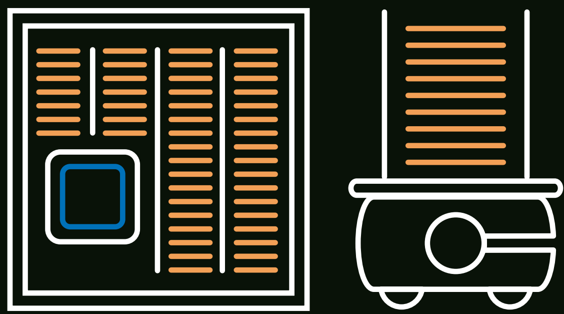
ESSEGI AUTOMATION



TOWARD THE LIGHTS-OUT FACTORY; USING AIV'S TO DELIVER ELECTRONIC COMPONENTS TO AND FROM AUTOMATED COMPONENT STORAGE SYSTEMS

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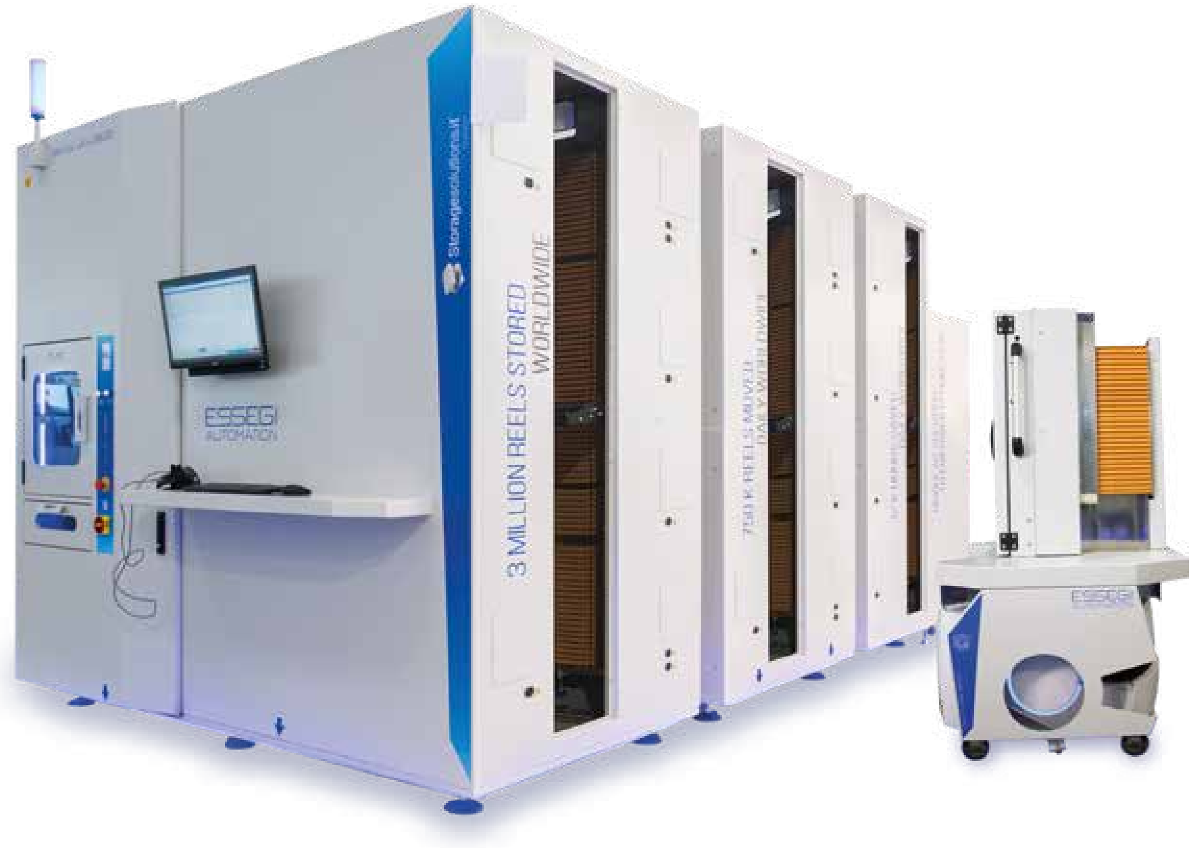
INTRODUCTION

