Automatic Guided Vehicles

Built with a number of variable components, automatic guided vehicles are flexible, versatile unmanned solutions that can safely and efficiently move product around your facility.

By **Lorie King Rogers**, Associate Editor

Of all of the materials handling equipment types in warehouses and distribution centers today, automatic guided vehicles (AGVs) are arguably among the most dynamic. Over the last few years, the equipment has been evolving and advancing quickly.

"AGVs are moving forward faster than other areas of materials handling," says Mark Longacre, marketing manager for JBT Corp. and chair of the automatic guided vehicle product section at the Material Handling Industry of America (MHIA).

Automatic guided vehicles were once an equipment type that served the manufacturing sector, and the automotive industry was king, Longacre explains. Since then, the food and beverage and consumer goods sectors have been stepping up the use of AGVs with vehicle types at both ends of the spectrum, from simple and inexpensive to complex and sophisticated.

So, while conveyors and lift trucks are still the most common materials handling solutions, AGVs are an increasingly viable alternative to both.

"AGVs were originally a simple concept of horizontal transport that was a replacement for conveyor, but they have evolved into a solution," says John Hayes, Dematic's manager of AGV systems. "People are more accepting of the technology and end users want us to push the envelope. We have automatic truck loading and now people want automatic truck unloading. Another application being driven by customers is the freezer application, where businesses want to save cost and don't want to put people in harm's way."

Whether you're working in a manufacturing plant, DC or warehouse, how you move product from point A to point B will impact your operation's throughput, efficiency and bottom line. In the right application, AGVs can redistribute workers to value-added positions, improve safety and material tracking, and reduce product damage and labor costs. AGVs can also be introduced without the need for plant modifications and are flexible enough to adapt to an operation's changing business needs.

That's what AGVs can do, but what are they, exactly? It's a simple question with a complex answer. MHIA defines AGVs as "battery-powered, computer-controlled wheel-based load carriers that run on the plant floor without the need for an onboard operator or driver. AGVs have defined paths or areas within which or over which they can navigate."

While this definition has remained accurate for the last decade and new vehicles can fit within the parameters of the definition, the application of AGVs is expanding. Today's AGV systems are being used in more sectors and are being applied to more diverse, strategic applications.

When considering the right type of AGV system for a specific application, a number of issues come into play, including the type of vehicle, the type of guidance system, the product being moved and the rate of throughput. Here's a look at the basic categories and components that create AGV systems.

AGV CATEGORIES

AGVs can be organized into a few basic categories.

basics

Tow vehicles, also called tuggers, are the simplest and least expensive type of AGVs. Like a locomotive pulling a train of rail cars, a tugger pulls trailers or carts. Add multiple trailers and a towing capacity of up to 60,000 pounds, and you can move more loads at one time than with a single lift truck. Tow vehicles are used when there is a set, predictable and repeatable path with distinct pick-up and deposit destinations.

Tuggers follow the designated route, stop at a station where workers load or unload material, and then move on to the next station. Since workers are needed to transfer materials, labor is not totally removed from an operation's process. However, the end user can automate the movement of materials between workstations, reducing non-value-added steps and increasing efficiency and productivity.

Unit load vehicles carry pallets, slipsheets, cartons or subassemblies on their decks. The decks can be equipped with:

- lifts that can raise or lower the deck;
- powered or non-powered conveyor to interface with other equipment; or
- multiple compartments to carry two, three or four pallets at a time.

Typically, unit load vehicles are used in a totally automated process. A unit load vehicle with a section of roller conveyor can integrate with a conveyor line, a production area or an automated storage and retrieval system.

Automatic guided carts, or AGCs, also fall under the heading of unit load vehicles. AGCs were originally considered more light duty than AGVs. However, according to Sarah Carlson, marketing director for Daifuku Webb Holding Co. and vice chair of the MHIA's automatic guided vehicle product section, AGCs are now capable of moving loads of up to 6,000 pounds. Additionally, Carlson adds, AGCs are typically less expensive than AGVs, which is one reason they have become so popular. They are easy to install and scalable, enabling users to simply add more carts to increase throughput.

