WHITE PAPER

Five Critical Elements of Uninterrupted Wireless Connectivity for AS/RS and AGV Systems

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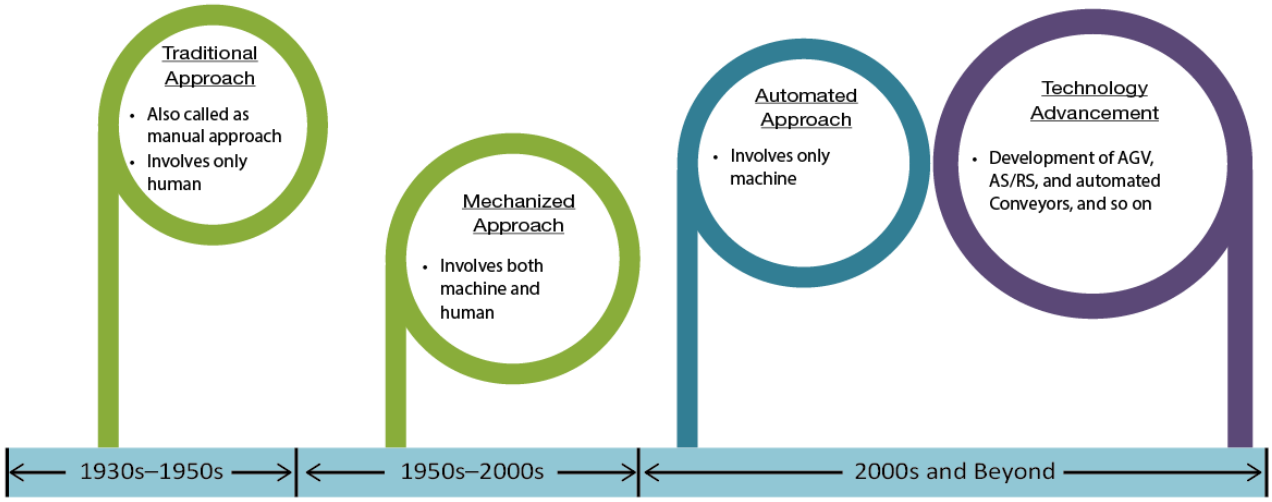
Overview—Evolution of Automated Materials Handling (AMH)

Automated Materials Handling (AMH) refers to automation of loading, moving, and unloading of materials used by a production unit. The main objectives of AMH systems are reducing the cost of operation, minimizing human errors by using automation, and meeting safety requirements in factories and warehouses. The traditional approach, which is still followed in some small and medium scale industries, is for workers to walk from one shelf to another in a warehouse to store and retrieve items as and when they are required. This activity is not only time consuming but also error-prone. Some industries adopted a mechanized approach to handling materials in a warehouse around the 1950s, which involved humans and machines working together to move materials and finished goods. Although the mechanized approach sped up material handling tasks, there was clearly a need for solutions to monitor and control the process and to increase the efficiency of materials handling in warehouses and factories. In the early 2000s, manufacturers started to automate their materials-handling process, resulting in fully-automated solutions being available in the market. Systems such as automated guided vehicles (AGVs), pallets, automated conveyors and sortation systems, automated cranes, automated storage and retrieval systems (AS/RS), and clean room transport and storage systems were built and implemented during this period.

EVOLUTION OF AUTOMATED MATERIAL HANDLING (AMH)



Source: Annual Reports, Press Releases, Investor presentations, Expert Interviews, and MarketsandMarkets Analysis

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Moxa is a leading manufacturer of industrial networking, computing, and automation solutions. With over 25 years of industry experience, Moxa has connected more than 30 million devices worldwide and has a distribution and service network that reaches customers in more than 70 countries. Moxa delivers lasting business value by empowering industry with reliable networks and sincere service for automation systems. Information about Moxa's solutions is available at www.moxa.com.