With the growing interest in industry 4.0, many OEM and EMS electronics equipment manufacturers are making steady progress towards the goals of "smart factories" and "lights out manufacturing". One of the key requirements for achieving these goals is streamlining the material flow between the warehouse and the production floor, assuring that all components reach the production lines accurately and at the proper time. In recent years, the Automated Component Storage System has come to play a major role in improving productivity and efficiency for many electronics OEM and EMS companies. By automatically tracking each component by UID, these systems keep the ERP and MES software continuously updated on the quantity, location, and availability of these components at all times. They automatically pull the Kit for each production run and automatically accept return of the unused components when the production run is finished.

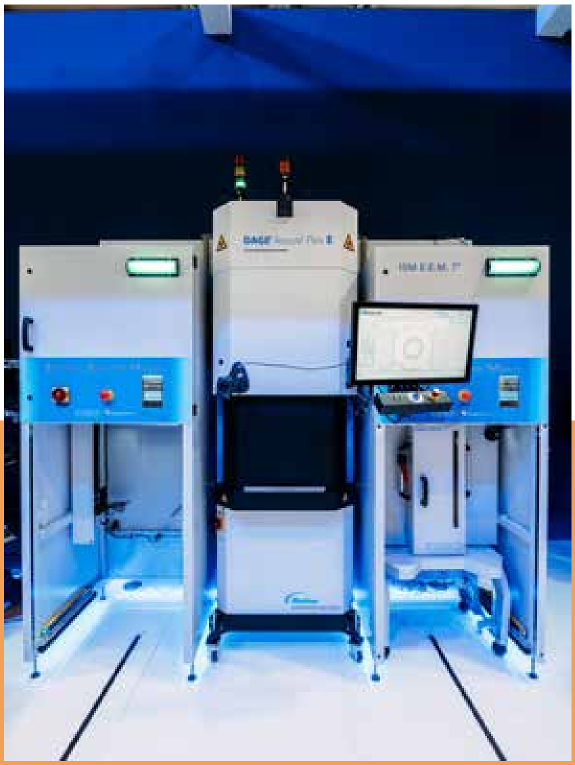
A fairly recent development has been the integration of AIV's (autonomous intelligent vehicles) and AGV's (automatic guided vehicles) to pick up the kits of components pulled from stock by the Automated Component Storage Towers, and deliver them to the production set up area. These vehicles can also pick up the remaining components after they are removed from the production line and deliver them back to the storage units which will automatically return them to inventory. In large factory floor settings, the vehicles can also be used to transport components from the main warehouse to the automated storage units located closer to the production line, or to transfer components automatically between warehouses or automatic storage locations. In this paper we will give an overview of how these automated vehicles are integrated and to show several of the ways they can be used to reduce the need for human intervention and labor in the electronic production environment. We will also show the equipment developed by the world's leading manufacturer of automated component storage, and how it can be modularly implemented in the factory to maximize ROI and minimize costs.



THE **MULTI-INTERFACE MODULE** (MIM)

The multi-interface module, or MIM, is used to connect blocks of automated storage towers to elevator modules allowing the automatic loading and unloading of electronic components into case carriers for transport to and from the production lines. As we can see clearly in figure 2, one side of the MIM is used for storage of components, while the opposite side acts as the interface to EEM's (external elevator modules) and also to x-ray component counters which we will describe in detail later in this paper. The MIM is connected to the last 3600 or 3900 module in a component storage block using the same linking conveyors as other modules. Please see our previous paper "Automated Component Storage, Key to the Automated Warehouse for Industry 4.0" for more information on the 3600 and 3900 modules. The MIM's robotic system can handle cases delivered from other modules in the block, or cases stored in the MIM itself, and stack them in a case carrier via the external elevator module. It can also accept an incoming case carrier and unload the stack of component cases via the external elevator module.

ELEVATORS AND INTEGRATED COMPONENT COUNTER



A unique feature of the multi-interface module is its ability to link with an x-ray component counter, and deliver and retrieve components to and from the counter automatically. By using this counter all incoming component cases can be counted prior to being stored in the component storage towers. It is also possible to automatically cycle count any component stored in the automated storage tower block during slack production time or even overnight. The updated count is reported to both the automated component storage system software and if the customer chooses, to the ERP system.

