

What Are Mobile Automated Vehicles?

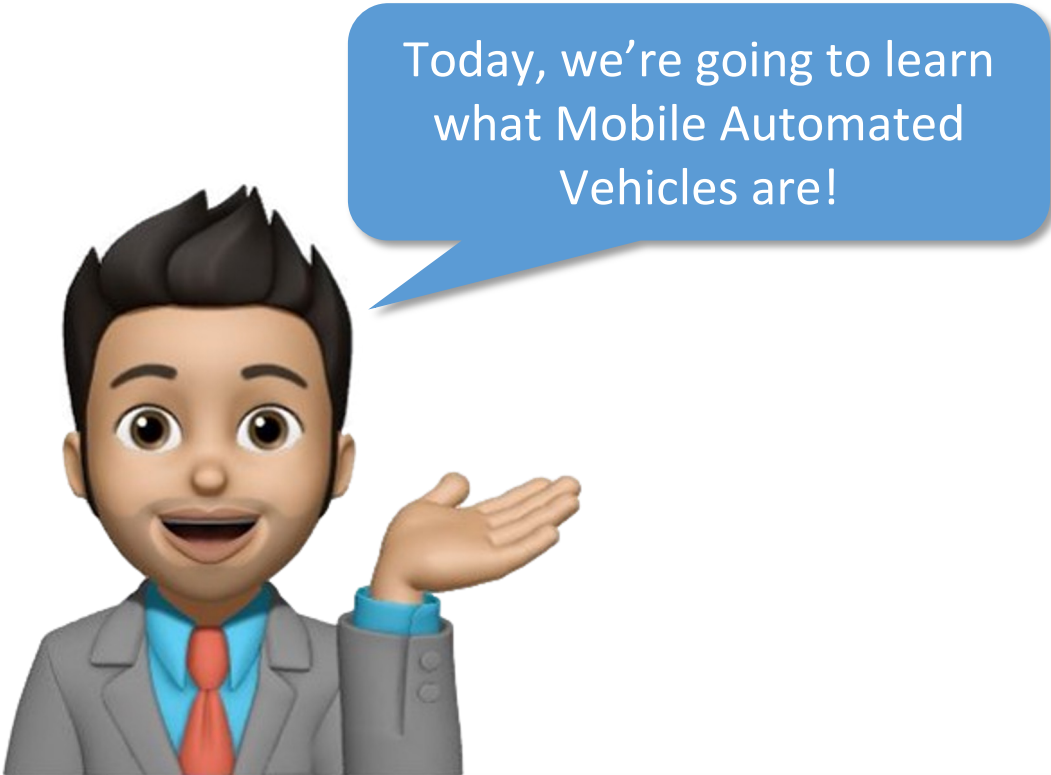


- **Mission:** To promote the market awareness, growth, and effective use of driverless industrial vehicle systems (e.g. AGVs, AMRs, and AGCs)
- **Vision:** To be the trusted, independent authority on driverless industrial vehicle systems
- **Members:** To meet the current members of the Mobile Automation Group, [click here](#).





Online Training Module 1: What Are Mobile Automated Vehicles?



Today, we're going to learn
what Mobile Automated
Vehicles are!

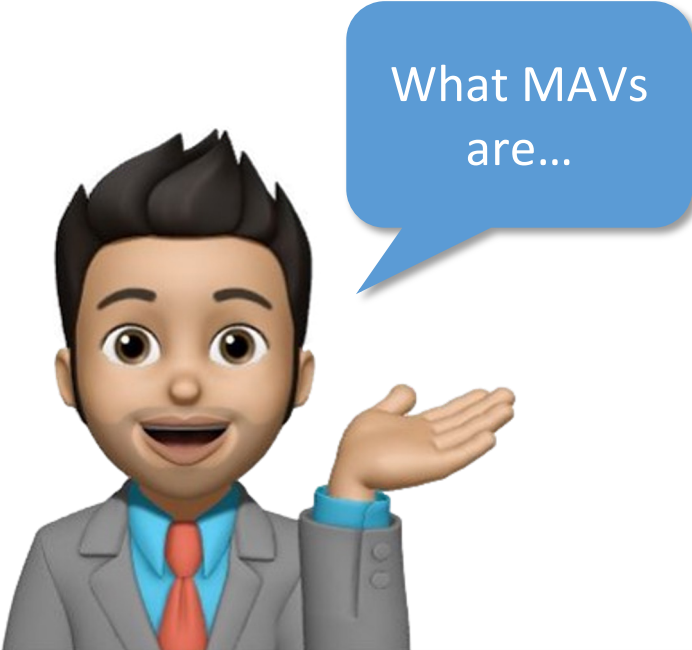
Online Training Module 1: What Are Mobile Automated Vehicles?