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What Are the Main Growth Drivers for the AMH Market?

The AMH market has seen a boom in recent years because of the many benefits that AMH solutions provide, and the need for manufacturers to be part of the next level of industrial automation—the Industrial IoT.

Benefits for Manufacturers

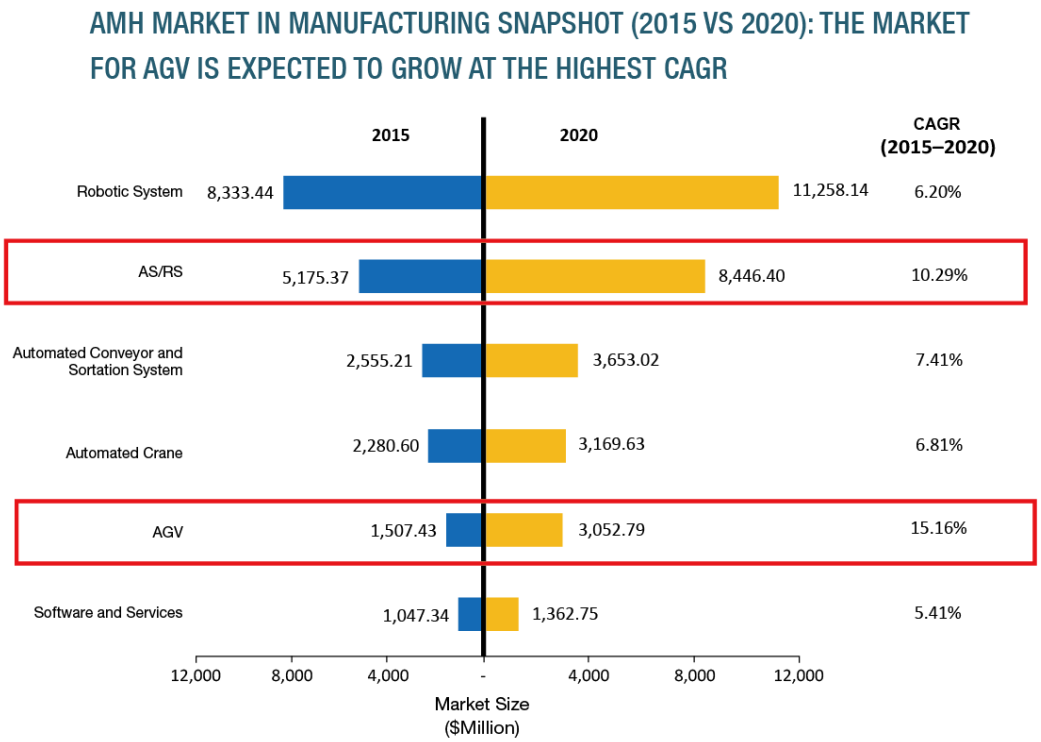
The AMH market in manufacturing is poised to grow at the rate of 5 to 6% between 2015 and 2020. This growth in the AMH market can be mainly attributed to:

- The ability of AMH systems to reduce manufacturing costs
- The ease of setting up new manufacturing facilities
- The need to improve safety and working conditions in manufacturing facilities
- Emerging markets such as China and India

Industrial IoT—The Future of Industrial Automation

The Industrial IoT (Internet of Things) is set to revolutionize how machines on a network interact with each other. Although currently the adoption of the IoT by industry is limited to achieving operational efficiency, its full potential has yet to be tapped. As the standards for the Industrial IoT evolve and move towards open standards, more and more devices and equipment on a network will be able to communicate directly with each other. The Industrial IoT is also expected to drive the communication interfaces for conveyors, AS/RSs, forklifts, and other AMH-related systems. The centralization of data collected from these types of equipment can provide useful information that can aid decision makers in the industry. The AMH industry is currently using Big Data applications to help with maintenance, service delivery, and managing and streamlining processes.

