The Evolution of Autonomous Mobile Robotics

How AMRs have changed manufacturing and logistics – and how Verizon is moving the robotics industry forward

verizon

Welcome!

Warehouses and industrial facilities are critical parts of our society. They're the reason we have next day delivery of online orders, assembled cars, freshly stocked fruits and vegetables and virtually any inventory at the store. Companies need these facilities to create, store and deliver products to consumers. But in order to maximize their efficiency, they need technology that helps them get their job done as quickly and effectively as possible.

Autonomous Mobile Robots (AMRs) are a rapidly evolving technology that many industries are adopting in their warehouses and manufacturing plants. These robots leverage advanced sensors, Automated Intelligence (AI) and new technologies to help automate and efficiently run these facilities. But what are AMRs, and where do they come from?

In this guide we will take a brief look at the history of mobile robotics, their present-day capabilities and the future Verizon can provide by integrating AMRs into wireless networks, including 5G, to transform industrial facilities.

Why is Verizon interested in robotics?

Verizon is here to help your business succeed. We recognize the value AMRs are bringing, and will continue to bring, to various industries. These industrial devices stand to benefit from the power, reliability and control made possible by Verizon's networks. That's why we want to provide the very best connectivity, hardware and software solutions that move the mobile robotics industry – and your business – forward.

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1953

Arthur Barrett invents Guide-o-matic, an early Automated Guided Vehicle (AGV)

1966

SRI International invents Shakey, the first Autonomous Mobile Robot (AMR)

1990s

HelpMate, an AMR for hospitals, opens the door for commercial adoption of AMRs

2010s

AMR technology sees widespread adoption in the automotive industry and many others

2021

Verizon acquires incubed IT, a software solution provider for AMRs

Future

AMRs to be integrated into 5G networks, with mass adoption in warehouses and across other supply chain use cases

The Past
Automated Guided Vehicles (AGVs)

The history of mobile robots starts, not in warehouses or manufacturing facilities, but in labs as proofs of concept. According to Control Automation, some of the very first mobile robots were developed by William Grey Walter in the late 1940s and 1950s. The robots, named Elmer and Elsie, were used in his research for neurophysiology advancement.

Elsie and Elmer had light sensors and bump sensors which enabled them to learn about their environment as they moved around. While these robots were very simple, they laid the early foundations for the autonomous robots in warehouses and facilities today—some 80 years later.

Automated Guided Vehicles (AGVs)

The next big step was increasing the reliability and autonomy of the robots. In 1953, Arthur Barrett created a robot called the Guide-o-matic by altering a towing tractor to follow an overhead wire. His company then released this driverless robot in 1954 for mass distribution.

The Guide-o-matic marked the beginning of Automated Guided Vehicles (AGVs): robots that are computer controlled and made to follow commands, following a set path without an onboard operator.

Since these AGVs move on predetermined paths, they have precisely controlled acceleration and deceleration, as well as automatic obstacle detection bumpers. They navigate by following magnetic tape, wires or (in newer AGVs) QR codes on the floor, sometimes assisted by radio waves, vision cameras, magnets or lasers.

The Guide-o-matic and similar robots pushed AGVs into the spotlight for augmenting human-driven vehicles in industrial settings. Soon, new and improved AGVs were developed.

There are many types of AGVs still used today:

- Automated carts - Simple robots that carry around cartons and boxes; typically a cheaper option.
- Unit load AGVs - Robots that transport discrete loads of pallets, bins, carts or bundles.
- Tugger AGVs - AGVs that pull heavy loads which other robots are incapable of carrying.
- Forklift AGVs - Machines to carry and transport pallets without an onboard operator

AGVs are used in a wide variety of industries, including:

