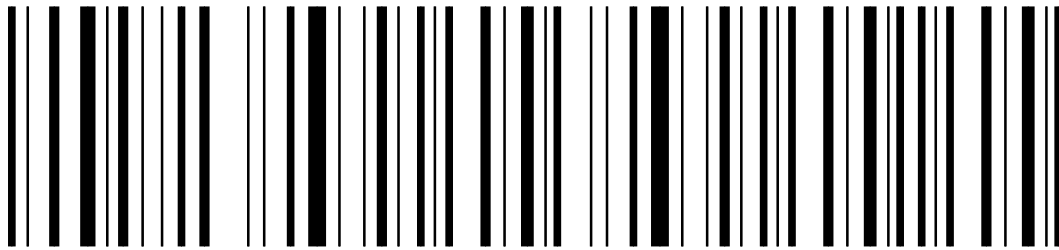


# Managing the EPC Generation Gap

*An overview of EPC standard migration from Generation 1  
To Generation 2 RFID tags.*



APPLICATION WHITE PAPER

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**Zebra Technologies**



## S u m m a r y

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Most leading organizations who have committed to using Electronic Product Code (EPC) technology—and are requiring their suppliers to ship products “marked” using it—have stated their intention to build their supply chain systems on ultra-high-frequency (UHF) EPC Generation 2 (Gen 2) chip specifications. The final UHF Gen 2 chip specification is expected to be ratified by EPCglobal in October 2004. At that point, compliant Gen 2 chip and reader products can be finalized and deployed. As a result, wide-scale Gen 2 RFID deployment is not expected until mid-2005.

Many organizations, particularly suppliers to the United States Department of Defense (DoD) and retailers such as Wal-Mart, are under mandates to start deployment of radio frequency identification (RFID) technology in January 2005, and cannot wait for Gen2 systems to become widely available before they begin their EPC deployment efforts. As a result, many companies are piloting programs and initial implementations with UHF Generation 1 (Gen 1) EPC-compatible products that are currently available.

Gen1 refers to the RFID chips supporting Class 0 and Class 1 RF protocols that specify the air and communication interface and commands between the readers and tags, as well as outline the functionality required in each class. It is clear that many companies will need to plan a migration path from Gen 1 to Gen 2 technologies, and both Wal-Mart and the DoD have built this consideration into their compliance mandates. For example, the DoD in its RFID policy document issued on July 30, 2004, states that it expects to continue to use Class 0 and Class 1 tags for up to two years after the introduction of Gen 2 tags.

This white paper will facilitate effective EPC system planning by:

- Outlining the original concepts that drove the creation of Gen 1 specifications;
- Describing the key differences between UHF EPC Gen 1 (Gen 1) and Gen 2 systems;
- Explaining how these differences relate to systems planning;
- Providing clear guidance and recommendations for application and IT infrastructure planning that will support an efficient migration to Gen 2 technology; and
- Describing how to create EPC systems with a clear and manageable upgrade path from Gen 1 to Gen 2 technology that will protect initial investments.



# I n t r o d u c t i o n

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The EPC Network of enabling technologies started development at the Auto-ID Center at the Massachusetts Institute of Technology and now is being commercialized under the leadership of EPCglobal. These technologies are the leading RFID-based solutions for global, open supply chain applications. The roster of companies committed to using EPC standards and mandating that their suppliers support EPC specifications is growing rapidly and currently includes the U.S. Department of Defense (DoD), with more than 43,000 suppliers; Wal-Mart, with more than 20,000 suppliers; The METRO Group; Albertson's; Target Corporation; Best Buy; Tesco; and others.

The EPC Network is comprised of five fundamental technologies:

ELECTRONIC PRODUCT CODE (EPC): Like the Universal Product Code (U.P.C.) bar code, the EPC identifies the manufacturer and product version, but has an additional serial number field to identify uniquely each identical item.

EPC ID System (tags, printer/encoders, and readers): EPC tags consist of a microchip attached to an antenna. The EPC data is typically stored in the EPC tag while embedded in a "smart" label being printed on an EPC printer/encoder. The label incorporating the tag is applied to an item during the manufacturing process. EPC tags communicate their data to EPC readers via radio waves and deliver information to local business information systems using EPC middleware.

EPC MIDDLEWARE: This software specification for services enables data exchange between an EPC reader, or network of readers, and business information systems.