THE **EXTERNAL ELEVATOR MODULE** (EEM)

The external elevator module is available in two sizes, one for 7-inch component cases, and another for 15-inch cases. There are two positions on the MIM where it EEM's may be mounted, one to either side of the rear of the MIM. The elevator modules are used to load or unload component cases from the case carrier. After a case carrier is delivered to the EEM by an AIV, the elevator will unload the cases and transfer them to the proper storage locations in the automated storage tower. When the kit is being pulled for transfer to the production line the MIM will deliver the kit to the case carrier via an EEM. The case carrier will then be moved to the production area by an AIV.

THE **CASE CARRIER**

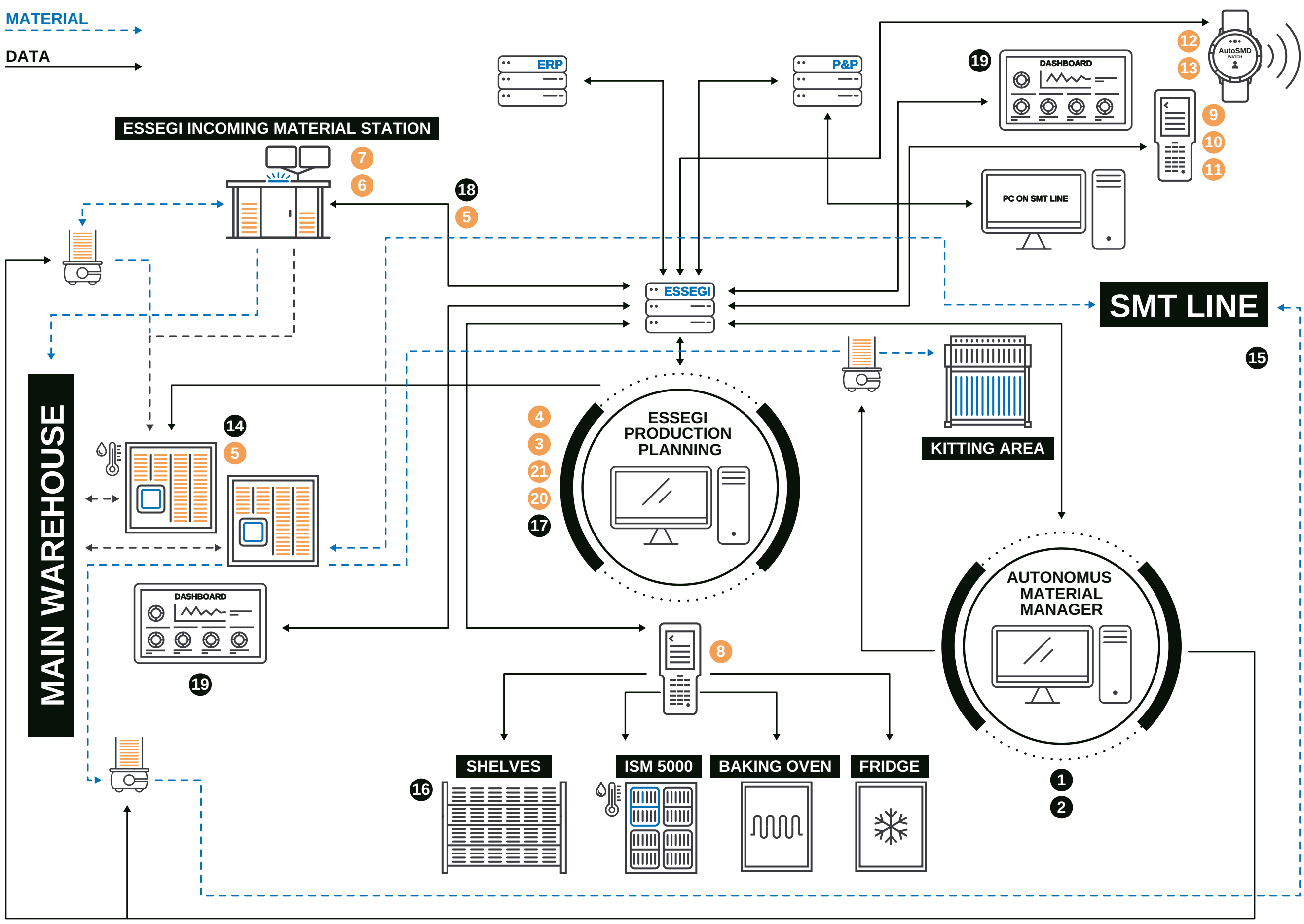
The case carrier is a wheeled trolley with a holding rack for stack of component cases on the top side, and an area below where an AIV can dock and latch the case carrier for transport to and from the automated storage systems. If an AIV is not available, the case carrier may be manually pushed by an operator using the attached handles. When an AIV delivers a case carrier to the EEM, it will unlatch and go about other duties while the EEM unloads the case carrier and then reloads it with a new kit of components. In this way, the AIV does not need to wait while the loading and unloading takes place, but can go about another task during this time. When the case carrier has been reloaded by the EEM, the AMM (autonomous material management system) will communicate with the Fleet Management software of the AIV to schedule another AIV to come and pick it up. This system of not dedicating an AIV to a case carrier allows the user to minimize the number of AIV's required for component transport. AIV's remain active and do not sit waiting for kits to be loaded or unloaded.