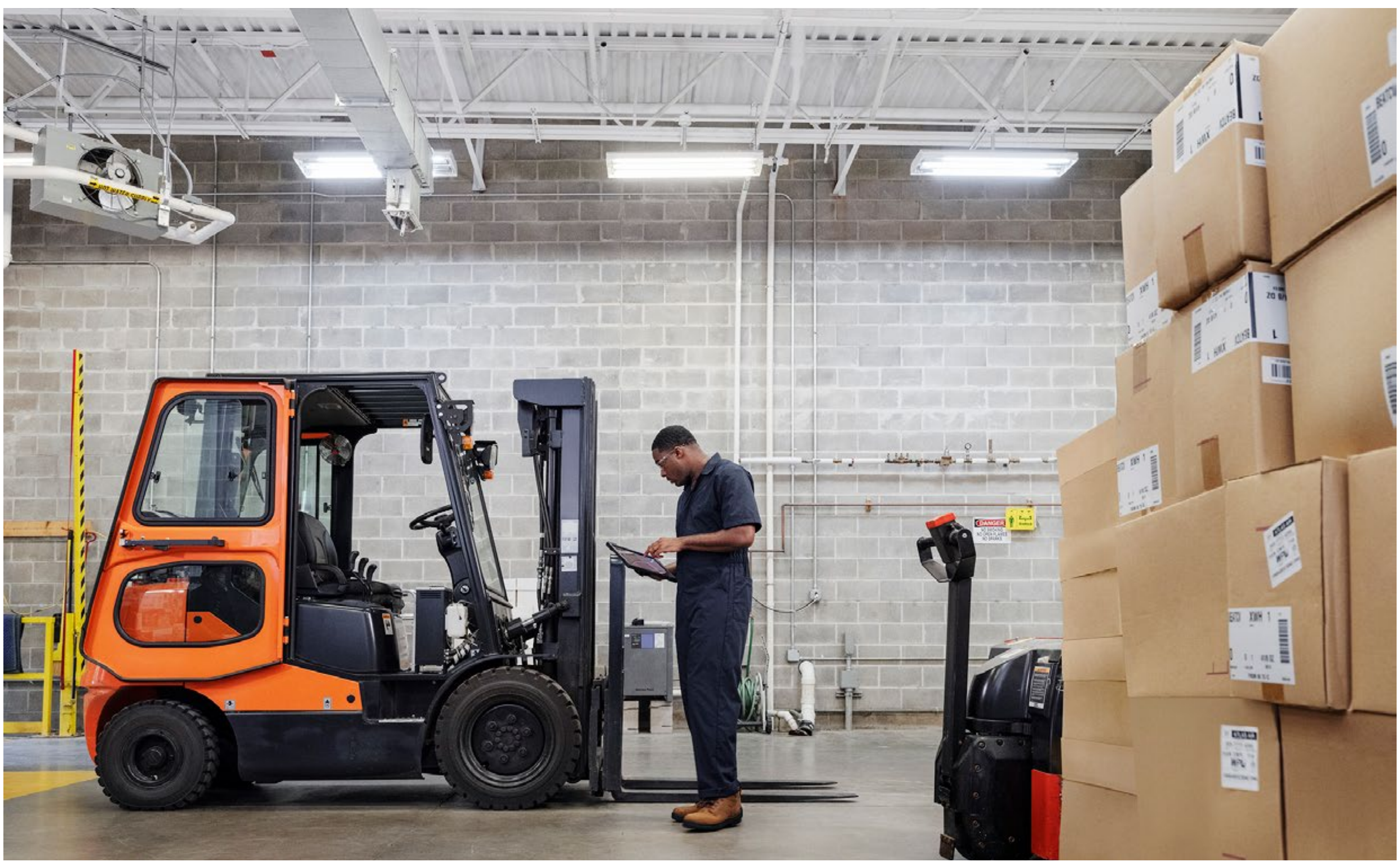
- Automotive assembly
- Military and defense
- Aerospace
- Material handling
- Food and beverage
- Chemicals, plastics and metals
- Commercial paper and printing
- Hospitals
- General manufacturing
- Pharmaceuticals
- Warehousing and distribution

The Problem with AGVs

AGVs can replace some of the work of forklifts, conveyor systems or carts by moving large volumes of material around factory floors, plants and warehouses. But there are drawbacks. With limited intelligence, they can only follow set paths, which require significant infrastructure investment. They don't operate together as a fleet. And changing the job they do requires a huge amount of human effort.

Additionally, AGVs are not able to change their routes. While they are usually able to stop before hitting obstacles, AGVs cannot determine another path to get to their destination. This can pose a problem. Like a train stopped in its tracks, a stoppage anywhere along the line has the potential to cause delays for the whole system.

Additionally, the tracks themselves can be problematic. If things change around in a facility, the paths need to be updated, taking up valuable time and money. Some of these tracks can also be fragile and need to be regularly maintained because of all the human, robotic and automotive traffic that travels over them.



