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How real-time locating systems can boost efficiency, visibility, and safety while enabling digital twins for production processes

Real-time locating systems (RTLS) offer precise, end-to-end visibility of moving objects and people in production and logistic processes, while supporting digital twins to boost efficiency, safety, and productivity.

Abstract

This paper provides an overview of the Siemens SIMATIC RTLS solutions and its enabling ultra-wideband wireless radio technology. This includes how it works, its many benefits, and 17 potential applications and use cases in industrial and logistics operations. Simple to install and operate, RTLS solutions use existing IT networks and can provide location data of materials, tools, vehicles, and workers to within a few inches or centimeters, with latencies of less than 1 second. RTLS can also feed data into higher-level MES and ERP systems for issuing alerts, alarms, or commands. Plant and logistics operators can use RTLS data to increase efficiency, visibility, and safety. At the same time, SIMATIC RTLS solutions can complete the picture of digital twins for production processes by providing dynamic location data in real-time for all physical objects and personnel, whether at rest or in motion.

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Two critical questions from the world's most modern factory floors

As the world's industrial plants modernize with more and more digitalization and automation, an increasingly critical question is emerging about their assets used in production and logistics: **"What's where, when?"** And, even more importantly, in terms of worker safety, is this: **"Who's where, when?"**

Precise answers to these two questions can often be hard to come by, despite the advanced technology deployed in today's dynamic, digital manufacturing enterprises. That's also the case with the emerging use of digital production twins—virtual proxies of their physical plants and workflows modeled in software.

Digital production twins use real-time operating data from sensors and machines to reflect the current status of physical plant operations. But it was once nearly impossible to know with much accuracy the location at any given time of the many physical objects and people on a plant floor, no matter whether they're at rest or, most difficult to track, moving from one place to another.

Of course, over the years, systems using barcodes, sophisticated RFID, and video surveillance have been used to help. Unfortunately, limits on both their purpose, coverage, and in the case of RFID, the laws of physics have fallen short of providing real-time, end-to-end tracking and visibility of raw materials, work-in-progress, and finished goods throughout production – plus the tools and people involved.

Big impacts. This lack of visibility can have big consequences. Take production logistics, for example. Should a feedstock assignment error occur, it could compromise output quality, reduce machine utilization, or even stop production. This can force large amounts of work-in-progress to be scrapped and production lines restarted at enormous costs.

Or, consider a less consequential example, such as misplaced tools. Until they're found, searching for them can waste expensive plant labor and possibly hold up production.

Life safety can be at stake, too. With automated guided vehicles (AGVs) free-roaming many plant floors, not knowing where floor personnel are in real-time can cause accidents. Workers can also inadvertently enter work areas that can become temporarily dangerous due to material movements or other situations. But pinpointing their locations in real-time can be used to prevent access – and possibly injurious mishaps.

Smarter smart factories. To make today's smart factories even smarter, operators need a way to fully synchronize everything and everyone in them and in real-time. Intelligent systems, such as mobile robots and AGVs directed by advanced automation software, must be able to autonomously sense and respond to the changing dynamics on their plant floors. These capabilities are especially needed for the self-organizing factories of the future.

The good news is now they do. It involves a technology that can complete a digital production twin's picture by providing full tracking capabilities for physical objects and people anywhere in a plant or its surrounding premises and at all times. It's SIMATIC Real-Time Locating Systems (RTLS) solutions from Siemens.

SIMATIC RTLS: Real-time location capabilities across entire plant premises

Using ultra-wideband (UWB) wireless technology and triangulation techniques, the Siemens SIMATIC RTLS platform can locate objects and people equipped with UWB transponders to within a few inches or centimeters of their actual positions with latencies of less than 1 second. It can also detect and report their motion, acceleration, elevation, and orientation. The RTLS system can then immediately relay all this positioning data to higher-level systems in real time, making it available for a variety of plant applications.

To enable its real-time location capabilities, the SIMATIC Locating Manager software calculates the position of each transponder by a method called Time Difference of Arrival (TDOA). Accuracy is increased still further using flanking measures such as automatic correlation of RTLS position data with the 3D model of the product and production environment stored in the digital twin. TDOA also helps extend the life of transponder batteries, ensuring reliable function over several years.

