

# White Paper

W I L L Y O U R E P C G E N 2 S Y S T E M  
B E U P T O S T A N D A R D ?

## Executive Summary

The promise of increased functionality in RFID systems created in compliance with the new EPCglobal Generation 2 (Gen 2) standard creates a foundation for a new era of RFID use in the supply chain. Momentum and mandates have quickly established Gen 2 as the RFID technology of choice for many global organizations and their trading partners. Despite its promise, it is important to understand Gen 2 is a starting point and is not the end of RFID supply chain innovation. Potential users may be surprised to learn there will be significant disparities in performance and capability among Gen 2-compliant products.

Gen 2 creates a foundation on which to build interoperable RFID products and systems that will improve inventory management, logistics and retail operations around the world. However, standard-based products don't provide standard performance. Wireless LAN technology users know this well. There are enormous differences in features and performance among the hundreds of products that comply with the IEEE 802.11b wireless networking standard. Some products are intended for families to use in the home, while others are engineered to support simultaneous transmissions from dozens of warehouse workers who complete thousands of transactions per day. Security ranges from practically none, to encryption strong enough to protect government secrets. There also are major differences in the time and effort required to set up, configure and maintain 802.11b-standard equipment.

Gen 2 RFID technology will follow a similar development path. The standard specifies basic RFID communications performance required for common supply chain business processes. However, although companies have similar information needs as their competitors and have comparable business practices, usage environments are anything but standardized or homogeneous. Gen 2 or any RFID technology won't provide exactly the same performance at any two facilities. That is why it is important to understand the difference between what Gen 2 specifies and the range of performance that compliant Gen 2 products could provide in real-world use. Gen 2 is a standard, and standards specify minimum performance requirements.

Many organizations know they need Gen 2. But how can they know they will get what they need out of it? By understanding the Gen 2 performance specifications and how different features will impact real-world performance, users can specify Gen 2 systems that provide the functionality and benefits they need.

This white paper will describe the six key user requirements for Gen 2 performance: speed, efficiency, reliability, range, security and cost. It will explain how they can differ among Gen 2-compliant products, equipping you with the information you need to define the performance and products that your environment requires.

## Speed

The ability to read RFID tags quickly and simultaneously is fundamental to many of the application benefits the technology can provide. Gen 2 speed requirements were developed and refined based on the needs and experiences users reported from systems that used Generation 1 technology in material handling and supply chain applications. Efficient sortation, distribution and inventory management requires the ability to identify and differentiate items on high-speed conveyor systems used at distribution centers without having to slow down the material handling system to accommodate EPC identification.

There is no firm or minimum speed specification within the Gen 2 standard, because reading speed depends on many variables, including power output, tag density and the RF environment. Gen 2 technical specs should enable readers to perform more than 1,500 tag readings per second in North America and 600 reads per second in Europe, which has more power and bandwidth restrictions. These speeds support the ability to identify objects on conveyor belts moving 650 feet per second, and those being carried by forklifts that pass through reader portals at eight miles per hour. The write rate, which is highly dependent on the amount of data written, is about 10 tags per second and is fairly consistent worldwide.

The Gen 2 spec supports "group select," a feature that is very important for providing high-speed reading and sortation. Group select provides the capability for RFID interrogators to be set to seek and read select groups of tags (based on data structure) and to ignore others in the read field. For example, interrogators can be set to ignore case tags and only record pallet tags. The feature reduces the amount of data the system must process, for faster reading.

Users always need to be assured that all tags will be identified as they pass through the read field; it is more important for reads to be correct than to be fast. Reliable systems make efficient use of their speed and identification protocols to constantly monitor the read field to ensure that tags that enter late are still identified. This functionality, which is not referenced in the Gen 2 spec, is called persistence.