The Present

Autonomous Mobile Robots (AMRs)

As AGVs were being adopted and refined, another branch of mobile robotics began to develop. In 1966, SRI International's Artificial Intelligence Center introduced Shakey, the first mobile robot to perceive its surroundings and determine its own paths. Shakey could autonomously perform basic tasks that involved planning, route-finding and rearranging objects. The possibilities this robot promised in artificial intelligence influenced the development of modern robotics.

Then, in the early 1990s, Transitions Research Corporation introduced another robot called HelpMate which assisted with moving items around hospitals: meal trays, mail, supplies, medications and more. HelpMate was an important step forward. Rather than just being used in experiments, it was a mass-market robot that performed real-world work.

HelpMate used sonar, infrared and vision systems to understand its surroundings. It could use elevators and had a safety system that included stops, turn signals and collision detection. It was a direct predecessor to the mobile robots we see today in warehouses and industrial facilities. This robot made it possible to see a future where autonomous robotics could help with workloads and cut costs for the labor used on simple tasks.

Autonomous Mobile Robots (AMRs)

Shakey and HelpMate were early examples of true Autonomous Mobile Robots (AMRs). AMRs are similar to AGVs, but with a few key differences. Modern AMRs are robots equipped with sensors and industrial processors that work in tandem with intelligent software to autonomously perform tasks without needing human supervision. They do not use tracks or a predetermined path like AGVs.

To imagine AMRs better, think of the robotic ground vacuums found in many households. (While this isn't a perfect comparison, in many ways these robotic vacuums are very similar to AMRs.) Newer generations of robotic vacuums can navigate the floor of a house, avoid obstacles and perform a job.

But now picture a robot ten to a hundred times larger, with industrial-grade sensors and safety features, and with different models designed to perform a variety of tasks. They may be carrying containers, lifting pallets, shelving merchandise, scanning stored products and more. They have many applications, including pick assist, material handling equipment and infrastructure replacement.

Now imagine putting five, ten – even a hundred of these robots to work in an industrial facility. With minds coordinated over one network, AMRs are able to do a lot more than just vacuum the floors. These robots are here to assist on the job for safe, efficient everyday operations of many kinds.

AMRs are already at work behind the scenes in warehouses and factories. They are transporting the package you returned, shuttling your online grocery order and moving pallets of your finished product. They're also helping relieve some of the strain from labor shortages around the world by automating some repetitive, low-value tasks and allowing people to focus on creative, dynamic tasks – which in turn leads to increased worker satisfaction.

To perform tasks, AMRs see their environments, determine the most efficient routes to take, avoid collisions, detect and move out of the way of obstacles, instantly re-route as needed and even collaborate with workers, infrastructure and other robots – all without direct human input.

Today, AMRs are commonly used to do simple, repetitive jobs, such as the transport of goods between shelves, fabrication machines, work stations and shipping docks. They are designed to safely work alongside humans doing manual operations. They can even reduce risks to workers by taking on certain hazardous jobs like loading a forklift.

These platforms can be fitted with various payloads: topped with conveyors, equipped to carry a robotic arm, optimized for pallets, outfitted with barcode scanners. AMRs are well suited for narrow environments, where stationary conveyors or fenced robotic arms would block a door or simply not fit.

What can AMRs do?

Automotive manufacturers, fast-moving consumer goods companies, ecommerce fulfillment warehouses and electronics fabricators are some of the biggest users of AMR technology. These nimble robots handle everything from cartons of fresh vegetables, to pallets of auto parts, to entire shelves of returned merchandise.

For example, take a plant finishing the microchips that power a car's smart systems. As microchips arrive, an AMR could quickly shuttle them to an assembly machine where the chips are soldered onto motherboards and placed in assembly cases.

The completed electronics could then be moved by AMR onto a conveyor system, where workers pack them into boxes for shipping. When a box is full, the worker could push a button and an AMR would pick up the box and transport it to the pallet station. Meanwhile, another AMR would move into standby near the workstation, routing around the dozens of other robots, people and vehicles sharing the floorspace. It would stand ready to take the next load as soon as the next worker pressed "Go."

