White paper

The 2D Revolution

How evolving business needs and improved technology are driving explosive growth in two-dimensional bar coding

Intermec®

Summary
Two-dimensional bar codes have quietly revolutionized many production, tracking and maintenance processes. Now, 2D bar coding is undergoing a revolution, thanks to important scanning technology advances and growing use in multiple industries. 2D applications are being adopted at more than double the rate of traditional 1D bar code technology, according to market research firm Frost & Sullivan.

Adoption is growing because companies are taking a fresh look at how 2D bar codes can meet their information, identification and traceability needs. The fundamentals of 2D technology capabilities, limitations and compatibility with legacy bar code processes have changed – and have changed faster than perceptions about the technology. Companies who have reexamined what 2D can do are benefiting from the effort.

This white paper identifies leading and emerging 2D bar code uses and benefits, explains why some commonly held perceptions about 2D scanning technology no longer apply, and shows how standards, regulatory requirements, business needs and technology advances are driving 2D adoption throughout the supply chain.

Introduction
Two-dimensional bar codes have always given organizations a reliable way to include information associated with a shipment, product, part or component, and are often the only practical option for accurate small-item identification. 2D symbologies have enough capacity to include intelligent data that can be used to drive decisions and processes in environments where traditional information systems don't reach. In fact, they are sometimes referred to as "portable databases" or "portable data files." If processes or workers could benefit from having more information, 2D bar codes are increasingly being used to provide it. Now that area imaging technology improvements have eliminated most of the functional and practical limitations to using two-dimensional bar codes, 2D applications are poised to revolutionize many business operations.

To understand how, compare how 1D and 2D applications typically work. Most traditional 1D applications use the bar code symbol as a "license plate" to encode a reference number to access information held in a database. License plates on cars do not tell the make and model of the vehicle or identify the owner. The plate number simply provides a unique number that corresponds to a database record with the information. Most 1D bar code applications are built on the same principle, which means the data encoded in the bar code has no use or value if it can't be associated with a database record.

One of the great values of 2D symbols is that they can encode enough information to drive applications that do not need database access. For example, in field service applications, technicians with no remote database access can simply scan a 2D code on a piece of equipment to get all the identification and configuration information necessary to complete the service work.

2D Basics
2D symbols can encode more data than 1D bar codes of the same size, and can encode the same amount of data in much less space. There are two main categories of 2D symbologies – stacked and matrix – and many individual symbologies. The primary differences between stacked and matrix symbols are how they are encoded and how they can be read.

Stacked symbologies are made up of two or more rows of linear bars and spaces. They take their name because they can resemble a series of small linear bar codes that have been stacked on top of each other. Leading stacked symbologies include PDF417, Code 16K, Code 49 and a version of GS1 DataBar formerly known as RSS Composite.

PDF417, a common stacked symbology

GS1 DataBar Composite combines 1D and 2D elements in a single bar code symbol

Laser scanners, linear imagers and area imagers are all capable of reading stacked symbologies, although not all readers can process all symbol sizes.

Matrix 2D codes encode data in dark and light geometric elements arranged in a grid. The position of each element relative to the center of the symbol is a key variable for encoding. Matrix symbologies are most commonly used for small item marking, and also for unattended and high-speed reading applications. Common examples include Data Matrix, MaxiCode, Aztec Code, Code One and QR Code.

Data Matrix, a leading matrix symbology

Matrix symbologies are decoded by processing the complete image to determine each element's relative position. Laser scanners cannot read matrix codes because they can't view the entire image at once – area imaging is the only bar code scanning technology capable of doing so. A major advantage to using area imagers is that matrix and other bar code symbols can be read in any orientation.

For comprehensive information about 2D technology, including descriptions of leading symbologies, guidance on how to choose, and information on 2D standards in various industries, see Intermec's white paper Sizing Applications for 2D Barcode Symbols, which is available as a free download from www.intermec.com.

"Manufacturing segments requiring high levels of visibility into individual parts tracking and automated assembly processes expect to be the largest end-user segment of 2D bar code. Products involving stringent documentation requirements throughout their supply chain movement also adopt data-dense 2D symbologies."

– Frost & Sullivan Research Analyst Priyanka Gouthaman[1]

The consumer goods and pharmaceutical industries also take advantage of 2D bar coding as an alternative to database access. Many consumer goods and pharmaceutical manufacturers use 2D bar codes to supplement identification labels with lot codes and expiration dates. The data is used throughout the supply chain to support many decisions and processes to ensure proper stock rotation, expedite shipments, remove unsaleable products from inventory and facilitate efficient tracking and recalls. Because the data travels with the products, access to the product manufacturer's information systems is not required for these applications. Logistics providers, wholesalers, retailers and other organizations in the supply chain can get the product identification and expiration data they need directly.

