WHITEPAPER SERIES

VECNA robotics

EVERYTHING YOU NEED TO KNOW ABOUT AMR AND AGV NAVIGATION

AND WHY IT MATTERS

VECNA robotics

AT FIRST GLANCE,

High-capacity Autonomous Mobile Robots (AMRs) and Automated Guided Vehicles (AGVs) perform similar tasks. That is, they are capable of moving materials through industrial facilities. However, a robot is only as good as the efficiency gains it provides your organization. It turns out that it's not what the robot does that matters, but how. Since navigation is one of the biggest factors affecting your solutions' efficiency, we will take a closer look at what goes into efficient navigation.

First, let's define our terms. Navigation is the ability to get to the right destination (or destinations) at the right time. Think about your last trip to your local home improvement store. You use navigation to get from the front door to the plumbing department and back to check out.

The four distinguishing navigation features that help achieve greater efficiencies are: localization, path planning, obstacle avoidance, and precision maneuvers, such as smart pallet handling. A combination of these features makes the AMR smarter, more flexible, and more efficient than traditional AGVs, and frees workers to do their jobs without distraction.

LOCALIZATION

The first component of any mobile robot navigation system is localization, which refers to the robot's ability to know where it is in space. AGVs and AMRs have multiple options available, resulting in different costs, accuracy, and efficiency.

The Move Towards Natural Feature Localization

Traditional AGVs require some sort of infrastructure beacon for localization – this could involve wires, magnets, tape, reflectors/mirrors, stickers/QR codes, or any combination of these. As such, these permanent facility changes resulted in static systems that could only operate along fixed routes in pre-defined areas, and required significant recommissioning costs and facility updates if any changes were needed.

In contrast, AMRs and some more advanced AGVs use what is often referred to as natural feature-based localization. This technology uses lidar and camera sensors to make a virtual map of static features in the environment – like racking, walls, or pillars – and use these landmarks to help localize the robot without any costly infrastructure changes.

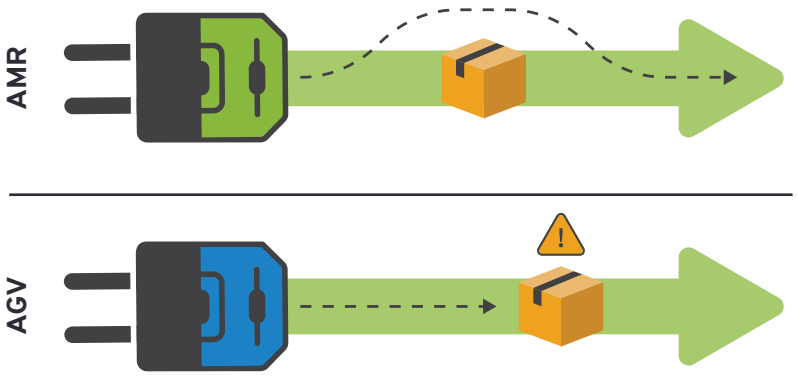
Indeed, many of these advanced AGV companies claim this is what differentiates an AMR from an AGV – the ability to navigate without infrastructure changes. However, as we will soon see, what makes an AMR is not its localization method, but mainly its intelligence.

Next to resource orchestration, navigation is one of the biggest factors affecting your operational efficiency. In this paper, we will discuss:

1. The difference between path planning and path following, and why it is critically important to the success of your automation program.
2. The role of obstacle avoidance in safety and efficient independent robot operations.
3. How localization, paired with path planning, create a robust solution, capable of adapting to changing environments.
4. Why smart pallet detection is central to keeping goods flowing throughout your facility.

THE BENEFITS OF PATH PLANNING OVER PATH FOLLOWING

PATH PLANNING VS. PATH FOLLOWING



Path Planning allows an AMR to adjust routing and navigate independently around obstacles without stopping and requiring assistance from workers.