The incubed IT software solution

While we're talking about the AMR solutions available today, let's take a look at how Verizon can help you get started with robotics.

incubed IT
a Verizon company

Verizon is building today's industrial robotics management platforms through software and services for connecting and managing autonomous fleets – while we work toward the near future of robotics powered by Verizon's networks. In 2021, Verizon acquired incubed IT, a multi-platform software solution for AMRs which brings together intelligent robotic control and extensive fleet orchestration.

Ultimately, Verizon helps major enterprises improve process flexibility and reduce costs by providing both integrated solutions and software to efficiently manage and scale diverse fleets of mobile robots, indoors and outdoors. Today, this is primarily done through the software platform of incubed IT, a Verizon company.

The incubed IT software solution

The incubed IT software solution enables users to seamlessly manage their entire AMR operation from a single platform, with increased visibility into operations and decreased silos between various hardware and software solutions.

incubed IT offers one software solution comprised of two parts: the Robot Autonomy Platform and the Fleet Management Server.

The **incubed IT Robot Autonomy Platform** is sophisticated, onboard software which provides localization and navigation capabilities for fleets of autonomous mobile robots (AMRs). It is the "brains" of the robot, enabling autonomy by coordinating with other robots, avoiding obstacles and performing jobs – all without human intervention.

Localization enables the robot to understand where it is based on sensor information and networked computing. This means it combines input from various sensors, like LiDAR and wheel odometry, to calculate the most likely position of the robot within the environment. Unlike traditional AGVs, localization allows the AMR to sense its surrounding area without the help of set tracks on the floor.

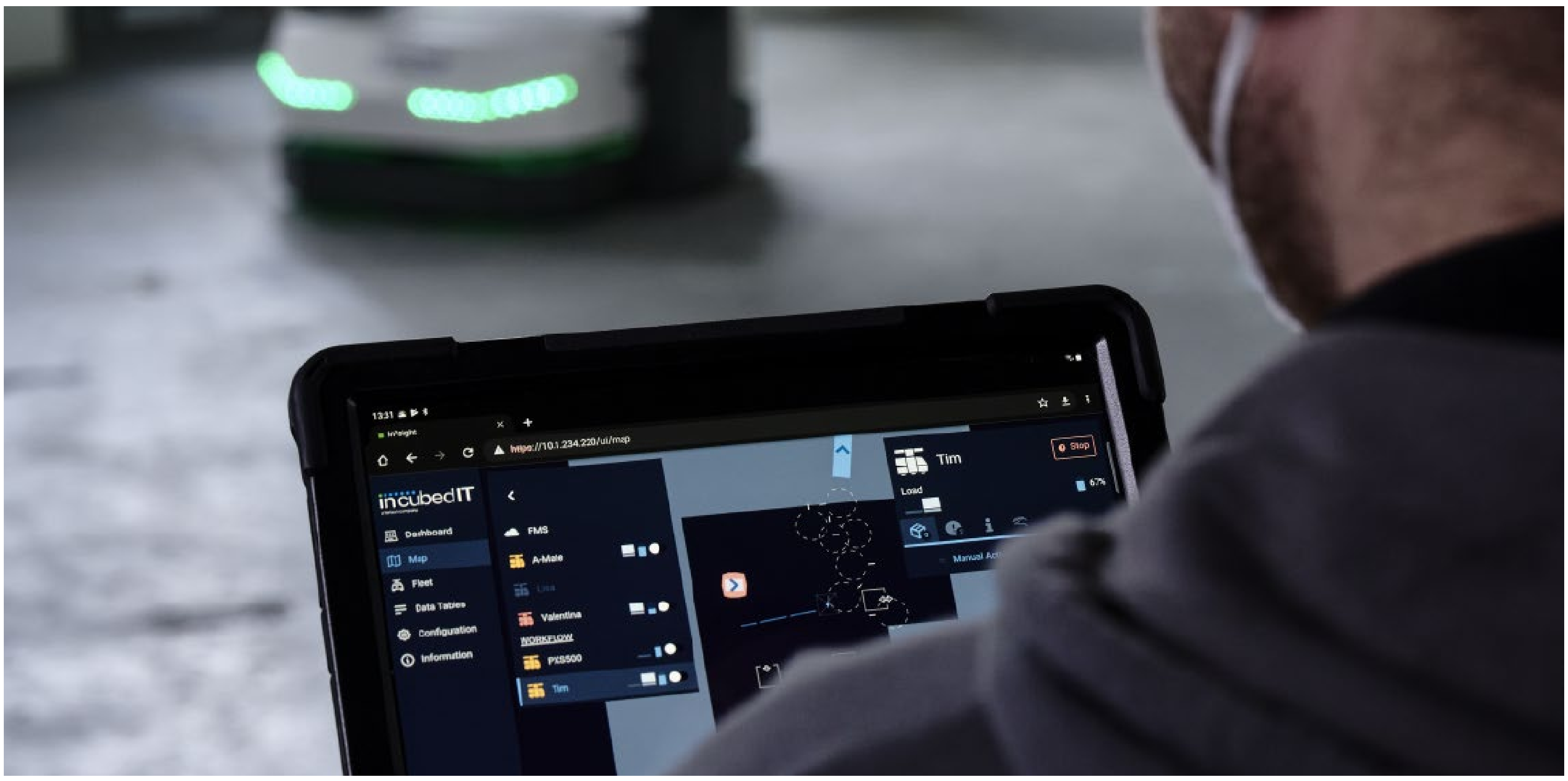
Autonomous navigation allows the AMR to choose the best path from point A to point B intelligently. It does this by a combination of different path planning algorithms which account for the size, shape and movement capabilities of the robot. With movement plans evaluated about 10 times per second, the Robot Autonomy Platform helps the AMR quickly react to changes in the environment, assess the situation through its sensors and choose the best route for moving around obstacles.