So... Let's first
define MAVs!

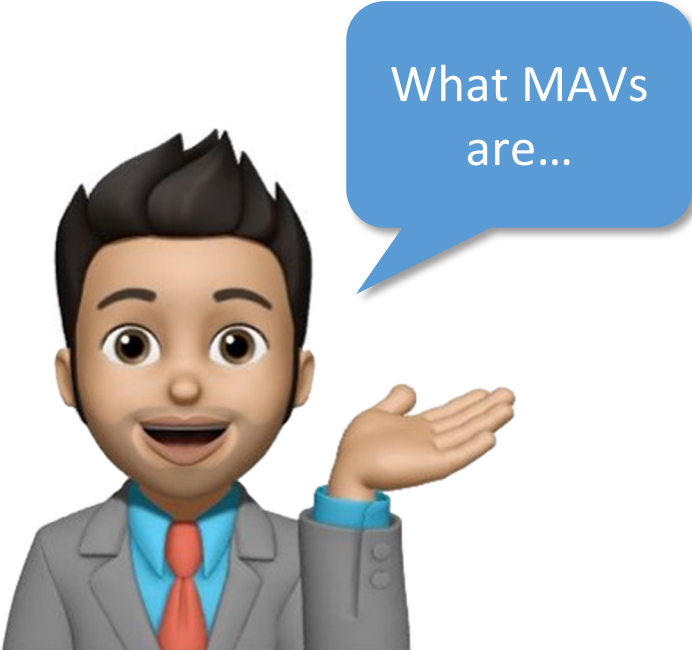
What are Mobile Automated Vehicles?



What MAVs
are...

- Mobile Automated Vehicles (MAVs) are computer-controlled, wheel-based load carriers (usually battery powered) that run on a plant or warehouse floor, or — if outdoors — on a paved surface.
- Although some applications call for just one mobile automated vehicle, most installations utilize a fleet of multiple vehicles.
- MAVs are sophisticated machines that represent a complete material handling solution and are installed in numerous industries and across a wide range of applications.
- They increase efficiency, increase productivity, reduce product damage, and reduce labor costs.


What are Mobile Automated Vehicles?



What MAVs
are...

- The original Mobile Automated Vehicles were called **AGVs**, for Automated (or Automatic) Guided Vehicles.
- More recently, a different type of vehicle was developed, which are called **AMRs** for Autonomous Mobile Robots.
- AGVs and AMRs were initially distinguished by the technology they used for autonomous navigation and by their payload capacities. However, these distinctions are blurring as navigation technologies develop, and as both AGVs and AMRs increasingly cover a broader range of payload sizes.
- The remaining significant distinction between AGVs and AMRs has to do with their methodologies for safe operation around people.


What are Mobile Automated Vehicles?



What MAVs
are...


- One of the most important features of both AGVs and AMRs is that they operate safely around people. They both use sensors to detect people and other obstacles and they both take appropriate measures to avoid collisions.
- Since AGVs were first introduced, there has been an ANSI standard (B56.5) that specifies (among other things) how they behave when they encounter obstacles. Another standard is being developed for AMRs by the Robotic Industries Association (RIA), (R15.08) that specifies a somewhat different approach to obstacle avoidance.
- As both approaches provide safe operation, this presentation will not make the distinction between these two types of MAVs.

What are Mobile Automated Vehicles?



What MAVs
are...

