

TECHNICAL REPORT

ISA-TR100.00.02-2009

**The Automation Engineer's Guide to
Wireless Technology: Part 2 – A Review
of Technologies for Industrial Asset Tracking**

Approved 2 October 2009

ISA-TR100.00.02

The Automation Engineer's Guide to Wireless Technology Part 2 – A Review of Technologies for Industrial Asset Tracking

ISBN: 978-1-936007-28-8

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ISA
67 Alexander Drive
P. O. Box 12277
Research Triangle Park, North Carolina 27709
USA

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The Automation Engineer's Guide to Wireless Technology: Part 2 – A Review of Technologies for Industrial Asset Tracking

1 Scope and Purpose

Tracking of assets in an industrial setting has been the focus of ISA100 Working Group 21 which, at the request of end users on ISA100, has compiled information pertaining to various types of RF technologies that could be considered for industrial deployment. This is a different operational matter than the supply chain management aspects of Radio Frequency Identification (RFID). What was originally associated with the RFID world has evolved into the more aptly named Real Time Location System, RTLS. While RFID could essentially be thought of as a database management system with readers that could inform the database as to which reader last observed the tagged asset, RTLS brings the tracking of devices into the realm of where an asset is right now. There are a wide range of wireless technologies that may be used to provide industrial RTLS functionality. As with most things wireless, there are certain technologies and techniques that are more developmental than others, with “new” advances popping onto the scene seemingly monthly.

This technical report presents a number of technologies that, as of the date of this document, are under consideration for deployment and utilization in industrial settings. In many instances, the technology was meant for a different environment – not the “canyons of metal,” variable attenuation, potentially multipath-laden environment of industrial settings. Not every specific detail of every candidate technology is reviewed, just a few that various end users such as those in petrochemical (on-shore/off-shore), pharmaceutical manufacturing, power systems (generation and distribution), and pulp and paper processing have inquired about.

While not inclusive of every possible asset tracking technology, those included are based on technical report contributions over an 18-month period.

1.1 Intended Audience

The audience for this ISA technical report includes all users of Manufacturing and Control Systems (including facility operations, maintenance, engineering, and corporate components of user organizations), manufacturers, and suppliers.

2 Asset Tracking - Using Wireless in an Industrial Setting

Consider the “typical” industrial facilities shown in Figure 1. In each of these locales, the amount of reflective and absorptive surfaces associated with the “canyons of metal” lead to variable attenuation and multipath conditions which are frequently dovetailed into requirements for the wireless devices to operate in a non-line-of-sight, explosive environments. This combination places considerable strain on the performance, reliability and maintenance of the components that comprise an RTLS system.

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Figure 1. Photos of industrial sites.

From a more technical perspective, in practice a radio signal may encounter many objects in its transmission path and undergoes additional attenuation depending on the absorption characteristics of the objects. There are many types of objects, including fixed, mobile and transient objects, that absorb RF energy and cause RF attenuation. Since a number of RTLS techniques involve the received signal strength value, with operation of the wireless devices at various frequencies, such a variation in the RF environment may cause havoc with the system performance. For example, similar to free-space propagation loss, higher frequencies attenuate much faster than lower frequencies. With respect to signal propagation through various materials, 5-GHz RF signals typically have higher attenuation than 2.4 GHz. The following table shows the attenuation (dB) introduced by various objects to RF signals at the 2.4-GHz and 5.8-GHz bands. Of particular note are the attenuation values for that material which is prevalent in most industrial facilities, concrete. The large disparity in the values shown arise from different types of concrete materials in use in different parts of the world. In addition, the thickness and coating differ depending on whether it is used in floors or interior or exterior walls. Brick walls usually have attenuation at the lower end of the range shown in Table 1.