The incubed IT Fleet Management Server is an integrated system for managing and coordinating fleets of robots. The software connects every individual robot[1] running in the facility to the big-picture operation. The software assigns and optimizes tasks for the robots without anyone needing to manually coordinate the robots and watch over them. This task allocation takes multiple optimization criteria into consideration and makes sure that the fleet executes the assigned tasks with the highest efficiency.

The Fleet Management Server also works like a traffic advisor, giving directions to robots. When the paths of two AMRs cross, incubed IT calculates the best possible path to prevent collisions and keep them running as efficiently as possible. One robot may stop and wait as another passes in a narrow corridor to ensure productivity is maximized and safety is prioritized.

Additionally, the software allows the creation of no-go zones. Areas where robots shouldn't go – for safety, sanitation, traffic flow or any other reason – can be reserved and locked, letting the AMR know it can't enter those areas.

You can also set "one-way streets" for AMRs to improve traffic flow, or set up waiting zones when an AMR does not have an active job. As you teach the AMR fleet your facility's "rules of the road," there is a great degree of flexibility in how the Fleet Management Server can direct traffic.



We've taken a look at the current state of AMRs and we've seen some of the ways Verizon supports them today.

Now let's look at the next step forward for this technology.

1 Robot must be equipped with incubed IT Robot Autonomy Platform software to be controlled via the incubed IT Fleet Management Server (FMS) software. It is also possible to connect position data from other robots or IoT devices to incubed IT APIs which will use the location data to make smarter route decisions for the AMRs in its control.

The Future
Verizon 5G and AMRs

At Verizon, we believe that 5G wireless networks will transform the way we work and live our lives. We anticipate a future that includes connecting AMRs to 5G networks and reaping benefits like high speed, low latency and massive capacity.

5G-connected AMRs are anticipated in the very near future. So what can you do now to start preparing to integrate the next evolution of mobile robots and transform your facilities?

What is 5G?

To understand 5G, it's helpful to understand what came before it. Broadly, the first generation of mobile technology, 1G, was about voice – the ability to use a phone in a car, or away from home really took root here. The advent of 2G introduced a short-messaging layer – pieces of which can still be seen in today's texting features. The move to 3G provided the core network speeds needed to launch smartphones. And 4G, with its higher data-transfer rates, gave us video with lower buffering and gave rise to many of the connected devices and services that we rely on and enjoy today. Now, people are beginning to experience 5G and its transformative capabilities. 5G lays the groundwork for the Fourth Industrial Revolution, the movement of rapid technological innovations which are a primary driver around the need for AMRs.

Today, across the country you can experience Verizon 5G Nationwide, which uses low-band spectrum to provide great coverage with performance similar to that of 4G LTE. Verizon 5G Nationwide can support a range of functions – from distance learning to mobile workforces – and it's only getting better over time.

