same medium. EtherCAT uses the Safety over EtherCAT protocol (FSoE: FailSafe over EtherCAT) to this end. Its Safety over EtherCAT frames are routed via the standard communication path – for example, via the EtherCAT Automation Protocol (EAP).

Beckhoff uses TwinCAT FSoE for communication between the wide range of TwinSAFE components and the safe drive technology. Combined with the powerful TwinCAT 3 Safety Editor, this enables the implementation of all functions required for safe operation of autonomous mobile robots – including safe velocity and safe selection of person detection fields, as well as safe lift and tilt monitoring. Since EtherCAT FSoE works according to the black channel principle, TwinCAT FSoE also works with wireless communication – an important aspect for communicating the safety conditions of each mobile robot to the fleet management system.

Low-voltage compact drives including integrated safe motion functions for stop, speed, position, acceleration, and direction of rotation – such as those provided by Beckhoff – are indispensable for the automation of mobile robots.

## Software defines functionality

Flexibility and features are paramount in mobile robots, so it follows that the underlying technology should have a similar focus. With TwinCAT, the basic components can be supplemented with additional TwinCAT functions, including machine learning and analytics for optimizing AGVs and AMRs. High-performance tools are

also available for diagnostics, including the TwinCAT 3 Scope View software oscilloscope for a comprehensive analysis of all signal curves and system states. EtherCAT and controller diagnostics can be integrated directly into the TwinCAT HMI system visualization via API with zero engineering effort involved.

Another major trend that requires flexibility is industrial mobile robots. Essentially, this means a mobile robot with an articulated robot arm that can perform picking or palletizing functions. The openness of TwinCAT and EtherCAT means the Beckhoff platform can support nearly any third-party robot.

Beckhoff has also announced a modular robot called ATRO (Automation Technology for Robotics). This unique, emerging technology increases customization in these and other applications.

ATRO is a modular robot system in which various link and motor modules can be used to build robot kinematics that are optimally adapted to the task at hand. Cables for communication, power, and pneumatics are routed through the center of the robot arm so that it can rotate endlessly on each axis. This eliminates the need for disruptive external cable guides

that limit the reach of the robot arm. Perhaps the greatest advantage of the ATRO system is that it is fully integrated into the TwinCAT control architecture, meaning no separate robot controller is required. The mobile robot controller from Beckhoff also handles the ATRO kinematics. ATRO is opening up new possibilities for mobile robots with added robot arms, providing the flexibility required by many end users in retail and parcel delivery services.



The modular industrial robot system ATRO simplifies handling in intralogistics and production

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**Autonomous mobile robots are playing an integral role in modern warehouse and distribution centers, with the market evolving rapidly as more and more providers enter the arena. Companies in this crowded space need ways to be more competitive by offering smaller, more agile mobile robots that combine long life cycles with straightforward maintenance. This is where Beckhoff represents an ideal partner, offering compact, high-performance, and safe control and drive solutions to give you the competitive edge required to establish a leading position in this rapidly evolving market.**

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