In one example, a unit drives under a cart, raises a pin into a receptacle, pulls the cart to its destination, retracts the pin, then moves to the next delivery. While this type of vehicle has most successfully been applied in manufacturing operations, Keith Soderlund, vice president of sales for Creform, says not to overlook the DCs. A distribution center that's performing kitting operations

Mobile fulfillment systems (top) bring the product to the worker, saving time and non-value-added steps. In warehouse operations (middle), employees and automated forklifts work in tandem to fill orders. When a worker picks an item, the AGV is ready and waiting for the product, then it moves along to the next destination to continue the process. Incorporating AGVs into a manufacturing environment (bottom) can help operations increase productivity and decrease costs.

could employ an AGC. They're easy to control and have smaller on-board control systems can manage up to 50 pathways, with 128 commands in each pathway. The advantage, Soderlund says, is that an operation could have 50 carts in a fleet working off of one drive unit.

Available in a number of different models, including counterbalanced fork and roller conveyor vehicles, AGCs can move up to 160 feet per minute and are also a good option for moving loads to and from stretch wrappers and from conveyors to the warehouse.

Fork truck vehicles operate just like lift trucks, but without drivers. Fork vehicles are popular AGV solutions because they are extremely flexible. Like unit load vehicles, fork truck vehicles can interface with automated systems but also pick up or drop off a load onto the floor.

Forked, or masted, these vehicles can move at a maximum rate of 1.5 meters per second, about 3 mph, or half the speed of a manually operated forklift. According to Longacre, the speed is a function of how quickly the vehicle can stop while maintaining the stability of the load.

Custom vehicles are built around the load and can be engineered to handle very heavy loads like a 120-ton vehicle; long loads like rolls of newsprint paper; or specialized loads like a vehicle designed to handle two different types of pallets or two different sizes of totes.

The key components that define a custom AGV are the gripper devices or attachments that interface with the load. Otherwise, they use the same types of software and guidance systems.

Mobile robotic solutions are a relatively new class of AGVs that also fits in the unit load category. Mobile robots, also referred to as mobile fulfillment systems, are picking up traction in distribution centers and being used for goods-to-person picking, meaning the robots bring the product to the

Automatic guided vehicles: Who makes what

Company	Web site	Unit load	Fork truck	Tugger	Mobile robots	AGC	Custom	Guidance
Amerden	amerden.com	x	x	x			x	
JBT Corp.	jbtc-agv.com	x	x	x	x		x	x
Creform Materials Handling Systems	creform.com	x		x	x	x		x
Crown	crown.com		x					
Daifuku Webb Holding Co.	daifukuwebb.com	x	x	x	x	x	x	x
Dematic	dematic.com	x	x	x	x	x	x	x
LM Efacec USA	efacecusa.com	x	x				x	
Egemin Automation	egeminautomation.com/en	x	x	x	x		x	x
Electtric 80	electtric80.com	x	x		x		x	x
Frog Navigation Systems	frog.nl	x	x				x	x
Kiva Systems	kivasystems.com				x			x
Kollmorgen	pick-n-go.com							x
Mitsubishi Caterpillar Forklift America	mcfa.com		x					
Murata Machinery USA	muratec-usa.com	x	x		x		x	x
The Raymond Corp.	raymondcorp.com		x					
RMT Robotics	adamrobot.com					x		
Savant Automation	agvsystems.com	x	x	x		x	x	x
Seegrid	seegrid.com	x	x		x		x	x
SICK	sick.com							x
SI Systems	sihs.com	x		x		x	x	
Toyota Material Handling USA	toyotaforklift.com		x					
Transbotics	transbotics.com	x	x	x		x	x	

This table represents a sampling of leading AGV and guidance suppliers.

At shipping and receiving dock doors, AGVs are capable of automatically loading and unloading product from the trucks.

worker, saving time and steps.