OBJECT NAME SERVICE (ONS): Business information systems need a way of matching the EPC to the database information about that item. The ONS is an automated networking service that provides this service by linking computers to sites on the World Wide Web.

EPC Information Systems (EPCIS): EPC Information Systems enable users to exchange data with trading partners based on EPCs.

The EPC Network grew out of perspectives that only open RFID systems and standards—paralleling the open EAN.UCC System of bar code standards—would support a global supply chain. RFID systems enable objects to "report" information about themselves in real time without human intervention and can give a company visibility into real-time information about inventory locations, histories, and quantities. The goal of the EPC Network is to let companies leverage their internal RFID structures to gain exponentially by capturing and sharing real-time business information *across entire companies and with trading partners*. In other words, *RFID deployments based on open, standardized EPC interfaces that enable interoperability and multi-vendor implementations may achieve the ultimate in global data sharing: Total asset visibility*. That is why so many leading companies are supporting and driving the adoption of EPCglobal standards for the EPC Network.

The scale of this undertaking is huge, unlike anything attempted with RFID technologies before. However, many leading consumer packaged goods (CPG) companies and technology vendors are no longer saying "if" but "when" the total EPC Network vision becomes a reality. A great deal of investment already has been made in RFID pilots. As with all emerging technologies and grand visions, the reality is that initial discovery phases lead to new conclusions and results that modify original thinking and—in the case of RFID—raised expectations for this technology.





In effect, this is what occurred with the UHF Gen 1 specifications. The Class 0 and Class 1 protocols that came out early in the cycle when the Wal-Mart and DoD mandates were issued for case and pallet auto-identification. What was needed was a methodology that would allow readers to communicate to low-cost tags that would carry only the EPC “license plate” number. The EPC would tie back through ONS to databases that could hold an infinite amount of dynamic data about each item.

***Gen1 UHF RFID technology stressed low cost and simplicity.*** The idea was to limit the EPC number to a “license plate” that pointed to the product-related data associated with each item stored on databases held in back-office systems. In addition, the Gen 1 protocols provided guidelines for the operating characteristics of readers and tags, covering frequencies, emissions standards, anti-collision methods (to address contention where multiple tags are seen the reader simultaneously), and secure data transmission practices.

Similar to the U.P.C. code that provides for manufacture, product, version, and serial data, the EPC data structure was envisioned to contain:

- A header that identifies the EPC version number;
- The EPC manager, which typically would be the manufacturers name;
- The object class or version information, which essentially is the product information; and
- A serial number, which would be information specific to of item in an object class.

Originally both 64-bit and 96-bit EPC data structures were proposed. Since many object classes and serial numbers were not needed initially, a family of 64-bit data structures was proposed to keep down the price of Gen 1 RFID chips. (The more robust 96-bit EPC provides unique identifiers for 268 million companies, each with up to 16 million object classes, with 68 billion available serial numbers in each object class).

The Gen 1 Class 0 and Class 1 tags were specified by EPCglobal to contain the EPC data structure, a cyclic redundancy check (CRC) to verify the tag data, and a kill or destruct code that would deactivate the tag and no longer allow it to respond to reader commands. As originally specified by EPCglobal, Class 0 were read-only tags. Class 1 were specified as write once/read many tags, so in addition to the other functions, Class 1 needed a “lock” command to prevent any further modification of the tag information once written. Both classes had a “kill” function to ensure user privacy after product sale. No other data or tag functionality was considered as part of the Class 0 and Class 1 specifications, however important variations did occur.

As with all new technology, Gen 1 products rapidly evolved beyond the original specifications. There are now 96-bit versions of both Class 0 and Class 1 in use. There are also versions that extend the Class 0 and Class 1 specifications published by EPCglobal:

- For example, while Class 1 specifies one-time-programmability of the EPC data field, in practice “Class 1 compliant” tags may be read/write.
- There are also “Class 0+” products that are one-time field programmable but are read using the specified Class 0 air interface protocol.

Gen 2 was developed in response to shortcomings of the Gen 1 technology that were discovered during pilot projects with early adopters. These early adopters soon found that it was more practical to leverage their significant investments in RFID to begin to transform their internal processes to be more productive. It became apparent that tags that could be read to and written to many times were more effective for many of their operations, such as pallet and case reshipment in distribution centers and third-party logistics operations. In addition, it made sense in many applications to allow the tags to carry more data than just a 64-bit EPC number. In effect, the tags themselves became mini databases of important information they could integrate directly with their existing bar code-based IT infrastructure without any need to reference a back-office system. Also, the Gen 2 RF transmission protocol specification was specifically designed to provide robust, international operation under new European and Asian UHF radio regulations for RFID that were changed after Gen 1 products had been designed.