To understand the primary difference between AGVs and AMRs, we'll first take a look at the differences between path following and path planning:

Path Planning refers to the ability for a robot to navigate freely in dynamic environments and tight spaces. By comparison AGVs historically utilize Path Following, which works by setting specific, predefined routes throughout a facility. Then, the AGV follows that path as accurately as possible.

There are several benefits to AMR Path Planning.

Obstacle Avoidance

All AGVs possess collision avoidance, which refers to the core robot safety systems that will sense any path blockages and safely slow down or stop the robot before a collision occurs. **However, only AMRs possess obstacle avoidance,** which refers to the ability of the robot to not only sense and slow down/stop for path blockages, but to also **reroute and circumvent those obstacles.**

Most warehouses are highly dynamic environments – goods are moving quickly, and workflows and floor plans change frequently. A Path-Following AGV is simply not robust to these changes. Obstacles in the path of the robot must be manually cleared, and staff must either temporarily re-route the AGV or program a new route to avoid congested areas. These frequent interventions and interruptions are cumbersome and consume workers' time, oftentimes even requiring dedicated labor resources. By comparison, an AMR will independently navigate around the obstacle and continue on its way.

Traffic Congestion

Another key difference in the way AMRs and AGVs handle obstacles that are near the path:

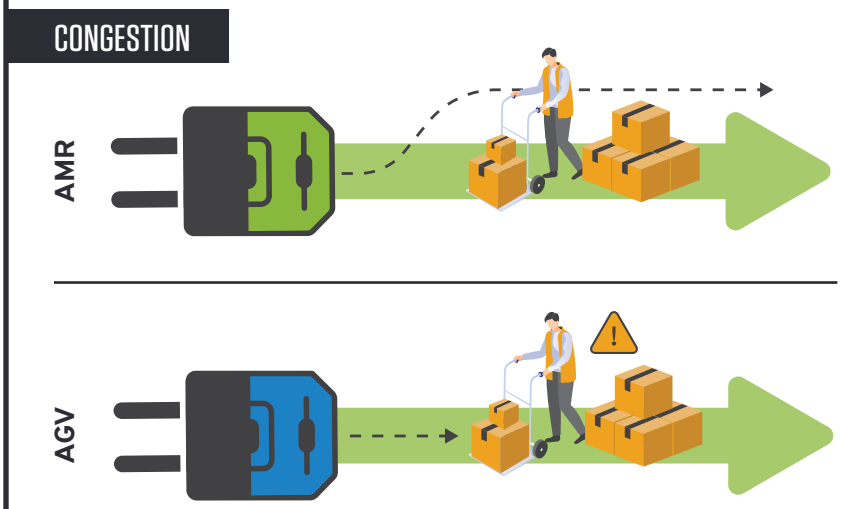
All mobile robots have safety fields with slow-down and stop zones and need a certain amount of buffer to drive at top speeds. Therefore, AGV vendors try to lay out paths to allow for this buffer during setup.

However, let's say a loading dock was clear when the AGV was installed, but the warehouse starts operating at higher capacity and some pallets are staged close to the travel aisle. This will cause an AGV to do one of two things – the first more benign than the second:

To optimize safety, most AGVs will slow down to a crawl while passing the pallets as their safety zones demand. However, to maximize productivity some AGVs might be programmed to ignore these and drive by the staging areas at a high speed, without leaving room for a person to egress.

The first scenario kills time. The second scenario is a major safety concern.

AMRs do not need to adhere to a fixed route. They use that ability to move over and provide more space to obstacles situated near the path, with ample room for people to safely move about.



By comparison, because an AMR is a Path-Planning robot, it does not need to adhere to a fixed route and can adjust its path to provide more space to the staged pallets near the path, allowing both the robot to drive at maximum speeds and still leaving ample room for people to safely move about.