Fastest Growing AMH Segments—AGV and AS/RS



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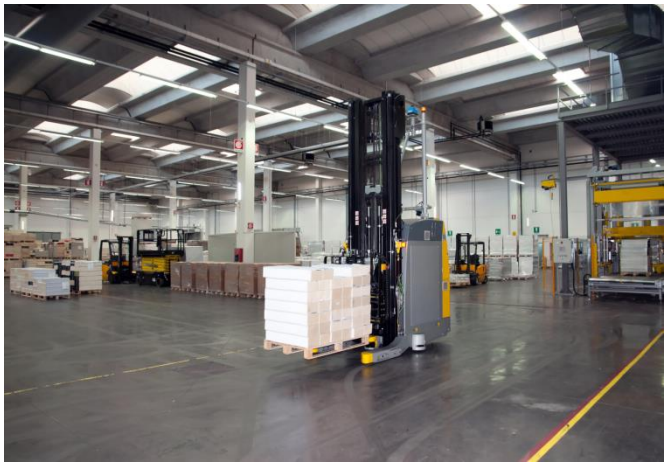
Among the AMH market segments, AGV is poised to grow at the highest CAGR of 15.16% between 2015 and 2020, followed by AS/RS at 10.29% in the same period.

Automated Guided Vehicles



An automated guided vehicle is a battery powered driverless vehicle that can be programmed with positioning and path selection capabilities. The AGVs can follow markers or wires on the floor, or use sensors, magnets, or lasers for navigation. They are often used in industrial applications to move materials around a manufacturing facility or warehouse.

Benefits of Using AGV Systems in Manufacturing

- Reduced labor and operational costs
- Higher operational efficiency

Common Applications:

- Logistics distribution and supply chain
- Warehouses

Automatic Storage and Retrieval Systems

An automated storage and retrieval system (ASRS or AS/RS) consists of a variety of computer-controlled systems that automatically pick, transport, and store materials based on pre-defined storage locations. AS/RS installations are typically used in applications where a high volume of materials are being moved in and out of storage. The storage density in such applications is a key factor in implementing AS/RS systems due to storage space constraints. The accuracy of the process is critical and any error in the process could lead to potential damage to the goods, which could be expensive. AS/RS systems can be used for applications with standard loads as well as non-standard loads.

Benefits of Using AS/RS Systems

- Faster and more accurate storage and retrieval of goods
- Produces smaller footprint and uses less space

Common Applications:

- E-commerce
- Retail business
- Medicine storage

In this whitepaper, we discuss the five critical aspects of developing wireless solutions for AS/RS and AGV systems in the manufacturing industry.

Critical Pain Points in Developing Wireless Communication for AS/RS and AGV Systems

Wi-Fi-based technology is the most commonly used communication method in AS/RS and AGV systems as compared to other technologies such as infrared, PLC (PowerLline communication) or FSK radio communication, for the following reasons:

- **Flexibility:** Compared to linear technologies such as infrared, wireless technology lets you deploy multiple access points to support the roaming of clients that are installed on moving platforms.

- **Easy Implementation:** Unlike devices using PLC technology, Wi-Fi-based devices on moving vehicles can communicate without a physical connection. Even though devices in some modern PLC-based implementations are able to power up and transmit digital data through metal rails, the underlying technology is relatively more complex to deploy.
- **Scalability:** The standardization of the 802.11 Wi-Fi-based technologies makes interoperability between wireless devices from different vendors much easier as compared to non-standard technologies. Expanding your system or network as well as finding replacements for the wireless devices deployed in the system also becomes much easier.

