AUTONOMOUS MOBILE ROBOTS: THE ESSENTIAL GUIDE TO SAFETY AND PRODUCTIVITY

VECNA robotics

SICK
Sensor Intelligence.

Workplace safety and productivity on the production floor are closely related. Manually operated material handling equipment can be subject to a great deal of wear-and-tear due to aggressive driving habits typical of fast-paced environments, as well as accidents and collisions. The high risk of injury and its associated cost from aggressive and inexperienced driving makes warehouse safety a top concern for industrial settings. OSHA estimates that 97,000 forklift injuries occur annually. In 2017, the Bureau of Labor Statistics reported an average of five injury and illness cases per 100 full-time workers for the warehouse and storage industry. Not only do these accidents and injuries take a toll on workers' health, but they also lead to costly insurance premiums. These factors – combined with low job satisfaction, high employee turnover, vehicle collisions, damaged goods, and wear-and-tear to material handling equipment – negatively impact productivity on the floor.

In response to these common challenges, the use of self-driving vehicles and robotics in the warehousing industry is rapidly becoming the norm. Automated material handling equipment – including Autonomous Mobile Robots (AMRs), Automated Guided Vehicles (AGVs), Visually Guided Vehicles (VGVs), and robots by any other name – can reduce the risk of workplace injury and increase equipment longevity, while also improving efficiency and reducing costs.

However, not all robots are made equally. SICK, Inc. and Vecna Robotics, Inc. have partnered to create a system that maximizes throughput, warehouse density, worker safety, and equipment longevity with a Performance Level D safety system, a high-level navigation system, and advanced braking.

This guide will take an in depth look at:

- How a Performance Level D safety system works and why you need one
- How robots operate efficiently in a highly dynamic environment
- How a properly implemented safety system reduces wear-and-tear on equipment and increases system reliability and safety

For facilities looking to implement an autonomous material handling solution, this guide provides information for understanding how robotic platforms work, and determining the best solution for your facility.

HOW A PERFORMANCE LEVEL D SAFETY SYSTEM WORKS AND WHY YOU NEED ONE

Not all robots are made equally. The average automated material handling robot on the market doesn't use all the features available with the latest safety technology, which means the vehicles are not performing to the highest level possible. Vecna Robotics' AMRs use SICK's components to achieve both high levels of safety and productivity.

Why Performance Level D Matters

A properly-designed robot will have a Performance Level D Safety System that brings the robot to a complete stop if it deems that the situation is, or could become, unsafe. Performance Level D is defined by ISO 13849 as a control system that has a probability of dangerous failure per hour between 10-7 and 10-6, which means there is a probability of 1 dangerous failure to every 1 million to 10 million hours. In other words, if the robots were running 24 hours a day, 365 days a year, it is mathematically guaranteed to run anywhere from 141 to 1,141 years of continuous operation without a fatal accident.

In light of current industry statistics, this Performance Level D Safety System is not only cost saving, but potentially life-saving as well. Vecna Robotics' solution running SICK's components is a Performance Level D Safety System that guarantees an electronic failure will not be the reason a robot collides with anything.

Building Blocks of a Performance Level D Safety System

There are several basic components that comprise a Performance Level D Safety System, including LiDAR, safety controller, encoders, relays, and a data gateway. These components work together to translate all the safety data to the robot's onboard PCs. Here's how it all works.

LiDAR

LiDAR, short for Light Detection and Ranging, is a device that is primarily used for navigation and collision avoidance. It uses the time of flight concept: the device sends a pulse of light, bouncing it off a target, and then measures the amount of time it takes to reflect back. Based on how long it takes and the knowledge of the speed of light, LiDARs can compute the distance to the target. Today's safety-rated LiDAR technology can scan 360 degrees to find the distances to all objects within the laser's plane, creating a data set that represents a two-dimensional understanding of its surroundings. In AMRs, LiDARs are typically used to give the robot a sense for how close it is to any object or human.

With strategic and proper use of 2D LiDAR, manufacturers can collect data and, essentially, create a map of the entire facility to be used by the AMR. This enables the AMR to move autonomously from different touchpoints in the production process all without human intervention.