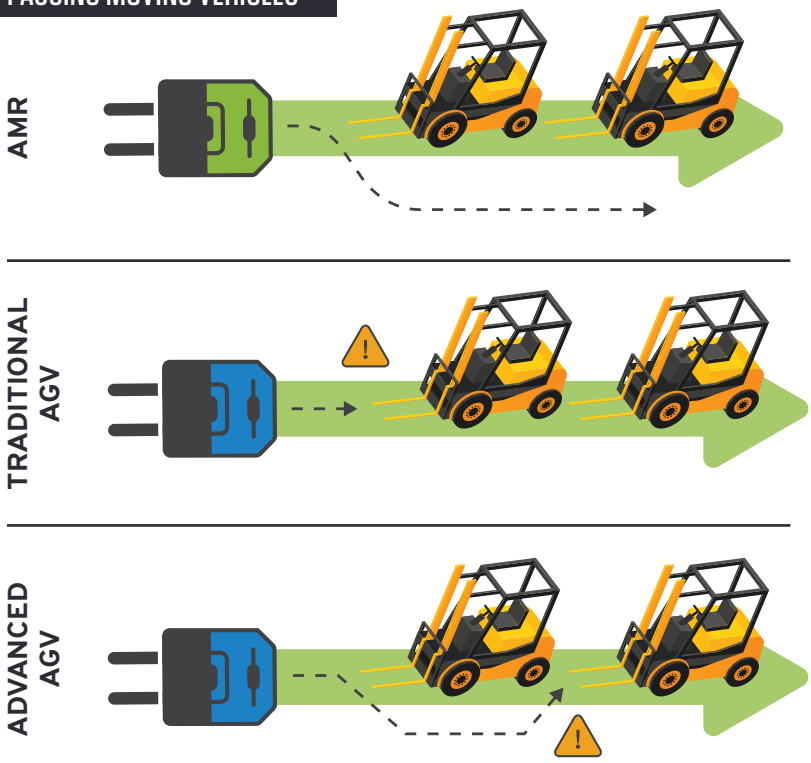
Dynamic Obstacle Avoidance

In a dynamic warehouse environment, AMRs share space with other AMRs, AGVs, and manually-operated vehicles. An AMR is designed to understand the "rules of the road" so it can operate seamlessly with the other vehicles and people in its shared space. That means in a situation where the AMR is encountering oncoming traffic, it will be able to move to the side to pass. It can also make smart decisions about when to return to the nominal path – returning only when the way is clear.

By contrast, advanced AGVs – and even some AMRs – use path following with limited obstacle avoidance behaviors. This allows AGVs to divert from their path for a short distance to avoid individual static obstacles. This is adequate for isolated instances, but when traveling in congested and/or high traffic areas, you often require smarter travel.

When applied in the case of oncoming traffic, the advanced AGV's limited obstacle avoidance behaviors could result in cutting another vehicle off or causing a deadlock that an operator has to resolve. In the same scenario, a traditional AGV will just stop, because it perceives an obstacle that it cannot go around. This AGV would block traffic altogether and likewise require an operator to intervene.