- As companies developed new products, they introduced different names to describe their mobile automated vehicles, such as:
 - **LGVs** (Laser Guided Vehicles)
 - **SGVs** (Self-Guided Vehicles)
 - **AGCs** (Automatic Guided Carts)
 - **IMRs** (Industrial Mobile Robots)
 - **UGVs** (Unmanned Guided Vehicles)
- **NOTE:** For this series of MAG Online Training Modules, the more generic term **MAV**, for **Mobile Automated (or Autonomous) Vehicle**, will be used to represent all the different acronyms used to describe mobile automation technologies.



That's a lot
of different
names!

What are Mobile Automated Vehicles?

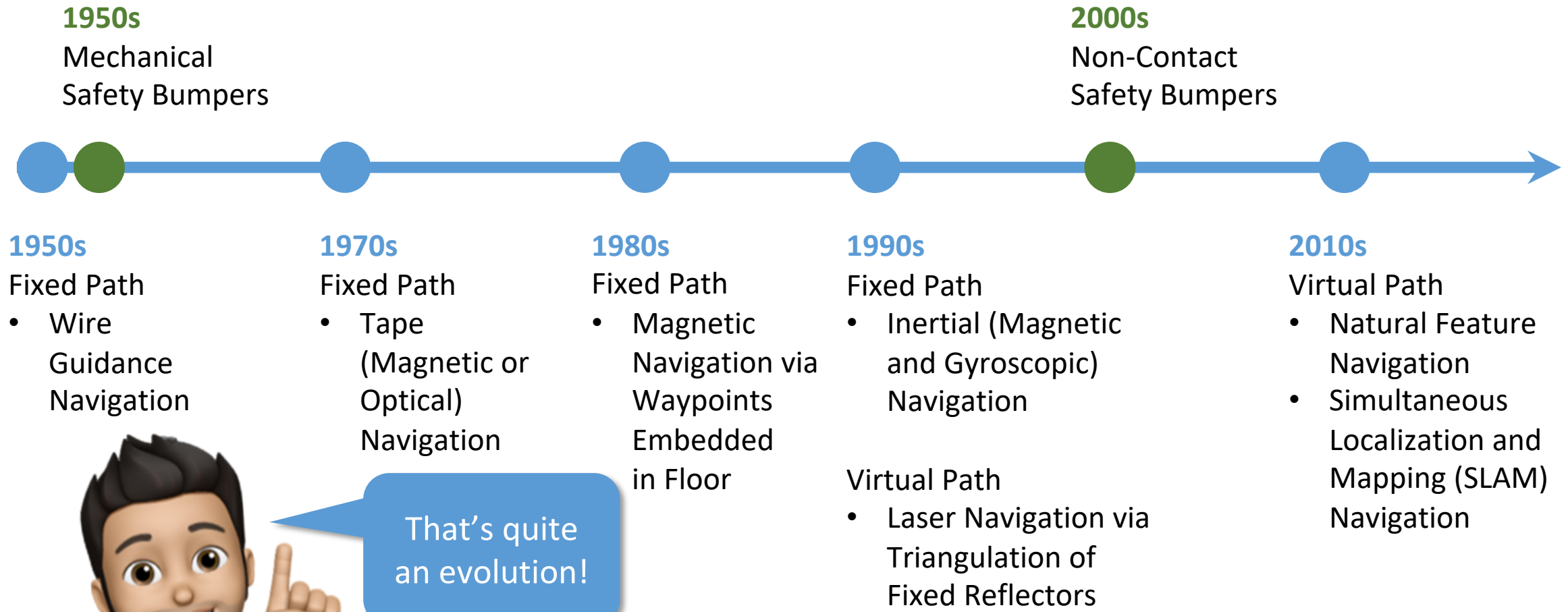
MAG | How did MAV safety and navigation technologies develop?



Next, let's look at how MAVs have gotten even safer over the years!

How did MAV safety and navigation technologies develop?


MAG | How did MAV safety and navigation technologies develop?





Now, let's learn why today's operations use MAVs, and in which types of processes.


Why are MAVs used, and in which processes?



There are a lot of great reasons to use MAVs!

- To provide safe, efficient, cost-effective movement of materials
- To supplement or replace manually operated material handling vehicles, such as forklifts
- For greater flexibility in material transport compared to fixed solutions such as conveyors
- In response to shortages in labor, allowing reassignment of employees to areas where they can add value
- To eliminate associate travel time during picking and order fulfillment


MAVs deliver a lot of benefits, including higher efficiency, productivity, safety, and flexibility.