"Mobile robotics and automation are creeping into all different parts of materials handling," says Rob Stevens, vice president of strategy for Kiva Systems. "They're all filling different roles even though the technology has similarities," he adds.

Some mobile robots are guided by small stickers on the floor, laid out in a grid pattern. Each unit is equipped with a camera that reads the stickers then marries the movement with the facility map that is stored in the memory of the system server.

When the mobile robot reaches its intended destination, it picks up the storage rack by driving underneath, lifting the entire rack off the floor, swiveling to redirect itself, and then moving to its next destination. It raises the rack up about an inch off the floor while it travels, which is enough to clear small obstacles but not enough to make the load unstable.

Some robotic AGVs are capable of handling loads up to 3,000 pounds. The vehicles travel at varying speeds depending on the load being moved. Stevens describes the speed as a brisk walking pace that's maintained for the duration of the task, unlike a worker's pace that's less brisk by the end of a shift.

GUIDANCE SYSTEMS

In addition to choosing the right vehicle for the right job, there are also choices to be made when it comes to AGV guidance, also referred to as navigation systems. Navigation systems can be closed path or open path.

Closed path systems use a predetermined set of rules that define the path plan, explains Bill Torrens, director of sales and marketing at RMT Robotics. But in an open path, the AGV finds the best path. Autonomously, robots adapt to the conditions they see in real time and are able to create a new path if necessary. And, according to Torrens, technology is enabling a higher level of autonomy. The units are capable of making their own decisions because the intelligence is moving from the control platform to the vehicle platform.

Wire-guidance is the simplest form of navigation, designed for a set, predictable path. Torrens likens wire-guidance to a hound dog following a scent trail that has verifications along the way. An RF signal is transmitted from the wire that's buried in a slot below the floor to a sensor under the vehicle. The sensor detects the signal and adjusts the position of the vehicle to keep it on the path. Because the slot must be cut into the floor, wire-guided systems are most commonly used in applications that require a high degree of accuracy on the path, like an AGV traveling back and forth between two workstations in a congested area.

Magnetic tape and **magnetic paint** are used to guide vehicles in applications that are relatively simple and where flexibility is paramount. "Magnetic tape allows customers to easily change their guide paths by simply pulling up and reapplying the tape," says Daifuku Webb's Carlson.

Customers who change the layout of their processes frequently can quickly and easily reconfigure routes because tape and paint are not permanent. They are also less expensive than other guidance systems.

Laser-guidance is a non-wire-guided navigation system that uses targets in predictable locations. With more than half of the AGVs using laser-guidance, it's the most popular navigation system in North America and Western Europe. An on-board laser reflects off targets mounted above the floor on columns, walls, machines or posts that are positioned about 25 feet apart. The system automatically measures the distance and angle of the reflected light to calculate and adjust the AGV's position on the preplanned guide paths. While the combination of accuracy and flexibility make laser-guidance systems very popular, they can pose challenges for environments with obstacles that can obstruct the laser signal.

Inertial, or gyro, navigation systems are often used in facilities with a significant amount of random floor storage that might interrupt a laser signal. An on-board gyroscope senses very small deviations in the AGV direction or travel, while small magnets or passive RF tags are installed in the floor approximately every 25 feet to serve as position points.

Camera-based imaging is the newest guidance technology, and according to JBT's Longacre, is becoming increasingly popular. The main reason for its growing popularity isn't so much for obstacle detection, as for load recognition. For example, a pallet stored by a manual lift truck might not be perfectly aligned in its position, but the AGV's camera can see the pallet fork pockets and adjust accordingly.

Camera-based imaging is used in several mobile robotic applications. While camera-based imaging requires a lot of processing power for its dynamic route planning, there are no rules. "A mobile robot sees what it sees and can evaluate its environment in real time," explains Torrens. "It looks for the ability to go around obstacles and can change its mind in a moment's notice." □

To read the industrial standards for AGVs, ANSI B56.5 Safety Standard for Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles, go to: **www.itsdf.org/pB56.asp.**