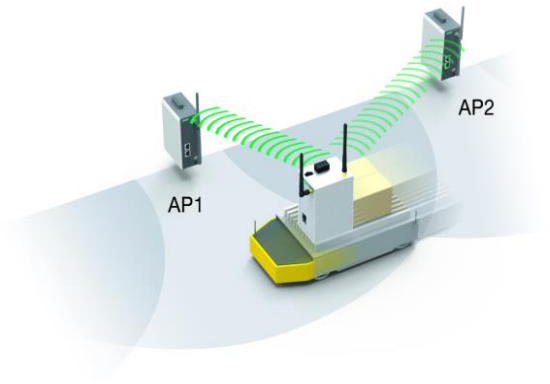
Although Wi-Fi-based technology has advantages over other communication solutions, there are some critical aspects that system integrators need to pay special attention to when they deploy wireless solutions in their AS/RS and AGV systems. The following sections discuss some of these critical pain points:

1. Dealing with Constantly Moving Platforms

Ensuring reliable communications while on the move is a key concern for AS/RS and AGV systems. Seamless roaming and anti-vibration protection of the client devices are the top two considerations when choosing a suitable solution.

Roaming Reliability

Wi-Fi networks have limited signal coverage, which means multiple access points must be installed to achieve full signal coverage in a warehouse. It is critical to ensure that the clients can roam smoothly between these access points with minimal handover time. Wi-Fi devices that are based on older technology commonly experience a 3 to 5-second disconnection time as they move between access points, causing severe disruption to real-time operations. If this happens to a client device installed on an AGV, the vehicle might simply stop until it reestablishes its network connection, causing production delays that could lead to an increase in operational costs.



The basic requirement of a reliable wireless roaming technology is to preemptively seek out neighboring access points with strong signals and prepare to connect to new access points as the client moves closer to them so as to eliminate downtime. The following advanced wireless roaming features can also increase the efficiency of the client devices:

- **Reliable roaming performance with multiple channels**
  Due to the limited bandwidth available on each channel frequency, system integrators must use multiple frequency channels to avoid channel congestion. The wireless-roaming technology should be able to provide smooth roaming between different APs using different channels.

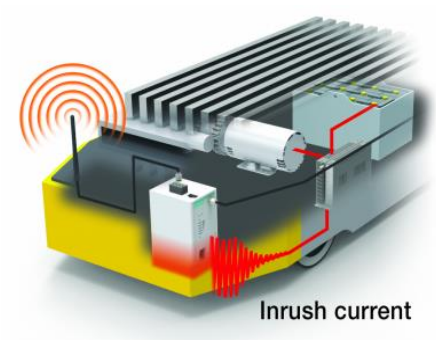
- **Adjustable roaming parameters**
  System integrators usually have multiple customers with widely-varying needs, so the roaming function must allow users to adjust the roaming parameters so as to adapt to different venues and site environments. The roaming parameters are configured to allow location-based load balancing to ensure that wireless clients are connected to the closest access point to avoid network traffic congestion.
- **Best wireless encryption possible without affecting the roaming performance**
  Wireless signals are transmitted through the air and are therefore vulnerable to hacking. However, encryption protocols that provide high data security such as WPA/WPA2 are complex to implement and can sometimes affect roaming performance—particularly by causing a delay during the secure key exchange process when the client moves to a new access point. An advanced wireless roaming function that can provide the most secure data encryption possible and millisecond-level handoff times for clients is required to secure the network.

Shock/Vibration Protection

AS/RS and AGV systems are constantly on the move to supply materials to production processes or store finished goods. Wireless devices mounted on systems that are prone to vibration and shock can cause electrical shorts, broken solder joints, loose PCB components, PCB delamination, and cracked device housings. Shock and vibration can also disable a wireless device by shaking loose wires for power, data, and redundancy. The IEC 60068-2-6 standard specifies the guidelines that wireless devices must abide by to ensure protection against high vibration and shock. Devices must be tested against these standards and pass the criteria set by the standards to be able to provide reliable performance in highly mobile environments.

2. Limited Space for System Integration

Mobile industrial equipment such as AGVs have very limited space and weight-carrying capacity. The main concern for most system integrators when choosing wireless devices for compact and reliable AGV systems is the ability of the wireless devices to withstand electrical interference.