Material

Attenuation (dB)

	2.4 GHz	5.8 GHz
Interior drywall	3-4	3-5
Cubical wall	2-5	4-9
Brick/Concrete wall	6-18	10-30
Glass/Window (not tinted)	2-3	6-8
Double-pane coated glass	13	20
Bullet-proof glass	10	20
Steel/Fire exit door	13-19	25-32
(note: materials chosen in response to End User requests)		

Table 1. Typical attenuation values for various materials.¹

Not included in the table are attenuation values for a number of other “materials” that are commonly found on an industrial site. Measurements of RF signal attenuation caused by water reveal higher levels of relative attenuation of signal transmissions in the 5.8-GHz ISM (industrial, scientific, and medical) bands than in the 2.4-GHz band ². However, rain, snow and fog attenuations are very small for frequencies under 10 GHz. The rain attenuation at 5.8 GHz is barely noticeable (< 1 dB per kilometer). Human bodies, being composed of predominantly (70%) water, attenuate RF signals approximately 3dB in the 2.4-GHz range and 5dB in the 5.8-GHz range.

Numerous industry groups have arisen to claim their share of the potential market for industrial asset tracking. In most cases, an organization aligns with a certain wireless technology that may be used for other means, but can be – and has been – adapted for asset-tracking applications. Please note that this comparison is subjective with ample room in each category to discuss the noted value (e.g., battery lifetime). This information is based on public forum presentations.

A number of candidate technologies associated with industrial RTLS are examined. Each technology has its own unique requirements for a supporting infrastructure to provide a somewhat comparable location resolution with, of course, an accompanying system cost. Of particular note are the many “varieties” of RFID technologies that are being used for pallet-level tracking. There are active RFID technologies that use proprietary tags and receivers that are used in the process industry environment as well for the “more traditional” warehouse management/supply chain application

¹ Additional information regarding signal attenuation for 2.4 and 5.8 GHz may be found at “Propagation Losses: 2.4GHz vs. 5GHz” 2002 Magis Networks, Inc. which can be found at the following link:

<http://www.am1.us/Papers/E10589%20Propagation%20Losses%20%20and%205GHz.pdf>. Formal approval to relay that information was not obtained, therefore it is left to the interested reader to read that article.

² In the context of this technical report with respect to water vapor, fog, rain, water, the phrase “attenuation” is used to convey any decrease in received signal strength, be it from absorption or scattering.

areas. Certain RFID technologies also exhibit a form of RTLS and presence detection capability. Many of these features are presented in the next section.

3 RFID-Based Asset Tracking

There are many different flavors of Radio Frequency Identification (RFID), ranging from systems that have no active components within the “tag” to battery-powered semi-active tags, to fully active tags (that are essentially microcontroller-based wireless devices even including the possibility for sensing). The key aspect of RFID systems is that they require a reader, sometimes referred to as an interrogator, and the tags themselves. By utilizing ISM (license-free) frequencies ranging from 130 kHz to 245 GHz (see Table 2), it is possible to tailor the entire system for specific needs. For example, if the goal is to track livestock, then a system operating at 125 (+/-) kHz is preferable to one at 2.4 GHz due to the significantly less signal attenuation caused by animals to the 130-kHz signal.

Center Frequency	Bandwidth (+/-)
130 kHz	5 kHz
6.78 MHz	15 kHz
13.56 MHz	7 kHz
27.12 MHz	163 kHz
40.68 MHz	20 kHz
915 MHz	13 MHz
2.45 GHz	40 MHz

Table 2. Frequencies typically used in RFID. Note that these are essentially the ISM frequency bands.

However, the bandwidth allocated to the 130-kHz ISM band is substantially less than that allocated to the 2.4-GHz band, therefore less information (a.k.a., bits) should be transmitted. There are many similar benefits and detriments associated with operation of the system at different frequencies, with a most obvious one being that the lower the frequency, the (physically) larger the antenna in both the reader and tag.

The general operation of RFID components includes a database system, asset tag readers (also called interrogators or gateways), and the tags themselves. The situation is shown in Figure 2.