A new feature in Gen 2 from previous generations is the use of the “Q algorithm” to identify tags and manage transmission collisions. The Q algorithm is an important innovation that enables many tags to be accurately identified quickly. To accomplish this, it establishes a structure for tag-reader communication and puts tags into a “sleep” mode until it is their turn to respond. Previously identified tags are ignored, so time-wasting re-identification is avoided.

The sleep mode can pose a problem. Tags on the edges or outside of the reading field don't receive full power from the reader, and therefore may not remember if they have been identified. “Persistence” is a feature that gives tags the ability to remember their status if they lose access to reader power. Persistence greatly improves read performance, especially in large tag populations.

Generation 1 EPC specifications did not support persistence, which contributed to some of the reliability problems reported by users. The ISO 18000-B RFID standard does support persistence, which proved the viability and value of the feature that led to its inclusion in the Gen 2 standard. However, not all Gen 2-compliant products will provide persistence.

### **Bandwidth Efficiency**

Wireless bandwidth is limited, highly regulated and must be managed carefully. There is much more to bandwidth management than selecting a frequency; signal modulation, power output and the presence and density of other RF devices in the environment must all be accounted for. Standards and specifications address most of these variables so users don't have to, but Gen 2 technology users still must make some important system decisions.

Gen 2 products can be used throughout the world without a site license and will provide the range, speed and other performance needed to meet the supply chain application requirements spelled out by users. Many Generation 1 products and implementations were developed based on U.S. Federal Communications Commission (FCC) radio regulations. FCC-compliant products, while following Generation 1 specifications, were not compatible with other government regulations around the world. Users needed to acquire site licenses to use the technology elsewhere in the world, which proved to be a major implementation obstacle.

The Gen 2 standard provides users some flexibility for how interrogators utilize bandwidth. System performance can be optimized based on the number of RF devices operating in the environment. In recognition of this, the standard defines three modes of Gen 2 product operation – single reader, multi-reader and dense reader. Specifications for each mode are intended to provide improved performance in typical usage environments. EPC Gen 2 tags are not made specifically for different reader modes and can be read and written to by products from each category.

The single reader mode specification is intended for implementations where there will only be one interrogator per facility. Single reader mode allows bare-bones compliance with FCC requirements for bandwidth management. It provides acceptable performance, but is not a good neighbor to other RF devices that may be operating nearby. Single reader mode wireless phones and older, non-802.11 wireless networks and other devices in the UHF frequency band could also pose an interference problem.

Multi-reader mode products are more RF friendly. Multi-reader mode products make more efficient use of bandwidth and manage their transmission more carefully. They can operate in environments with up to about 10 readers present without causing significant performance problems.

Dense reader mode is for use in facilities with more than 10 readers, which includes most distribution centers and factories where RFID systems operate. RF channels are used very precisely to minimize the chance of interference. For example, tags and readers communicate on different channels, which reduces collisions and makes them easier to manage. Using separate channels also minimizes interference and aids high-speed reading.

Dense reader mode is the safest choice for implementing EPC equipment. It provides the most focused and efficient use of bandwidth, which optimizes performance and protects against interference.

Just one single-reader or multi-reader device in a dense reader environment could easily overpower other devices and cause interference that prevents tags from being read. Single reader mode is like blasting music from a boom box – it's acceptable if you're by yourself, but not if you're on a crowded airplane. Dense reader mode is more like headphones, which deliver what you want to hear without disturbing those around you.

Gen 2 technology customers need to be aware of the modes and their differences and plan accordingly, especially when considering system upgrades. Single-reader mode products are the easiest to design and cheapest to produce. Legacy RFID equipment that is said to be upgradeable to comply with the Gen 2 standard may only be upgradeable to single reader mode. There are extremely limited opportunities to use single reader mode products in real-world environments, so it is important for customers to specify dense reader mode compliance where it is called for, keeping potential future system expansion in mind.