MAVs can meet
a variety of
workflow needs!

- Dynamic, variable settings and environments
- Location and picking of objects
- Routine interfacing with associates
- Processes that critically require on-time deliveries and late deliveries result in inefficiencies or downtime
- Processes that require accurate material tracking
- Frequent, repetitive movement of materials
- Regular delivery of stable loads
- Medium throughput and volume rates

MAVs are ideal for processes and workflows with these characteristics.



Let's dial it in and focus on some key processes using MAVs.

PROCESSES

- Manufacturing
- Warehousing
- Order Fulfillment
- Special Applications

INDUSTRIES*

- Retail & eCommerce
- Automotive
- Consumer Packaged Goods
- Food & Beverage
- Pharmaceuticals & Healthcare

**Additional details about how MAVs address specific challenges in each of these industries can be found in the MAG Online Training Module 2.*

MAVs are used in multiple processes across multiple industries.

Let's look at a few examples, starting with Manufacturing.



- Component, parts, materials, or ingredients receiving and transport to and from storage
- Raw materials delivery to production, including paper, steel, rubber, metal, plastic and roll handling
- Work-in-process (WIP) movement, linking manufacturing cells, or as the main assembly line
- End-of-line transport
- Parts and tooling delivery
- Finished goods movement
- Removal of waste to recycling

Manufacturing Processes

MAVs are used for movement, transportation, and delivery of parts, tooling, WIP, components, and ingredients. They can also act as an assembly line.


Here are some ways
MAVs are used in
Warehousing.



- Goods receiving and transport to and from storage
- Pallet handling from receiving to storage or to palletizer prior to outbound shipping
- Automatic truck/trailer loading
- As an ASRS in high bay storage

Distribution: Warehousing Processes

MAVs are used for movement, transportation, and delivery of products to and from warehouse storage positions.



Here are some ways
MAVs are used in
Order Fulfillment.

- Case or tote storage and retrieval transport
- Case, tote or item handling from receiving to storage
- Picker support by transporting picks from storage to packout
- Material movement to support a wide range of picking strategies (zone, batch, goods-to-person, etc.)
- Transport of batch-picked items to manual or automated sortation areas
- Goods-to-person picking applications

Distribution: Order Fulfillment Processes

MAVs are used for movement, transportation, and delivery of products for picking to fill customer orders and for store replenishment.

Here are some ways
MAVs are used in
Special Applications.



- Shipping container handling at maritime terminals
- Airport luggage cart tow trucks
- Precision processes
- Clean rooms material movement
- Amusement park rides

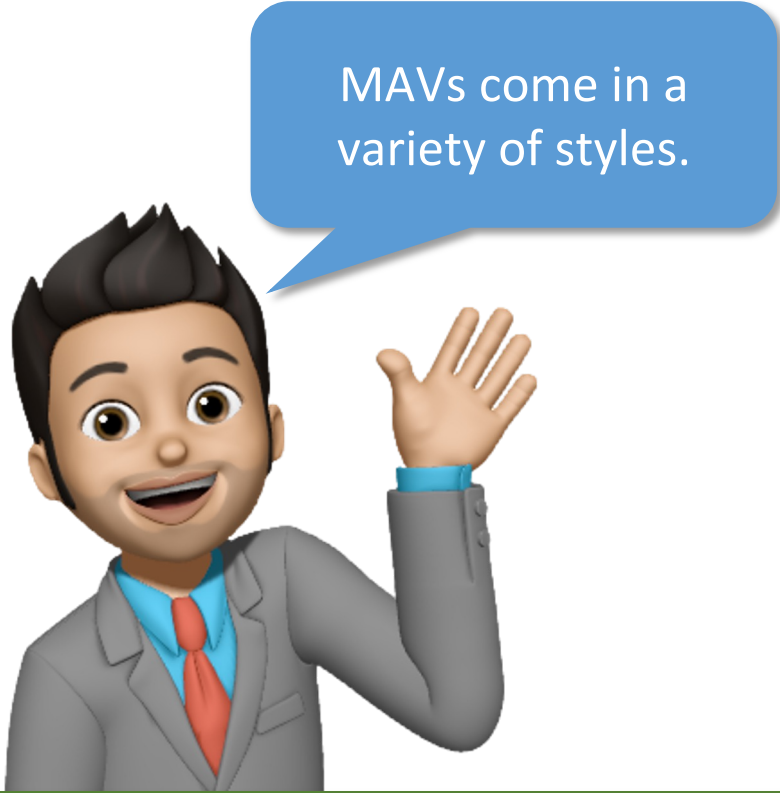
Special Application Processes

MAVs can be customized for unique load movement and transport needs.