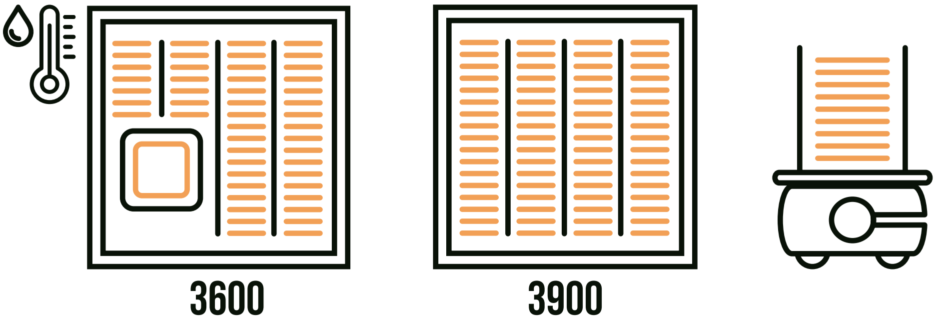
THE **AIV** (AUTONOMOUS INTELLIGENT VEHICLE)

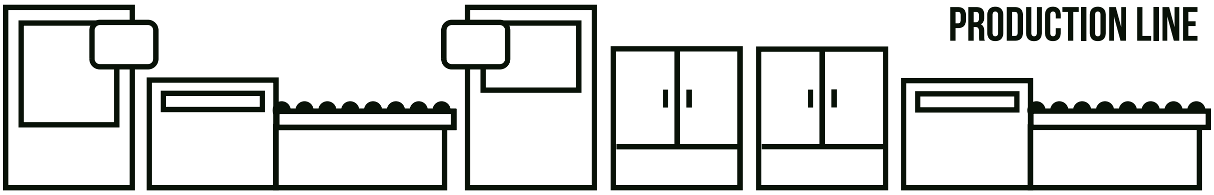
Autonomous Intelligent Vehicles, formerly known as AGV's (automatic guided vehicle) have been around for almost 50 years. The earlier examples were guided by following a track on the floor, usually a metal tape glued to the floor along the route the vehicle was to take. Today's AIV's are far more advanced, and require no tapes or markers on the route, but are guided internally by sensors scanning the front, back, and sometimes sides of the area the robot is traversing. Modern units learn the environment through which they will travel in a process that usually can be done in less than a day. These AIV's also can sense approaching obstacles, or individuals blocking their progress and will stop automatically and then attempt to find a way around the obstruction to continue on to their destination. These systems are capable of traveling great distances at speed, and we have a couple of large factory customers where components are transported up to 1 km between warehouse and production line locations. The AIV's typically can work up to 6 to 8 hours before needing a recharge. When charging is needed the AIV will inform the AIV Fleet Management software and automatically proceed to a charging station and dock with it. When docking at locations where great accuracy is required, a short floor marker can be used for even greater accuracy, but when traveling between locations, just the onboard guidance is necessary to guide the AIV during its trip. The photographs in this paper show the use of an Omron AIV which was chosen by this customer for general factory use. Other brands of AIV can also be used with the Essegi storage systems at the preference of the customer. This should be discussed and decided as part of the initial project planning.