Safety controllers

Safety controllers aggregate all of the data from the robot's LiDARs and other sensors. They use this data to determine if the robot is safe or could become unsafe. If the safety controller deems the situation is unsafe, it has a safety-rated actuation system that brings the robot to a complete stop. Safety controllers typically run custom application code written by the developers of the robot. The more flexible the base safety controller, the more finely attuned the safety system response to the outside world.

Encoders

Encoders are sensors that either measure the speed of a motor, which determines the speed of the robot, or the vehicle's wheels' rotations per minute (RPMs). For instance, on the robot's drive wheel, an encoder can sense the angular velocity and position as well as the steering angle of the robot's drive wheel, therefore telling the robot what direction the wheel is pointing and how fast it is going.

Relay

A relay is a device that use one signal to switch another signal on and off. In the context of AMRs, the safety-rated relay is the device that uses the output of the safety system to control truck power, switching it from on to off or vice versa.

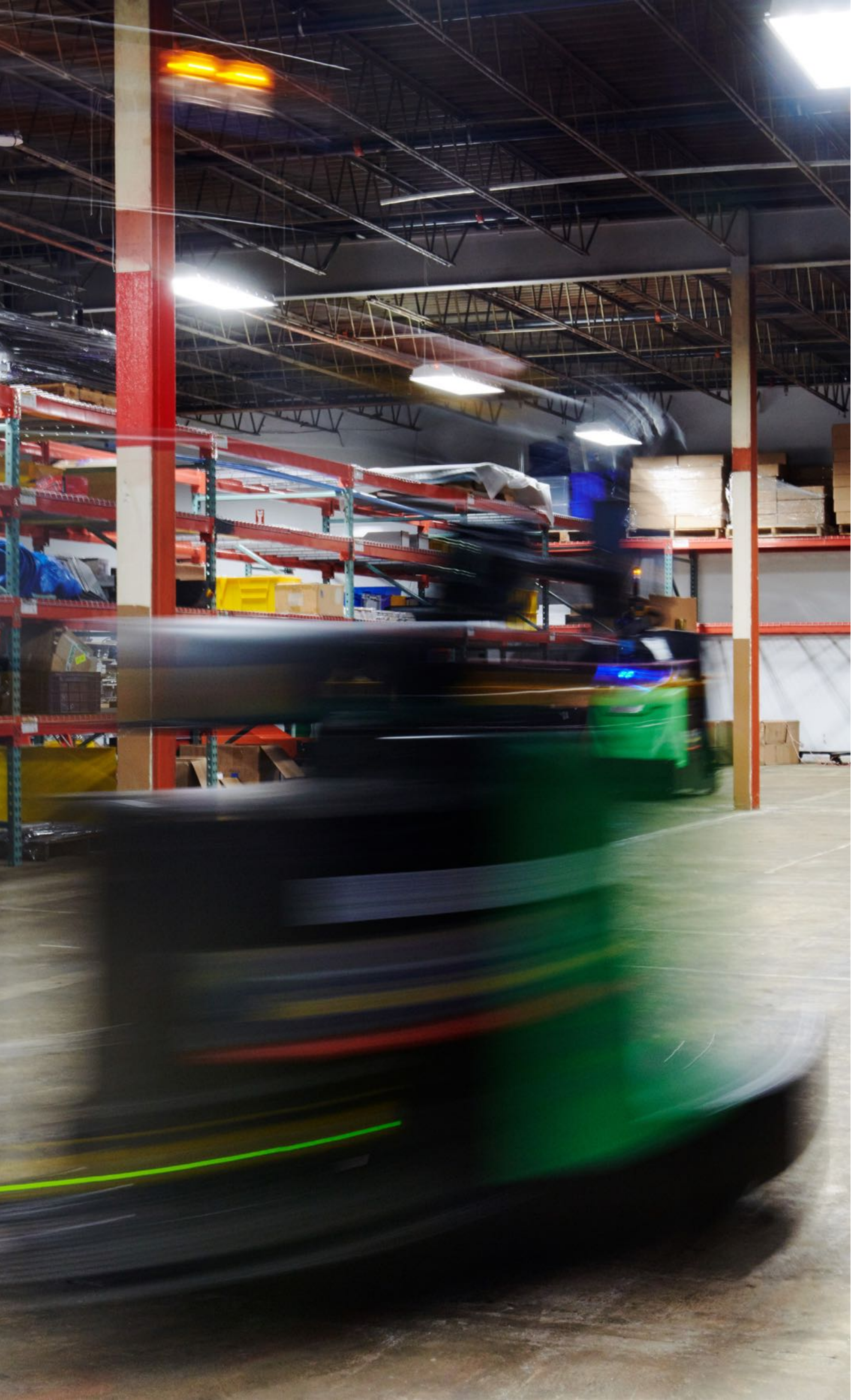
Safe EFI-Pro System

The Safe EFI-Pro System from SICK is a bridge between the robot's safety system and onboard PC. The industrial Ethernet-based EFI-pro network technology enables the quick exchange and transmission of safe and non-safe data throughout all levels of communication including software, systems, platforms, and sensors.

The sensors connect to a PC-based controller over Ethernet using EFI-Pro Gateway that provides access to the safety system. This allows manufacturers to see if a vehicle is stopped, why it stopped, how fast it went, how many times it stopped, and what it stopped for (e.g. a static object or a moving object). This data empowers you to gain better control of your processes to make them more efficient. Vecna Robotics' solution uses SICK's encoder data to tell onboard computers what the vehicle is doing at all times.

A Comprehensive Solution for Productivity and Safety

Performance Level D Safety Systems are industry standard, however, there is a wide variety in the way that robots use components and features that make some automated material handling equipment stand out from the rest. Vecna Robotics' platforms use SICK's Performance Level D Safety System components in a uniquely innovative way, which enables robots to gather more data for safer stops and more effective operation in unstructured, dynamic industrial environments.