But it's Verizon's high-performance 5G Ultra Wideband that can provide game-changing benefits. It offers fast speeds and low latency not only for phones, but also for devices of all types on the Internet of Things (IoT). 5G Ultra Wideband coverage continues to expand around the country, we expect 5G Ultra Wideband to help revolutionize industries and provide a transformative impact for customers.

With its high speed and low latency, 5G Ultra Wideband could make drone delivery, seamless warehouse automation with AMRs and other applications live up to their full potential. From emergency response, to global payments, to next-level gaming and entertainment, the possibilities are virtually limitless.

Benefits of 5G for autonomous mobile robots

Given this background knowledge on 5G and AMRs, what do these two technologies have to do with each other? A lot, as it turns out. 5G has huge potential to unlock powerful capabilities for AMRs.

Let's take a look at several applications of 5G for AMRs.

Improved Robot Design
AMRs today have onboard computers that process the data they get from their sensors as they observe their surroundings, not unlike our eyes and ears. This helps the robot understand where it is at that moment in time (localization), where it needs to go (navigation) and how to best complete a job. These computations, however, take a lot of power.

Faster networks like Verizon 5G Ultra Wideband, coupled with the ability to shift computational effort to the edge of the network (so-called "mobile edge computing" or "MEC") could enable "thin client" AMR setups. With a thin client setup, computing that currently happens onboard robots could be shifted to the edge of the mobile network and rapidly processed nearby. This means that an AMR's "brain" will no longer need to be on the robot itself. MEC enables a very low latency connection that can transfer a significant amount of computation away from the robot. These capabilities should lead to benefits such as improved battery life for more consecutive time spent working rather than charging.

Inventory Optimization
Consumer demand can be unpredictable, and today many major manufacturing and logistics companies are seeing overwhelming demand for goods and services. Additionally, worker shortages have been causing companies to struggle to staff their warehouses. This can mean that routine tasks that are vital to running the business are not performed. Automating certain tasks can be a way to allow a workforce to focus on higher value-added tasks that move production forward.

5G-connected AMRs may be able to help with this automation. Robots today use lasers or sensors to get a feeling of their environment. But what if they were also equipped with a high definition camera and connected to a high-speed 5G network? What if, while the robots are stocking shelves in warehouses and facilities, they could also scan the inventory, document it with pictures and regularly upload the data?

Such real-time inventory intelligence, gathered automatically by AMRs, could let managers know when inventory is running low. AMRs equipped with cameras and 5G could compile a detailed record of the inventory and keep it updated, increasing inventory accuracy and freeing workers to perform more valuable jobs.

Network Capacity
Another challenge with today's networks is capacity. When multiple devices are using the same network at once, performance can be dramatically affected.

For example, say there are multiple devices connected to a network at a warehouse, all using data at once. Some of these devices are carrying out business-critical tasks, such as a fleet of AMRs that travel throughout the facility carrying pallets. Other devices use data for less critical purposes.

When many devices are connected, low performance may result, which can cause business-critical functions to slow down or even stop. If AMRs can't get the commands they need from the network, operational efficiency would be significantly reduced.

However, 5G networks have the potential to enable network slicing, in which "slices" of the network are prioritized for certain devices. For example, if an AMR needs 100 Mb per second to work at full performance while a work phone only needs about 3 Mb per second, network slicing would be able to allot the network accordingly. This would ensure that 100 Mb per second is always available for the robot, while less essential devices are deprioritized during peak loads.

Additionally, private 5G networks could allow large enterprise and public sector customers to bring a custom-tailored 5G experience to indoor or outdoor facilities where high-speed, high-capacity and low-latency connectivity is crucial – regardless of whether or not the premises is within a public 5G coverage area. It also addresses the need for dedicated bandwidth capacity and range, security, high-quality connections and consistent, always-on service to help reduce downtime.

These benefits of 5G will be crucial for successfully launching and scaling reliable AMR operations that improve efficiency and overall performance for warehouses and other industrial facilities.

Learn more.

Verizon 5G stands to completely transform how AMRs are used in warehouses and industrial facilities around the world. Don’t miss out on this thrilling future – visit the Verizon Robotics website to learn more about AMRs and stay up to date on our latest innovations.

Ready to get started with AMRs at your facility?

Visit the incubed IT website or contact office@incubedit.com to meet with a representative.

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