UWB, also known as pulse radio, provides "see-through-the-wall" radar-like capabilities, so little or no RF engineering is required to install. That's because its penetrating signals don't bounce off metal or get absorbed by liquids as other wireless radio technologies can.

With an extremely wide frequency range (3–7 GHz), UWB uses a bandwidth of at least 500 MHz to transmit relatively low-energy wireless signals that can still provide short-range communications for location purposes. This alleviates the possibility of interference with other wireless systems in plants, warehouses, and any operating yards between or around them.

Siemens SIMATIC RTLS systems consist of wireless hardware transmission and signal-gathering infrastructure, a locating server, and the integration with the RTLS information and events to higher-level systems, as shown in Figure 1 below.

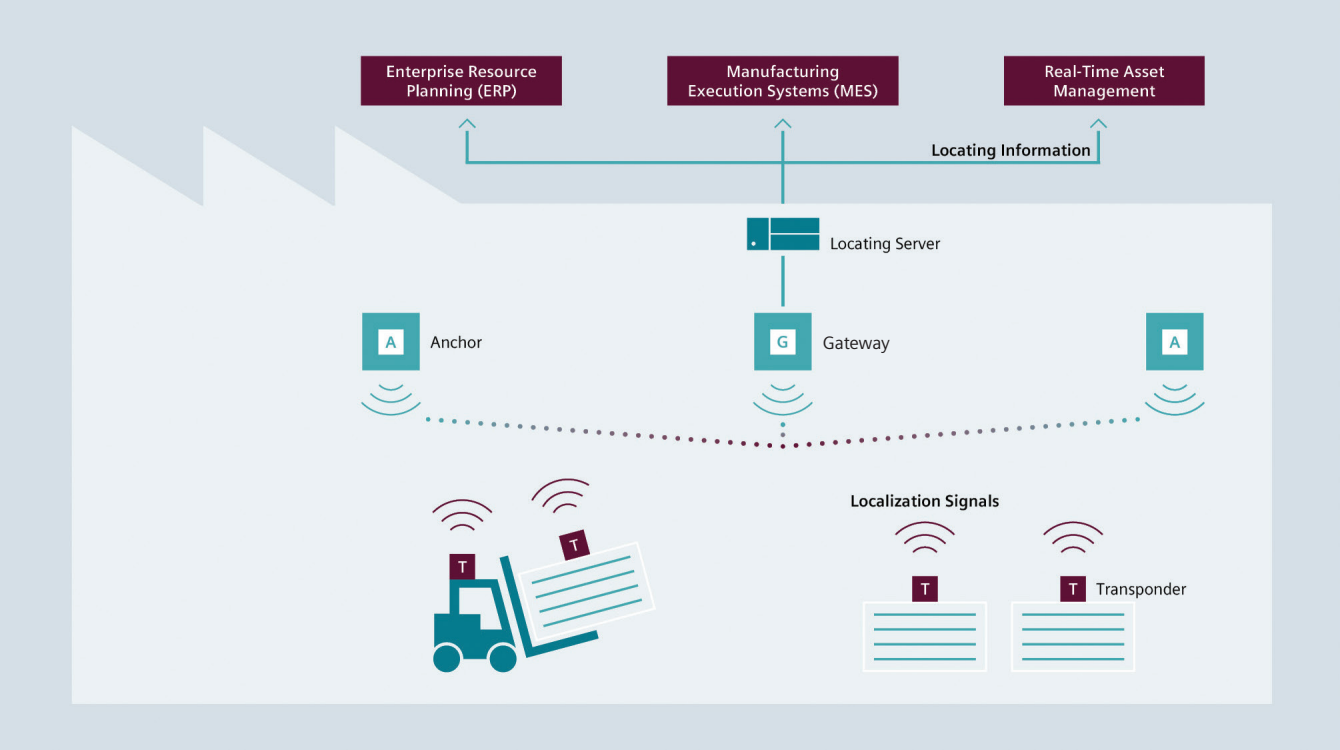

Figure 1. The Siemens SIMATIC RTLS solution architecture consists of (from bottom to top): (1) the data-gathering hardware infrastructure; (2) the locating server; and (3) the integration with higher-level OT and IT systems, with extensibility to cloud-based platforms, such as the Siemens MindSphere open IoT operating system, designed specifically for industry.