HOW ROBOTS OPERATE EFFICIENTLY IN A HIGHLY DYNAMIC ENVIRONMENT

The production floor is a rapidly changing environment. Traditional line-following AGVs were inflexible to dynamic environments. With these, an AGV had a predetermined path, requiring it to stop and wait for the path to clear if anything came in its way. It was also limited in its ability to do anything more than shuttle goods from point A to point B. Many solutions that have come to market since line-following AGVs are still limited by obstacles and multi-purpose capacities, as they lack effective navigation, obstacle detection, and onboard safety modules.

Why Two Encoders Are Better Than One

Many companies now use self-guided vehicles for various tasks, but moving around obstacles can be a challenge without proper sensor technology in place. Where most self-guided vehicles measure speed alone, Vecna Robotics' AMRs also take vehicle direction into account. On each vehicle, Vecna Robotics uses two SICK encoders: one to measure speed and the other to measure direction. This information is used to optimize the shape and size of its safety zone. The safety zone is a protective field around the robot that acts like a virtual bumper. If the robot senses that something has entered or is touching the edge of the safety zone, it will come to a stop. The size and shape of the safety zone has big implications for aisle width and productivity.

The incremental encoder used on Vecna Robotics systems is SICK's DFS60S Pro, which monitors wheel speed. The encoder sends this data to SICK's Flexi Soft modular safety system. It then interprets and monitors for safe speed, safe limited speed, safe direction, and safe brake control. The incremental encoder is used together with an absolute encoder (AFS/AFM60), which is placed near the tire to determine the steering angle of the vehicle.

The shape and size of the safety zone depends on the data from these two encoders. If the vehicle is going slow, the safety zone will be small; if it is moving fast, the safety zone will be bigger. If the wheel is turned to the left, the safety zone will shift left. If the wheel is turned to the right, the safety zone will shift right.