## **Reliability**

Not every application requires the high-speed reading and advanced bandwidth management that the Gen 2 standard provides, but every user needs to be sure that all tagged items are identified accurately. The Gen 2 standard includes several improvements over the Generation 1 specifications to make reading performance more reliable. There also are ways to implement the standard and compliant equipment to further improve data integrity and system reliability.

EPC numbers follow a defined data format, which makes it possible for systems to verify data read from and written to the tag. The Gen 2 standard shifts data checking from the reader (as in Generation 1) to the air interface, which enables faster execution. Gen 2 also adds protection against receiving false positive readings, also known as ghost tags. Ghost tags are recorded when the reader picks up portions of data from different tags and interprets them as the identification of a single (non-existent) tag. Improvements to the Gen 2 air interface are intended to prevent the incidence of ghost tags that plagued Generation 1 systems.

Gen 2 tags will also perform more reliably in a wider range of operating temperatures. Traditionally, synchronizing tag and reader timing could be accomplished in a tag manufacturing procedure that added expense and limited the temperature range in which the tag could function. Gen 2 tags can be produced in a way that reduces tag cost and increases temperature parameters, but not all manufacturers will produce tags this way.

Unlike CDs, Flash memory and other storage media, Generation 1 RFID tags do not automatically verify data written to them. The Gen 2 standard adds support to verify data written to tags. Generation 1 technology users experienced lost and corrupted data, and made verification a requirement for the Generation 2 standard. Generation 2 is by design a more robust and reliable protocol that overcomes the Generation 1 data reliability problem. Insist on products that provide write verification if the integrity of written data, or the assurance that tags have been disabled, is important to your operations.

Device reliability can take on added importance in RFID systems, because they tend to feature more unattended operations. A worker with a handheld bar code reader can keep trying to scan a symbol until he or she gets a confirmation beep. Users can also call attention to equipment that may need service or fails altogether. These safeguards aren't available for unattended RFID conveyor, portal and similar systems. Remote monitoring, diagnostic and notification capabilities should be built into the equipment itself so the system can provide the performance, uptime and reliability RFID operations require.

## **Range**

User requirements – not standard specifications – dictate the range required from Gen 2 EPC systems. Companies at one point in the supply chain may only need to capture pallet tag information from a few feet away with handheld readers before shipping pallets to a customer. At the next stop, tagged cases might be stacked high on warehouse shelves where much longer read range is required. As with speed, there is no range requirement in the Gen 2 standard because of the many variables that effect range, which include interference, reader power output, duty cycle (the amount of time the reader can continuously transmit), reader density and more. The Gen 2 specifications enable range to satisfy user-defined supply chain application requirements.

The country where Gen 2 equipment is used can have a significant impact on range. Power output and duty cycle regulations are different around the world. Because of these differences, users can get more range from Gen 2 systems in North America than some other regions. Therefore it is important to test and evaluate equipment for all the locations and environments in which it will be used.

Manufacturers can take advantage of flexibility within Gen 2 specifications to improve reader range. Gen 2 allows, but does not require, spread spectrum radio transmission. Spread spectrum technology broadcasts over multiple channels, which makes efficient use of bandwidth and provides improved range over other transmission techniques. Under FCC rules, spread spectrum communication also enables continuous operation and higher power output. Alternative communication methods broadcast intermittently and with less power, which can result in slower performance and reduced range.

## **Security**

Standard EPC tags are protected against tampering. The standard protocol includes encryption and requires the tag and reader to create a secure link before data is transmitted, which makes it very difficult to alter the EPC number. Disabling (killing) tags in the field so their data can never be accessed is a requirement in the retail and consumer goods industries to allay customer privacy concerns, so the standard supports this ability. It also has authentication requirements to prevent unauthorized and accidental disablement of tags. Additional security needs arise depending on how tags are used, which require features in read-write equipment beyond what's needed to read standard tags.