PASSING MOVING VEHICLES

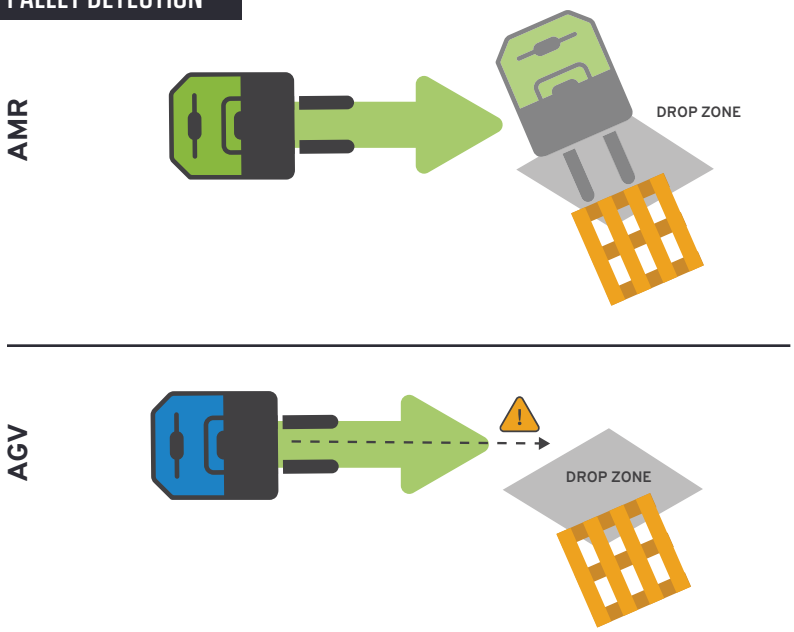


PALLET DETECTION

High-capacity AMRs and AGVs have one primary goal: move pallets efficiently. However, AMRs and AGVs are not created equally when it comes to pallet pickup and drop-off. This is a key area to understand when selecting a solution to maximize efficiency and performance.

One important distinction is how self-driving forklifts approach pallet pickup. Many AGVs are unable to pick up pallets and require a human to manually load the pallet onto forks. Even advanced AGVs that can independently pick pallets come with significant constraints on where and how pallets are staged and what range of pallets they can handle. However, AMRs are the most robust and flexible pallet-handling solution in the self-driving forklift category. Needless to say, independent pallet pick up is critical to overall efficiency, so workers don't have to stop what they're doing and assist the AGV.

PALLET DETECTION



AMRs make use of detection – that is, positive confirmation via on-board sensors – to determine if the pallet is there before they attempt the pickup. If the pallet is askew, or slightly out of the drop zone, the robot will be able to identify it. If the right pallet is not where the AMR anticipated it should be, it will move to the next drop area and search again.

The difference lies in pallet detection. AGVs are designed to navigate to a location where they think their target pallet should be. If the pallet is placed askew, or if the pallet is not in that exact location, the AGV will still attempt the pick until it realizes nothing has been loaded onto its forks. It will then wait for help from a human worker. We all know that a warehouse environment is far from precise and perfect where goods and people are moving at lightning speed.

While AGVs drive to predefined positions to pick up pallets, AMRs make use of intelligent pallet detection – that is, positive confirmation via on-board sensors – to determine if the pallet is there before they attempt the pickup. AMRs will travel to the area that they believe the pallet should be and look around for the right pallet just as a human would scan supermarket shelves for their favorite brand of soda. If the pallet is askew, or slightly out of the drop zone, the robot will be able to identify the fork pockets and adjust accordingly. If the right pallet is not where the AMR anticipated it should be, it will move to the next drop area and search again. This approach unlocks a massive amount of efficiency gains as it allows operators to work more quickly with less specificity around how and where they drop off pallets.

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BRINGING IT ALL TOGETHER: HOW AMRS MAXIMIZE EFFICIENCY AND SAVE ON LABOR

When comparing AMR and AGV navigation, it's important to take not just localization and infrastructure requirements into account, but also intelligence.

While both AGVs and AMRs use natural feature localization, the additional intelligence and flexibility from path planning and intelligent pallet detection makes AMRs much more robust to changes in their environment. As the warehouse environment changes, an AMR is confident that it can use path planning and obstacle avoidance to move safely forward and adjust accordingly. This approach saves not only travel time, but also the time that workers are required to help a lost AGV find its way.

AMR Performance Improvement Over Time

The benefit to this method is that AMRs are more flexible to changes in their environment. AGVs expect that a warehouse is always exactly the same as it was when they were first mapped. Because the environment is constantly in flux, performance over time will gradually become worse and worse. An AMR that relies on a combination of smart sensing and dynamic planning will never degrade in performance – and in fact, as a software- and data-driven platform, actually has the potential to improve over time when paired with continuous learning capabilities.

The Key to Increasing Operator Efficiency

The gains created by path planning, obstacle avoidance, and pallet detection give AMRs the upper hand when it comes to efficiency and flexibility. Perhaps more importantly, AMRs allow operators the freedom to work without interruption with fewer stops and calls for assistance, and the ability to forgive some imperfect pallet placement in pick and drop zones. This makes AMRs the key to maximizing overall productivity and efficiency.

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