The SIMATIC RTLS portfolio features four interworking components:

- **Transponders**. These devices are active UWB transmitters that come in various models and sizes for being fitted to material containers, workpieces, robots, AGVs, forklifts, and people's work badges or attire. Whether in motion or at rest, they send UWB signals at defined intervals to receivers called anchors.
- **Anchors.** These devices are typically wall-mounted inside plants and warehouses and record the signals emitted by different transponders. Anchors have a steady position within the localization network. They serve as reference points for the localization calculations and enable the collection and transmission of localization data. At east four anchors mark the transponders' UWB signals with a fixed position and time stamp, then pass the data to the gateways.
- **Gateways.** These devices, which can also be used as anchors, collect the recorded data and transmit it to the Locating Manager server. Gateways act like anchors, but feature an interface for IT network connection. Localization data and optionally application-specific data can be exchanged between the wireless localization network and the localization server via the IT infrastructure.
- **Locating Manager.** This server-based software application calculates the real-time position of individual transponders and relays the data to higher-level systems for use in RTLS-enable locating applications. With a rules engine as part of the Locating Manager application, it is possible to define specific events and locations and configure higher-level system responses, such as alerts and action commands.

A white paper issued by: Siemens.

Easy deployment and expansion. Siemens SIMATIC RTLS solutions are extremely easy to deploy and configure, especially because they do not require RF engineering. A qualified electrician's skills are all that are necessary. In addition, these RTLS solutions are highly scalable, so plant and logistics operations can add RTLS capacity in stages as site needs grow – right up to a company-wide infrastructure – with no additional configuration costs.

This scalability allows companies, which are taking their first steps toward becoming fully digital enterprises and using digital production twin operating models to conduct pilots, then invest further as the technology validates its value.

Higher-level systems integration. What's more, the Siemens SIMATIC RTLS technology and location data can be integrated in higher-level production systems, such as safety systems, manufacturing execution systems (MESs), and enterprise resource planning (ERP) systems.

For example, location data can be used by an MES to trigger a production step or execute an order to deliver more feedstock to production, while notifying the plant's ERP system to decrement inventory numbers and, if levels have fallen below par stocks, to order more from the plant's supplier.

RTLS data can also be used for fleet management of moving vehicles, such as forklifts, AGVs, and mobile robots. This can help to augment maintenance records and to assess utilization rates, helping engineers find ways to improve the availability and utilization of these assets.

To gain a complete enterprisewide view across multiple plants, even those located on different continents, companies can use cloud platforms like Siemens MindSphere, the open IoT operating system, to link each one and combine its RTLS data with other plants' data streams. This capability can facilitate self-organizing plant operations, while also enriching data streams for advanced analytics.

Many other benefits. RTLS location data generated by Siemens SIMATIC RTLS solutions can help plant and logistics operators in many other ways:

- **Improved visibility,** via the continuous monitoring of goods that combines process and position data to reduce waste and improve traceability.
- **Better container utilization**, to ensure their location, availability, and accurate assignment.
- **Reduced costs,** with more efficient processes and less extra work.
- Improved productivity, by reducing or eliminating inefficient process steps.
- **Better quality,** with fewer potential errors in material handling.
- **Optimized maintenance,** with RTLS-based guidance for service technicians.
- **Advanced logistics concepts,** via AGV or forklift routing and better control of picking processes.
- **Improved documentation,** by mapping actual location data of physical objects and personnel in motion against a workflow's engineered designs.

Diverse applications and use cases for SIMATIC RTLS solutions

RTLS information can be employed in many ways, as subsequent use cases will illustrate. One application, for example, is the tracking of tools and how they are used in a production process, such as in auto interior assembly, illustrated in Figure 2 below.

In this scenario, a SIMATIC RTLS transponder is affixed to the powered, auto-fed screwdriver tool being used by a single assembly worker. The left diagram shows the tool's actual path into and out of the car body. The right diagram shows the real-time location of the tool, as indicated by the small dots.