There are multiple ways to implement additional security, which will create differentiation among Gen 2-compliant products. "Cloaking" enables tags to be set so they will only communicate with authenticated readers. Readers must provide a password before the tag will respond with any communication. Passwords may also be required to write to tags or disable them.

New applications, such as lot code or expiration date tracking, likely will emerge to take advantage of the data content flexibility that Gen 2 allows. Supplemental data doesn't automatically get the same protection as the originally encoded EPC number, so users must take steps to secure and validate data. Security is required to ensure additional data written to tags is protected. Supplemental tag data also can be password protected so it is available only to select business partners or internal process users. Write protection and password protection are not standard features and will not be supported in all Gen 2 products.

## **Cost**

A leading motivation for development of the EPC system was to create RFID technology that was cost effective for use in supply chain operations. Development efforts focused on creating specifications to enable the production of low-cost chips and equipment. Initial user experience with Generation 1 EPC technology revealed that low-cost designs had fatal limitations when used in real-world operations. Reliability, data security and range were among them. The user community provided clear direction to the EPC standards committees to improve tag and reader functionality. The Generation 2 standard was created specifically to satisfy user desires and concerns. The EPC Gen 2 standard strikes a balance between cost and functionality that should lead to the development of cost-effective products that satisfy real-world application requirements.

The previous sections have established why standard-compliant Gen 2 products will not provide standardized performance because of the range of features and options available in Gen 2-compliant systems. Differences in features and performance must be considered when assessing system costs. Value is a more important consideration than cost, but is not easily compared among different products without a good understanding of the functionality required from the system. A good starting point for comparison is to determine the features needed from the Gen 2 system and to create a checklist for meaningful product comparisons. Figure 1 proves an example.

**Figure 1: User requirements for Gen 2 functionality checklist**

	Product A	Product B	Product C
Can the product perform in dense reader mode?			
Expected cost to upgrade to dense reader mode?			
Is persistence provided?			
Is group select supported?			
Is continuous operating mode available?			
Can the interrogator write to tags?			
Is write verification performed?			
Can data be write protected?			
Is password protection available?			
Is remote management and configuration possible?			

### **Intermec Intellitag® Gen 2 RFID systems**

The checklist shows some of the many ways EPC Gen 2-complaint products will differ from one another. Gen 2 provides standard protocols and minimum performance requirements that chip and equipment readers can use to create equipment, which will likely range from highly intelligent and adaptive products to bare bones, limited feature offerings designed to meet minimum requirements.

Because of Intermec’s extensive RFID development history and close involvement with EPCglobal standards development, Intermec is intimately familiar with the Gen 2 standard, the variations of how it can be implemented, and its potential performance in real-world systems. Intermec Intellitag® Gen 2 systems are designed to move beyond the limitations in the basic Gen 2 standard to provide high-level performance. Many of the optional features that Gen 2 supports are standard in Intellitag Gen 2 products. Intermec provided royalty-free use of core intellectual property that made the EPCglobal Gen 2 standard possible, and it remains actively involved in supporting EPCglobal Gen 2 standards committees.

In addition to the basic Gen 2-compliant air interface protocol adopted by EPCglobal, many features exclusive to products from Intermec and its partner technology licensees provide optimal Gen 2 performance. These features have proven their value in Intermec RFID systems that have been implemented over the years. Intermec Intellitag RFID systems provide the following functionality to meet customer’s Gen 2 implementation requirements.

- **Dense reader operation** – Without dense reader capabilities, multiple readers and tags operating in proximity will experience interference that can render the system unusable. Intermec readers fully comply with dense reader mode requirements, allowing multiple readers to be used in the same area – an essential function in commercial applications. Intermec readers transmit on very narrow channels with tags responding on side bands, a capability that makes extremely efficient use of bandwidth. Many pre-standard Intermec RFID interrogators can be upgraded to dense reader mode, Gen 2-compliance without requiring hardware replacement, allowing hundreds of Intellitag readers to be used in the same facility.