Now, let's look at some examples of different types of MAVs in use today.

Common MAV Categories and Examples



MAVs come in a variety of styles.

- **Unit Load**
- **Fork/Clamp** (including High Lift and Reach Trucks such as Very Narrow Aisle VNA and Narrow Aisle)
- **Tow/Tugger**
- **Pick-Assist or Cart**
- **Platform**
- **Conveyor Top**
- **Custom Engineered**
- **Dual Purpose** (combine manual and autonomous control)

**Each of these vehicles are explained in more detail in Module 4*

There are several common categories that MAVs* are grouped into, despite not necessarily being distinct.

**Each of these vehicles are explained in more detail in Module 4*

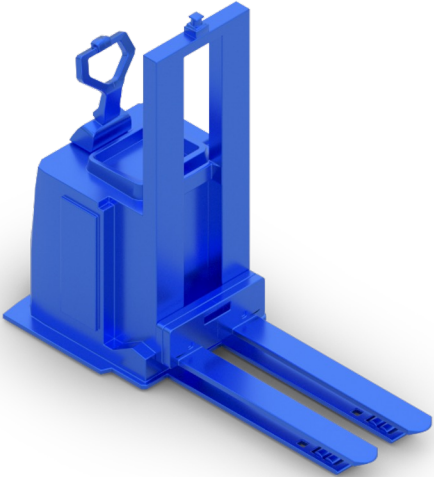
MAG | Examples of Unit Load MAVs



MAG | Examples of Fork/Clamp MAVs



MAG | Examples of Fork/Clamp MAVs



MAG | Examples of Tow/Tugger MAVs



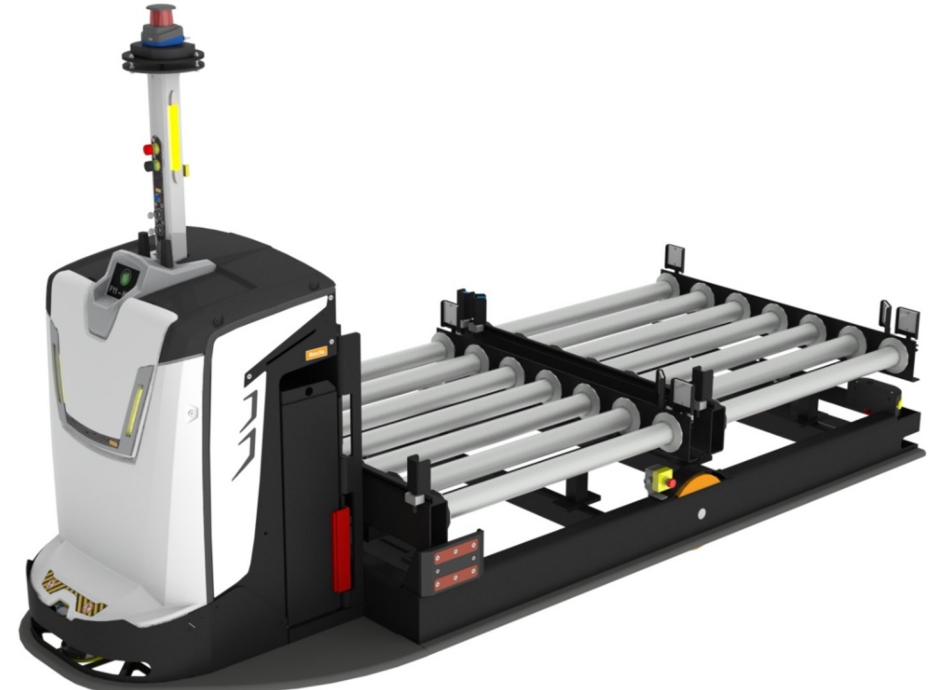
MAG | Examples of Pick-Assist or Cart MAVs



MAG | Examples of Platform MAVs



MAG | Examples of Conveyor Top MAVs



MAG | Examples of Custom Engineered MAVs



MAG | Examples of Dual Purpose MAVs



MAG | What are the most common system components in MAVs?