With this data, it's possible to determine exactly where inside the car body that the worker is able to screw in a component, and the torque and angle of the screwing motion, the latter made possible by a sensor inside the RTLS transponder. In turn, engineers can analyze the movements and potentially find a more efficient, time-saving approach for workers to conduct this step in the assembly process.

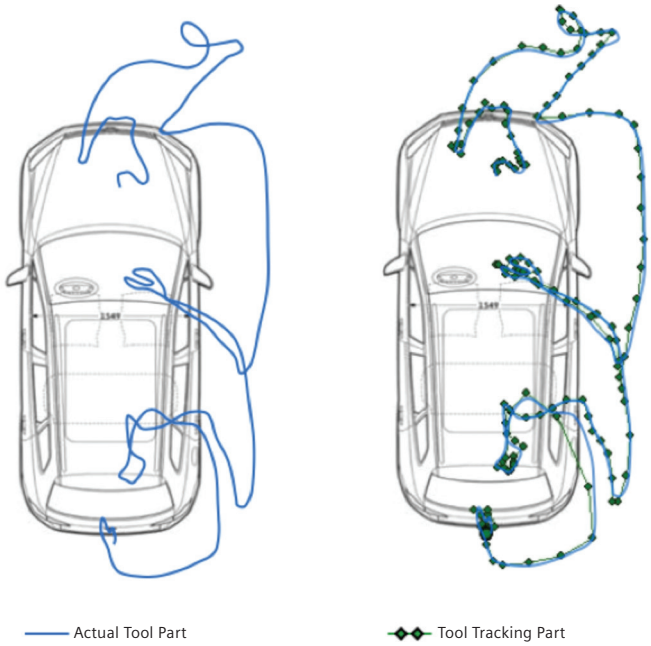

Figure 2. How the Siemens SIMATIC RTLS solution can track a powered, hand-held screwdriver's path during the installation of an auto interior, then analyze the tool's use for possible optimization of this assembly step.Actual Tool Part

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Also, it's worth noting that, by coupling the RTLS location data with geo-spatial fencing technology, the screwdriver tool ceases to operate when the worker steps outside of the tool's defined work area. In this case, such a capability can safeguard workers against accidental injury from the tool's auto-feed function.

Other RTLS applications and use cases include:

- **Inbound logistics**

  Standing time records: This SIMATIC RTLS application can provide automatic recognition of a vehicle's time of arrival on a premise and its departure from the premise. It can generate an overview containing the standing times of the truck, enabling operations engineers to reduce inefficient idle times.

  Automated parking allocations: In this situation, a SIMATIC RTLS system can be used to automatically assign arriving supply trucks their designated unloading spaces as soon as they pass a plant's gates into its receiving area.

  Access control: SIMATIC RTLS location data can automatically determine which RTLS-tagged vehicles are eligible to enter what areas. Gates will only open for vehicles with appropriate privileges.

  Tracking delivered goods: The SIMATIC RTLS system records the location and condition of scanned delivered goods. In addition, scanned data can be linked to video recordings to associate video footage with the goods. Further processing steps can be tracked in real-time.

- **Intra logistics**

  Forklift localization: With all of the forklifts of a plant or logistics operation equipped with a SIMATIC RTLS sensors, their locations, routes, availability, and status can be called up instantly. In addition, access restrictions can be assigned with geo-fencing used to keep the forklifts from entering unauthorized areas.

Siemens acquires Agilion, the world's RTLS technology leader

In 2018, Siemens acquired the world's RTLS technology leader, Agilion. Based in Germany, the company brought a long-standing reputation for precision engineering and sophisticated expertise.

Agilion pioneered the use of UWB wireless technology in RTLS solutions for manufacturing and logistics. It brought to Siemens a base of about 150 customer RTLS installations in more than 20 countries.

The company joined the industrial communications and identification business of the Siemens Process Industries and Drives Division, with North American headquarters outside Atlanta, Georgia.

Container and pallet localization: Products in containers or on pallets can be located via the location of transportation vehicles such as forklifts. The SIMATIC RTLS system knows the exact location as soon as a container or pallet is deposited at a designated storage location. The location is transmitted to the transportation vehicle driver's terminal device once the stored goods in the container or on the pallet have to be processed.