THE **AMM** (AUTONOMOUS MATERIAL MANAGEMENT) SOFTWARE

The Autonomous Material Management software, or AMM, acts as a traffic control system which directs the AIV's in their tasks of transporting components loaded in case carriers throughout the factory. The AMM also forms a bridge between the ISM software controlling the automated component storage towers, and the Fleet Management Software provided by the AIV manufacturer. When the ISM software receives a request for a kit from the ERP or MES software used by the customer, it contacts the AMM and requests an AIV to pick up the case carrier which it has loaded via the MIM/EEM. The AMM will communicate with the Fleet Management Software which will direct a specific AIV to pick up the case carrier and transported to its destination. The AMM can be programed with multiple pick up and drop off points throughout the factory and warehouse complex. A number of zones can also be defined in the layout. The AMM software is capable to handle a large number of AIV's and Case Carriers from an infinite number of automated storage blocks.







FLEXIBILITY – READY FOR FUTURE GROWTH OR CONFIGURATION

This entire factory automation system is designed with complete modularity and the ability to be expanded in phases as the business needs grow. A user may begin with one 3600 automated storage tower and one incoming material station used as standalone units. As the business expands, one or more 3900 expansion storage units can be added to increase the quantity of components in automated storage.

When a second block of 3600/3900 units is installed, the automated transport through the use of AIV's can be added. An MIM can be added to the rear of each block with the appropriate EEM elevator module(s) to load and unload case carriers transported to and from the production area by AIV's. The user may choose to add an x-ray counter to one of the blocks mounted at the center position of its MIM. It is not necessary to have an x-ray counter mounted to every block, as the AIV's can transport components from one block to another to be counted and then returned.

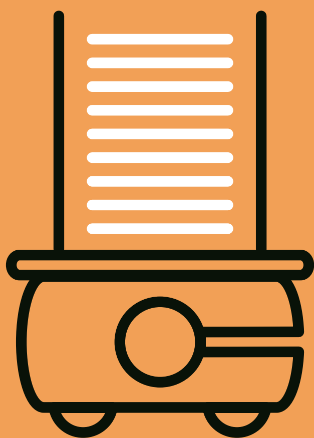
As more blocks of automated component storage units are added in different locations within the factory, the automated component transport system can keep all of them connected as part of one cohesive factory layout.

COMMON **LAYOUTS**

Because of the modularity and flexibility of the automated component storage systems several different types of layouts are possible. For smaller companies, storage units located near the production lines may be able to hold the entire component inventory and pull and return kits of components right to the production set up area.

For companies with large centralized warehouses, where large quantities of components are stored, a main warehouse/point of use model may be more practical. In this example storage towers are located adjacent to the production lines with a ratio of perhaps one storage tower for each two production lines. The components needed for the upcoming days production, are stored in these towers and the kits are pulled directly adjacent to the line set up area. With linkage between the pick&place systems and the component storage tower software, it is also possible to deliver quickly replacement reels when a component is about to be exhausted. This is done through an emergency drawer on each machine which enables it to pull a rapidly needed real even when it is performing an entire kit extraction. In addition, as production is run and components are used, the line storage tower can send automatic messages to the main warehouse requesting replenishment of components needed for the upcoming production runs. The main warehouse storage systems will then pull these kits and direct that they be delivered to the line side component storage units. In this way the components that are needed are stored close to the point of use at the production line, and are automatically replenished as production occurs.

And many other configurations are possible. We have one large customer who has a large central warehouse building surrounded by several adjacent production buildings with their own small warehouses. They were in the process of setting up an automated system where the AIV’s pickup at the main central warehouse and deliver to the warehouses in the adjacent buildings. The possible configurations are limited only by the customers imagination.



CONCLUSIONS

As companies continue to push towards the goals outlined in Industry 4.0 and set their sights on achievement of the “lights out factory”, automated component storage systems with integrated component counting and AIV transport can be vital building blocks in achieving these targets. As the pace of innovation quickens over the next few years, you can count on major advances continuing in the field of automated warehousing, component management, and automated transport of the material used in production.

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