The Gen 2 specification stipulates more EPC memory on the chip, a minimum of 96 bits and up to 256 bits. Most of the organizations that have committed to Gen 2 technology have issued supplier requirements that specify the use of 96-bit identifiers. Therefore, suppliers and other participants in these supply chains must have an IT infrastructure capable of processing 96-bit data to produce and read Gen 2 tags.

Differences between Gen 1 and Gen 2 technology are summarized in Figure 1.

	<b>Generation 1</b>	<b>Generation 2</b>
<b>Frequency</b>	860MHz – 930MHz	860 – 960MHz
<b>Memory capacity</b>	64 or 96 bits	96 to 256 bits
<b>Commercial products available as of 9/1/04*</b>	Yes	No
<b>Field-programmable</b>	Yes	Yes
<b>Re-programmable (read/write)</b> <i>(Per EPCglobal specifications – see text for current Class 0, 1 product configurations)</i>	Class 0 – Specified as read only Class 1 – Specified as Write once/Read many	Yes
<b>Field-killable</b>	Yes	Yes

There are other differences among the Gen1 and Gen2 RF transmission protocols that for the most part are transparent to users and are unlikely to impact implementation planning. The complete specifications are available on the EPCglobal Web site (<http://www.epcglobalinc.org/>). It is also worth noting that EPCglobal recently performed some interoperability testing to provide guidance to the market on the essential functions of “EPC compliant” products. For example, tags made by “Manufacturer X”, are compliant with the Class 1 specification, and can be read using a reader made by “Manufacturer Y” when encoded by “Printer/Encoder Z.” Zebra’s Class 0 and Class 1 printer/encoders met all required tests for interoperability. Full testing results can be seen at <http://www.epcglobalinc.org/interoperability>.



## Managing the Migration

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Most discussion of Gen 2 technology has been focused on issues such as accommodating new RF emission regulations, immunity to interference by competing radio signals, and enhancing the performance of “densely spaced readers” (a situation where a large number of readers are within relatively close proximity to each other, such as at the doors of a cross-docking warehouse). However, the change in tag memory size and its resulting impact on data structures is potentially far more disruptive to companies that already have begun to implement 64-bit EPC technology.

The migration to Gen 2 will be similar to the effort required to prepare for Y2K compliance and, in a more industry-relevant example, the upcoming UCC 2005 Sunrise, when 12-digit U.P.C. numbers will become obsolete and scanning systems must be able to process 13-digit EAN-13 codes. For Y2K compliance, no one had to purchase a new PC with a larger screen in order to view the four-digit date format required for Y2K compliance, and most modern bar code scanners already are capable of scanning EAN-8 and EAN-13 symbols. In both situations, compliance or migration to the new standard mostly requires information systems software updating and integration.

The same principles hold true for migration from Gen 1 to Gen 2 EPC technology. Hardware costs typically account for about 30 percent of total RFID system implementation expenses, and tags are just one part of that cost. Software redevelopment expenses for converting 64-bit EPC tag applications to process 96-bit EPC tags will generally cost much more than any savings produced from using lower-cost tags in the pilot. Therefore, *it makes little sense to ever deploy 64-bit tags in a Gen 1 EPC system when 96-bit Gen 1 tags are available.*

In many cases, Gen 1 EPC printer/encoder and reading equipment can be made compatible with Gen 2 specifications through a simple firmware upgrade or installation of some components. Some manufacturers guarantee their customers that EPC equipment purchased prior to the finalization of Gen 2 specs will be upgraded or replaced at new cost when new, compliant equipment becomes available.