You've learned what MAVs are, how they developed, why and where they're used, and what they look like. Now, let's take a peek under the hood.

Key MAV System Components

MAG | What are the most common system components in MAVs?


There are 7 key system components used in MAVs.



1. Vehicle
2. Controller
3. Sensors and Actuators
4. Fleet Management System
5. Wireless Communication
6. User Interface
7. Power Source

MAV System Components

MAG | What are the most common system components in MAVs?



Each MAV's function is directed by a controller.

1. Vehicle

- The machine that provides material movement
- A system can have one vehicle or a fleet of multiple vehicles (100+)

2. Controller

- Microprocessor, embedded microcontroller or personal computer
- Controls its own travel routing and communicates with each vehicle in a system
- Communicates with facility operation software (WMS, WES, WCS, ERP, MES)

MAVs are equipped with a control system that communicates with the facility software and directs vehicle functions.

MAG | What are the most common system components in MAVs?

Sophisticated devices facilitate safe MAV travel.




3. Sensors, Actuators, and Encoders

- **Sensors** are used for:
 - Position location
 - Determining proximity of other vehicles, people, building structures, other objects
 - Safety
 - Collision avoidance
 - Triangulation
 - Navigation
 - Determining the slope, angle, or tilt of objects handled by Fork MAVs
- **Actuators** are the motors that move the vehicle's wheels and any other powered attachments
- **Encoders** measure angular or linear distance, as well as speed and velocity

MAVs use a variety of technologies to aid in safe, accurate, and efficient navigation and movement throughout a facility.

MAG | What are the most common system components in MAVs?



Fleet management software acts like a control tower.

4. Fleet Management System

- Controls and communicates with each vehicle in a system
- Directs traffic routing to maximize efficiency and minimize congestion
- Assigns material movement requests to each vehicle
- Monitors the system and all external inputs/outputs (I/Os) required to support travel (battery charging, automatic doors, load presence detection systems)
- Communicates with facility operation software (WMS, WES, WCS, ERP, MES)
- Notifies operators of errors or alarms
- Generates standard reports to analyze system performance
- Simple vehicles may operate without fleet management software

An overarching fleet management system synchronizes and streamlines the operation of one or more MAVs.


Here are some ways MAVs communicate and why.



5. Wireless Communication

- Host system exchanges communications with each vehicle via a wireless network, radio-based signals, or ethernet
- Data exchanges include information about:
 - Movements
 - Charging levels
 - Usage
 - Diagnostics
 - Location
 - Positioning
 - Tasks and more

MAVs “talk” with the facility’s host system to exchange operational data, receive commands, and more.



MAVs “talk” with human operators through a user interface.

6. User Interface

- May be located on the vehicle, on a computer elsewhere in the facility, or both
- Where material movement requests and programming occur
- Offers information for review and resolution of alarms
- Offers analysis of vehicle utilization for productivity improvements
- Allows operator to follow commands and confirm task completion

Information is shared and received via an MAV’s user interface, which can be on-board, on a separate computer, or both.

MAVs are usually powered by rechargeable batteries.



7. Power Source

- Most vehicles are powered by rechargeable batteries that are swapped out when depleted, opportunity charged at a charging station during slow periods, wirelessly charged through inductive charging, or connected to charging shoes at a workstation.
- Battery types include:
 - Thin plate puree lead (TPPL)
 - Flooded lead acid
 - NiCad
 - Sealed
- Some MAVs are powered by fuel cells

Most MAVs are designed with integrated, on-board rechargeable batteries to power their operation.

Congratulations!

You've finished the first training module!



**Next Up... Online Training Module 2:
How Are Mobile Automated Vehicles Used?**

For More Information...

Contact MHI's
Mobile Automation Group (MAG)
mhi.org/mag