- **Write verification** – An RFID system is only as good as its ability to verify that the tags in that system have been read. Timing and synchronization methods developed by Intermec provide fast, reliable verification of data written to tags. The technique differs from others in that it can be implemented without increasing tag cost and does not limit the range of operating temperatures in which tags can be used.
- **Persistence** – Intermec supports persistence in its Intellitag systems, which provides reliable performance with extremely fast read rates, even in dense reader environments.
- **Range** – Intellitag uses frequency hopping spread spectrum (FHSS) communication, which enables maximum read range. In the U.S., FHSS provides 100 percent duty cycle reading. In Europe, ETSI (European Telecommunications Standards Institute) radio regulations prohibit 100 percent duty cycles. Intermec was the first manufacturer to demonstrate an ETSI-certified, Gen 2-compliant EPC interrogator.
- **Write protection** – Write verification activates the write-protect feature built into Intellitag systems. Intellitag Gen 2 systems provide the option of permanent or password-reversible write protection.
- **Tag kill** – The write protection, write verification and password features of Gen 2 Intellitag products also enable users to set readers to kill tags in the field.

It bears repeating that these features are standard in Intellitag products and correlate directly with user requirements for successful Gen 2 implementations.

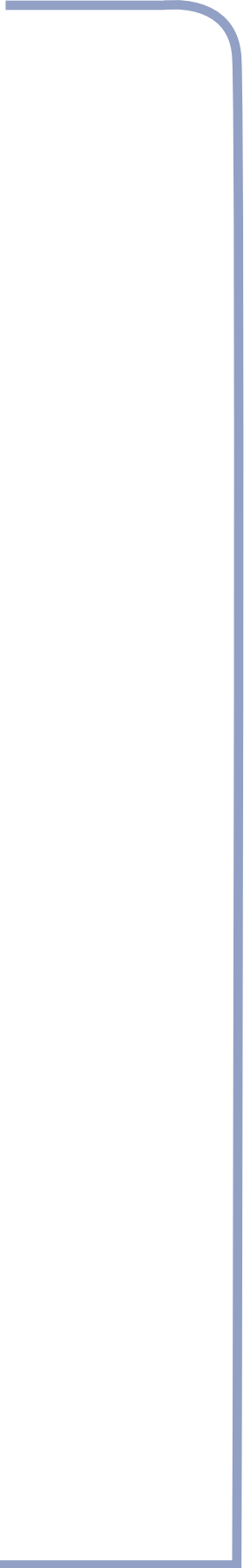
The advantages Intermec provides go beyond the unmatched features in its Gen 2 products. Intermec has established close collaborative relationships with leaders in all segments of the RFID industry, from chip makers to integration specialists. These relationships and technology sharing agreements make it possible for Intermec and its partners to provide systems that take full advantage of Intellitag's unique product features.

## Conclusion

By understanding the disparities in performance, reliability and ease of use that different standard-compliant products will produce, Gen 2 users can make the best decisions about the products that will form the foundation of their applications. The most important thing to remember about EPC Gen 2 technology is that "standard" does not mean "equal." In its years of RFID development, Intermec has placed high value on creating systems with functionality, reliability and value. Users seem to agree. Intermec was honored to be recognized in 2004 as the best radio frequency identification (RFID) hardware provider by the readers of *Consumer Goods Technology* magazine. The Reader's Choice Awards are determined by polling the magazine's readership about which vendors they use in a variety of categories and then asking them to rate them on a scale of one-to-five on their customer experience, including factors such as return on investment, usability, performance, implementation and customer service.

To learn more about how your company can benefit from Intermec Intellitag Gen 2 systems, contact Intermec Technologies Corp., 6001 36th Ave. West, Everett, WA 98203 USA; 800-347-2636; or [www.intermec.com](http://www.intermec.com). To learn more about Intermec's parent company UNOVA, visit [www.unova.com](http://www.unova.com).

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