# M i g r a t i o n   R e c o m m e n d a t i o n s


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Organizations can take tangible action immediately to implement UHF RFID systems that are EPC “Generation 2 ready,” even though the Gen 2 specifications and compliant products are still in development. The fact that the Gen 2 specification is not yet ratified is not a good reason to defer RFID system planning and implementation. Based on what is known about the relatively mature draft of Gen 2 specification, and the supplier requirements put forth by early adopters, systems can be implemented now that will be readily upgradeable to Gen 2, provided proper consideration is given to system design, software development, and equipment selection. Two key considerations going forward are:

- Most new RFID peripherals will be able to handle a mix of tag generations
- Data processing applications software can be modified to support new EPC code structures

Zebra makes the following recommendations for system development to implement “Generation 2 ready” systems:

- ***Commit to business process changes before committing to equipment.*** Do not get too involved in evaluating tags, printers, and readers before the organization has determined the internal business processes that the EPC RFID system will impact, internal applications for the technology, and performance requirements. Business process improvement is where the opportunity lies to make RFID pay for itself. Each organization must also understand the internal and trading partner environments where the RFID systems will be used. Only with this knowledge can system planners undertake meaningful tests and comparisons of EPC RFID equipment.
- ***Use only 96-bit identifiers in all EPC systems from the beginning.*** Pilot projects, smart label printing/encoding, software applications, item databases, and supporting information systems based on either Gen 1 Class 0 or Class 1 should all be designed to use 96-bit data structures. This is the single most important aspect that has an impact on the cost and complexity of migrating RFID and information technology infrastructure to Gen 2 tags from Gen 1 EPC tags.
- ***Gain experience with 96-bit Class 0 or Class 1 tags and equipment that are available now.*** The tag data structure is only one element of an EPC implementation. Organizations must learn how to encode, print, and read smart labels; where to place these tags on cartons and pallets; determine optimum reader and antenna configurations for more consistent reading performance; integrate data into business processes and IT systems; solve interference challenges to ensure tags are readable—and do all of this with an open mind to potential opportunities for business process changes. Much of the knowledge necessary to meet these requirements with Gen 2 tags can be gained by working with Class 1 and especially Class 0 systems. Experimenting and conducting pilots with currently available Gen 1 products will provide an important head start for when the time comes to implement Gen 2.
- ***Assess equipment upgrade ability.*** The effort and expense of upgrading EPC printer/encoders and readers to support the Gen 2 tags is an important consideration and potential differentiator among products from competing equipment suppliers. Upgrade ability to Gen 2 must be considered when hardware and middleware products are evaluated and selected. Organizations should understand the migration strategy and upgrade policies of their equipment vendors. Typically this sort of information will be gleaned by the customer through a formal request for information (RFI) or request for proposal (RFP) document and questionnaire.



These recommendations are specific to managing the migration to Gen 2 EPC RFID technology. For a broader discussion of RFID system planning, see *Zebra's RFID Readiness Guide: Complying with RFID Tagging Mandates* white paper at <http://www.zebra.com>.

## C o n c l u s i o n

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Gen 2 UHF EPC technology already has secured an important role in future supply chain operations. Organizations who participate in these supply chains do not need to wait for future developments and can begin building efficient EPC systems today. The key is to balance deployment of current Gen 1 technology against future needs and develop an infrastructure that will support a seamless migration to Gen 2. Using 96-bit EPC data structures as a foundation, and equipment that supports it, will facilitate successful infrastructure development over time.

Zebra Technologies does not manufacture RFID chips and supports all EPC tag classes and RF communications protocols. Zebra actively supports the development of open EAN.UCC and EPCglobal standards. Zebra works closely with leading suppliers to ensure our customers will have a variety of smart label printing and encoding solutions to meet their varying needs.

This white paper was developed to help companies complete their EPC implementation plans. For general information about EPC and other RFID technology and applications, download Zebra's white paper, *RFID: The Next Generation of AIDC* from <http://www.zebra.com>. For guidance on managing an RFID compliance project, download *Zebra's RFID Readiness Guide: Complying with RFID Tagging Mandates*.

Zebra Technologies is a world leader in providing on-demand bar code labeling solutions that deliver information in forms that enable organizations to improve security, productivity, quality, and customer service. This leadership extends to RFID technology. Zebra was the first company to introduce an RFID printer/encoder, which simultaneously prints a bar code and encodes the embedded RFID chip in a smart label. Zebra can offer its customers the expertise and products necessary to support their bar code and RFID label printing needs. As a member of EPCglobal, Zebra has access to and supports the latest supply chain EPC RFID technology and standards development activities. Contact Zebra to see how your organization can gain a competitive advantage by using the right combination of bar coding and RFID smart labels. You will find a wealth of information on Zebra's RFID micro-site, <http://www.rfid.zebra.com>.



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