Electrical disturbance usually interrupts wireless transmission by entering through the power inputs and antenna ports. To utilize the limited space on AGV systems, all the onboard devices usually share the same power source, including wireless devices and motors. When the motor is turned on, it could generate inrush current that can damage the wireless device through the power port and in extreme cases stop the wireless communications. The antenna extensions are usually mounted on the metal casing of the AGV or the shuttles used by the AS/RS to achieve better signal strength, which sometimes leads to airborne electrostatic charges damaging the wireless components through the antennas and antenna cables. System integrators typically use extra power and antenna-isolator accessories to strengthen their system, but this method could increase the system cost and also require extra installation space. Wireless devices should be provided with built-in isolation to protect them from electrical disturbance.

3. The Intricacies of Wireless Installations

A brief interruption of a few seconds to wireless service is viewed as a mere nuisance for routine applications, but in an industrial setup, especially one that involves critical processes or functions, any disruption to wireless service—even one that lasts just a few seconds—can lead to catastrophic results. Therefore, it is extremely important to set up your wireless network correctly in the first place to avoid operational glitches.

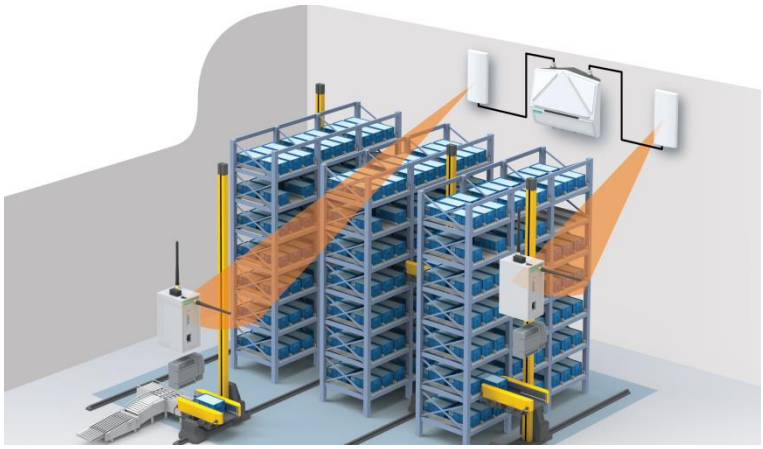
Countering the Effects of Multipath Propagation

In wireless communications, multipath is a propagation phenomenon that results in radio signals reaching the receiving antenna via two or more paths. In a typical warehouse environment, metal frames and shelves can easily cause reflection and refraction of the radiated signals resulting in multipath fading. The fact that reflected/refracted signals traverse a longer distance than direct line-of-sight transmissions could cause the signals to arrive out of phase, leading to signal degradation at the receiver's end. However, you can utilize 802.11n MIMO technology to turn the effects of multipath propagation to your advantage by reconstructing a strong signal at the receiver by applying error-correction techniques on the weak reflected/refracted signals.

Maximizing Wi-Fi Coverage with MIMO Technology

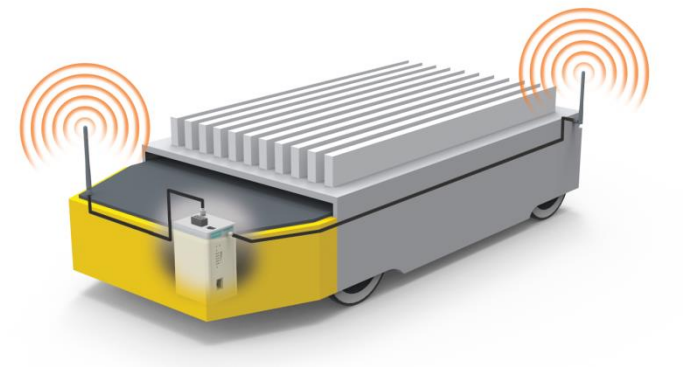
Multiple-input and multiple-output (MIMO) provides a way to utilize the multiple signals between a transmitter and a receiver to improve the data throughput available on a given channel. By using multiple antennas at the transmitter and receiver and by applying some complex digital signal processing, MIMO technology enables the wireless devices to set up multiple data streams on the same channel, thereby increasing the data capacity of a channel. In addition to overcoming the effects of multipath propagation, MIMO radios can also be used to increase the Wi-Fi coverage and improve signal reception on the wireless devices.