In an industrial setting, dual encoder-enabled navigation is critical as it directly impacts productivity and warehouse density. A robot should only stop if there's something in its path that puts the robot or personnel at risk. When solely detecting speed, a robot traveling forward it may come to a full stop if it sense an object beside it, even if that object doesn't cause a threat to safety. These frequent stops and starts impact productivity on the floor. This is similar to a pedestrian walking down a busy sidewalk. He doesn't – and shouldn't - stop each time a passerby or cyclist enters his peripheral vision; it would take a much longer time to get where he needs to go. Vecna Robotics' AMRs running SICK's safety system operate like a human in that regard; they only stop when an obstacle presents a hazard in the safety field.

In addition, if a robot can only sense speed, aisle width must be up to 12 feet wide because the safety field has to be large enough to account for every possible angle the vehicle could move. Wide aisles can cut into the amount of storage space available in a distribution center by up to 20 percent, often requiring warehouse expansion – which comes with a long list of associated costs.

However, by sensing speed and direction, the size of the safety fields shrink to make it narrower and aimed in the direction that the wheel is turned. This can save distribution centers up to five times in warehousing capacity and eliminate the need to expand or reconfigure the space.

How Multiple LiDARs Improve AMR Agility

SICK's microScan3 safety laser scanner enables self-guided vehicles to make smarter decisions when stopping, while still providing a maximum level of protection for humans working alongside it. With a 275° scanning angle and up to 128 protective fields, it provides a more flexible safety integration on robots that keeps processes moving. It is an agile solution that allows for simultaneous protective fields and contoured detection fields that can be optimized to fit any facility and application. In addition, it is built to function well even in harsh industrial environments. This eliminates forced stops as a result of dirt, dust, ambient light, and even insects.

The LD-OEM 2D LiDAR sensor is used for long-range navigation. This LiDAR laser scanner also works well in harsh industrial environments, but it provides reliable detection of small objects at long distances, up to 180 meters. Its long-range navigation works well for collision avoidance that can help keep aisles narrow.

With the combination of safety-rated and non-safety rated LiDAR sensors used on the machine, the safety zone responds to the robot's environment, enabling it to make smaller, tighter turns. It also provides a 360-degree view of the entire area surrounding the AMR. With a more nimble and agile solution, the machine can more easily navigate a facility. In addition, this LiDAR solution gives the robot the situational awareness needed to accomplish advanced tasks such as auto-hitching, auto-palletizing, and backing up.

How LiDAR Enables High-Level Mapping

With SICK LiDARs, Vecna Robotics' fleet management system Pivotal™ can collect data to create a map of the entire facility. This enables robots on the floor to move autonomously from different locations in the production process, all without human intervention. Not only this, but it enables robots to find a more efficient route through the facility if it detects a traffic jam. Thus, goods get from point A to point B faster by using the best route available.

HOW TO REDUCE WEAR-AND-TEAR ON EQUIPMENT WITH A MODULAR SAFETY SYSTEM

The average forklift runs 2,000 hours per year, with a lifespan of anywhere from 10,000 to 20,000 hours.[i] The wide variation in the average longevity of standard material handling equipment (MHE) is due in part to wear-and-tear and the variability of aggressive and inexperienced driving.

Self-guided vehicles are also subject to wear-and-tear if the systems installed in these vehicles communicate directly with the brake and power lines. This approach causes emergency shock stops, which can harm the vehicle's systems and loosen the brakes.

Modular Safety System to Control AMRs

Properly implemented safety systems embedded within robots can help to extend equipment longevity. LiDARs, safety controllers, and relays work together to create an advanced braking system that dramatically reduces emergency stops. A virtual bumper is determined by the LiDARs, which scans 360 degrees around the robot to determine its proximity to nearby objects. The safety controller then calculates the likelihood that the robot will hit an obstacle using the information in the safety field, the velocity of the vehicle, and pre-programmed knowledge of the vehicle's stopping distance. If the virtual bumper ever encounters an object, a stop command is issued. That command may be either an emergency stop or a safety stop.

The most common default stop command in robots today is an emergency stop, which occurs when vehicle power is cut abruptly via the safety-rated relay. Once the power is cut, it instantly engages the parking brake. An emergency stop puts unnecessary wear on the vehicle's brake system. Parking brakes are not designed for shock loading; they are designed to keep the vehicle at a stop. By putting unnecessary pressure on them with forced emergency stops, they will likely fail prematurely.