Container management: The SIMATIC RTLS system can record and monitor all container flows within a plant's container normal circulation patterns. This can ensure that the containers are available at the correct location, at the right time, in the right condition, and in the correct number at a minimum of costs. This reduces the chance of loss and optimize production processes.

- **Production logistics**

  Tool localization: With SIMATIC RTLS sensors attached, plant tools for an inch-perfect localization and furthermore supports the production process intelligently. For instance, various commands regarding a screw gun's torque control along the production steps can be stored or the battery status retrieved.

  Work-in-Progress: Intelligent, real-time localization with SIMATIC RTLS can help plants automate specific steps along entire production lines. Machines, tools, and workers can get detailed information from the RTLS sensor on the workpiece about where it came from and how it needs to be processed. This can provide efficient process control and transparent material flows.

  Production progress monitoring: SIMATIC RTLS can be used to monitor the different stages in a product's manufacture. It can provide detailed, time-based overviews of production progress, so engineers can gain insights how to better optimize the production process.

- **Outbound logistics**

  Product storage localization: Storage of overproduced goods can be localized to within centimeters. In automotive manufacturing, for example, overproduced vehicles are parked in large spaces, which often requires time-consuming and cost-intensive inventory management. But precise SIMATIC RTLS localization enables specific vehicles to be identified by location, eliminating physical searches.

  Truck loading: SIMATIC RTLS can localize finished goods for truck loading, whether they're to be picked up straight from the production line or from a warehouse. This can simplify otherwise complex communications, reducing errors, and enhance the transparency of outbound logistics.

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Departure time recording: Departure times of loaded, outbound trucks can be captured and recorded automatically upon the truck leaving the premise, using SIMATIC RTLS solutions. This enables plants to document times of departure and better monitor their logistics process.

- **People tracking**

  Manpower planning: SIMATIC RTLS transponders can be affixed to employee badges or work attire, including hardhats (see sidebar) to locate and track individual personnel through their shift activities. This way, plant engineers can conduct data-driven manpower planning to increase employee efficiencies, while ensuring headcounts are always optimized for variable plant workloads.

  Workplace safety: With a SIMATIC RTLS infrastructure operating, plant operators can have exact to-the-second localization of all employees. This can be especially critical in inherently dangerous industrial work, such as mills, mines, excavation, and demolition. If an accident occurs, responders can immediately identify all affected employees, where they are, and even who is standing or has fallen.

  Access restriction: Using SIMATIC RTLS technology, plant and logistic operators can ensure that only authorized employees can gain access to dangerous working zones.

SIMATIC RTLS: Ready for deployment today

By providing real-time location data for physical objects and workers, whether at rest or in motion, Siemens SIMATIC RTLS solutions can help plants and logistics operations to achieve several key advantages:

- **Streamline workflows** for greater efficiencies, asset utilization, and production throughputs.
- **Gain greater visibility** into those workflows, by combining RTLS data with other data, and apply advanced analytics to identify process improvement opportunities.
- **Boost worker and overall plant safety,** by knowing where workers are at all times and their status, as well as by restricting worker and vehicle access to accident-prone or inherently dangerous areas.

In addition, Siemens SIMATIC RTLS solutions can help a company achieve higher levels of self-organizing operations by way of RTLS technology delivering real-time location data of physical objects and people to the digital twin of its production model. This makes the digital production twin much more dynamic and reflective of current operating conditions inside a factory or logistics facility.

In this scenario, RTLS systems will supply the essential foundation intelligent production, enabled by the real-time synchronization of different production resources, such as mobile robots interacting with material-handling systems and production machinery. This means the actual location of a machine or robot will become a key variable factor, so autonomously controlled, highly efficient workflows can only be organized given a real-time view of a plant's current spatial configuration.

With approximately 150 RTLS systems installed worldwide, Siemens SIMATIC RTLS systems are proven in diverse applications in plants across many different industries. Today, they're helping these companies realize greater efficiencies, visibility, and safety in their operations, while establishing the basis of being a fully digital enterprise in the future.

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