MIMO-Enabled APs



When you use an AP with 2 x 2 MIMO technology, you only need one AP device to achieve the network coverage equivalent to two single-antenna APs. By applying this technology to a warehouse scenario, AS/RS systems can avoid signal-sheltering by the metal shelves and high walls using APs with two directional antennas to ensure full wireless coverage along the two corridors of a warehouse shelf.

MIMO-Enable Clients



The wireless clients installed in AGV and AS/RS systems often suffer loss of signal due to line-of-sight issues when the vehicles or shuttles turn, or pick up and offload goods. To increase network coverage and signal reception, you can install antenna extensions for MIMO device antennas on the sides of the vehicles or shuttles.

4. Complex Configuration and Maintenance

Wireless networks are known for their ease of deployment, but many industrial operators still need to deal with complex installation processes. The hundreds and sometimes thousands of wireless devices that need to be set up before enabling the entire wireless network in warehouses makes the task even more daunting. The wireless clients deployed in AS/RS or AGV systems have to be set up one-by-one to ensure proper connection with the APs. When device errors occur, the AS/RS or AGV systems need to be halted, or in a particularly bad situation, they have to be taken apart for troubleshooting. Restarting or rebooting these systems is extremely time-consuming and disruptive for operators. Although the demands on APs are far less than for wireless clients, making manual setup much easier, access points that are installed on the top of storage shelves to provide greater coverage make device maintenance difficult. Wireless devices that are easy to configure and maintain can make installation and troubleshooting easier in warehouse environments as well as increase efficiency and productivity.

To make wireless network deployments easier in warehouses, wireless devices require a smart setup function that can simplify the setup, configuration, and maintenance processes for operators. This setup function should be able to detect the role of each wireless device inside a warehouse and automatically choose suitable setup options to connect APs and clients, thereby reducing installation time.

5. Environmental Restrictions

Some warehouses are subject to less-than-ideal environments, such as very high or low humidity, or sub-zero storage temperatures. AS/RS and AGV system integrators need to build systems that can adapt to different customer needs and many different environments. For this reason, it is important to choose wireless devices that can handle sub-zero temperatures and have sufficient ingress protection to keep out dust and moisture.

Moxa Solutions

Moxa's AWK-A series devices provide all the basic building blocks for a reliable, high-performance mobile Wi-Fi network and a solution that is tailor-made for AS/RS and AGV markets. The AWK-A solution comes with the following features to ensure reliable Wi-Fi systems for your mobile applications:

- Turbo Roaming technology for seamless roaming with millisecond-level handover time
- Adherence to IEC 60068-2-6 standards for protection against severe onboard vibration
- Power and RF isolation for disturbance-free Wi-Fi connections
- 2 x 2 MIMO technology to maximize Wi-Fi availability
- Wide operating temperature range from -40 to 75°C

To find out more about our AWK-A series wireless solutions for AS/RS and AGV systems, please visit: www.moxa.com/Event/IW/Wireless-AGV/index.htm

Credits and Sources

1. Automated Materials Handling Market in Manufacturing - Forecast to 2020, MarketsandMarkets

2. Definition of AS/RS: https://en.wikipedia.org/wiki/Automated_storage_and_retrieval_system

3. Definition of AGV: https://en.wikipedia.org/wiki/Automated_guided_vehicle