The potential consequences of this braking method are dangerous and costly. In this scenario, only the parking brakes are mechanically employed to stop the robot with no backup system. If the brakes fail, and the robot doesn't stop, there's a high chance of injuries or damage occurring in the warehouse. Emergency stops are like highway guardrails: they do damage to the vehicle, but they're still a better alternative than running into oncoming traffic or going off a cliff. Still, a guardrail is not a good default braking system.

In order to protect the longevity of the vehicles, the safety stop is preferable. Vecna Robotics' platform uses an advanced stopping mechanism offered only by SICK's modular safety system and encoders.

[i] https://www.tmhnc.com/blog/how-long-will-a-forklift-last-and-forklift-average-use

How to Eliminate Emergency Shock Stops

A Vecna Robotics AMR using SICK technology has encoders installed on it to measure two different elements. On each vehicle, two encoders are used: one to measure speed and the other to measure direction. In addition, LiDAR is used to monitor the navigation of the robot, including three safety laser scanners, one non-safety rated.

The encoders and safety laser scanners are able to communicate with one another through the use of SICK's Flexi Soft modular safety system. A motion monitoring module is used to monitor the speed of the vehicle, relaying that information back to the scanner.

The speed and position information is determined by the two encoders. The encoders are connected to the motion control module and Flexi Soft communicates the information to the scanners via EFI-Pro Gateway, depending on the exact hardware being used.

SICK's sensing technology communicates directly with the motor instead of the brake line to virtually eliminate emergency stops, and instead issues a stop command through the robot's non-safety-rated control system. The motion control module then monitors that the stop is executed via a safety-rated encoder. The mechanical braking system serves as an additional failsafe. A safety system equipped with the motion control module will only resort to cutting vehicle power if the vehicle's standard control system fails to bring the vehicle to a stop within a predetermined deceleration.

By using SICK's safety-rated motion control module, Vecna Robotics' soft stopping mechanism does not just make it more reliable, it also stops the vehicle faster. When the high-level auto system is in control of the wheels, the system kicks on an antilock brake to achieve the optimal stopping distance. This serves as yet another layer of safety.

THE MOST ADVANCED SAFETY FEATURES AVAILABLE TODAY

From production to delivery, automation is happening in all industries. Industry trends show that the use of autonomous mobile robots show no sign of slowing down. Gartner estimates that by 2022, one in five workers engaged in mostly non-routine tasks will rely on artificial intelligence to do the job instead.

As the use of these machines continues to increase, finding an appropriate safety solution that provides consistent protection of your workers and maintains a long lifespan for your equipment is critical to your success. Vecna Robotics' AMR solutions take full advantage of SICK's sensing technology, creating the most advanced safety features available on the market today. Adopting a Vecna Robotics solution utilizing SICK's innovative sensor technology can extend the life of your machines, increase production in your facility, and provide ample protection to your workers.

SICK

Sensor Intelligence.

SICK, Inc. is one of the world's leading manufacturers of sensors, safety systems, machine vision, encoders and automatic identification products for industrial applications. With more than 1000 patents, SICK continues to lead the industry in new product innovations. The diversity of its product line allows SICK to offer solutions at every phase of production in the logistics, automotive, packaging, electronics, food and beverage, and material handling markets. SICK AG was founded in 1946 and has operations or representation in 65 countries worldwide.

Learn more at SICK.com.

VECNA robotics

Vecna Robotics, Inc. is dedicated to helping companies better compete in today's e-commerce driven environment with cost-effective automation that improves throughput in distribution and fulfillment. Its fleet of intelligent, next generation robotic vehicles and AGVs optimize logistics and material handling operations and work seamlessly alongside humans. With extensive research and development, Vecna's case picking, goods-to-person, person-to-goods, robot-conveyor hybrid material handling systems have been proven in the most challenging environments.

Learn more at VecnaRobotics.com.