2D to the Mainstream

These examples illustrate the benefits of 2D bar codes – and also illustrate why a commonly held perception is no longer true. Until recently, 2D was widely considered a "niche" technology beneficial only for a few industries and processes. This perception has outlasted reality, because 2D adoption today is increasingly varied and widespread. With adoption growing rapidly in industries including manufacturing, maintenance, pharmaceutical and retail, in applications including production control, maintenance, product authentication, distribution and inventory management, 2D can hardly be considered a niche technology any more. Each month thousands of new products are marked with 2D codes for the first time as a result of initiatives in the pharmaceutical and defense industries, and an emerging standard has set the stage for millions more consumer products to carry 2D symbols. The following sections examine the implications of these and other developments.

Product Identification

Matrix codes occasionally appear on consumer goods packaging to supplement the U.P.C./EAN symbols with batch or lot codes and for product authentication. Now GS1, the international standards body that created the symbology and also manages the U.P.C./EAN system, is bringing 2D coding into the retail mainstream.

GS1 has established January 1, 2010 as the "sunrise date" for requiring scanners used at the point of sale and other retail operations to read and decode GS1 DataBar symbology bar codes. The GS1 DataBar family includes both stacked and composite 2D bar codes that can be used to encode standardized application identifiers (AIs), including lot codes and expiration dates, and others that can support enhanced security through authentication and traceability. GS1 estimates 85 percent of retail scanners will be DataBar capable by 2010.

GS1 made the decision to require DataBar after receiving extensive input from manufacturers and retailers who felt U.P.C./EAN symbols were too large and inflexible for encoding the information they wanted. In its business case analysis for DataBar (available from www.gs1.org/), the organization asserts users can get a positive return on investment through reduced packaging, improved identification of small, loose and variable-measure items, improved category management, and by taking advantage of improved traceability enabled by additional data encoding.

Pharmaceutical & Healthcare

Widespread 2D item identification may occur even sooner in the pharmaceutical and healthcare industries. In the U.S., numerous state and federal drug pedigree requirements have recently been enacted or are pending. These requirements typically require tracking chain-of-custody for prescription medications by lot code and/or serial number. RFID is frequently proposed for these applications, but 2D bar codes can handle the data requirements and often integrate more easily with legacy systems and processes throughout the supply chain. The European Association of Pharmaceutical Full-line Wholesalers (known by its French acronym, GIRP) has recommended the use of Data Matrix 2D symbols encoded with ID number, lot code and expiration date to identify and track pharmaceutical goods.

In the U.S. the FDA has already required medications to be dispensed in hospitals to be marked with a 1D bar code encoded with the National Drug Code (NDC) number. The FDA stopped short of requiring lot codes, expiration dates or specifying 2D coding, but noted there are many beneficial reasons for encoding and scanning this data and also noted 2D symbologies are an effective enabler for these applications.

2D symbols are also used on patient wristbands and this application is also poised to grow rapidly as more healthcare facilities implement scanning systems to take advantage of unit-of-use bar codes. Bar codes are ideal for patient identification because they satisfy both HIPAA privacy requirements and Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) accreditation guidelines. But linear bar codes have proven problematic on wristbands because the symbols are long enough to be affected by the curvature of the wristband. This makes it difficult to read the bar code accurately because the scanner can't always see the ends of the symbol which get obscured by the curve. Compact 2D symbols avoid this problem, plus they have the capability to encode more information than the patient identification number.

Industrial

Reliable performance on curved surfaces is one of the many reasons 2D matrix codes are the symbols of choice for industrial marking and tracking applications. Even when produced at sizes small enough for electronics components and other small items, Data Matrix and other 2D symbologies have the capacity to encode a unique serial number, lot code, configuration data, time stamps and other production information. Small 2D symbols can be read reliably with handheld or unattended fixed-position imagers in a variety of industrial settings including automated routing and assembly, work-in-process tracking, data entry for quality control testing, product genealogy and lifetime tracking.

[1] Frost & Sullivan. "Migration of 1D to 2D Barcode Scanners Market in North America," November 2, 2006.

There are numerous 2D standards to support traceability and manufacturing automation in the aerospace, automotive, defense, electronics, semiconductor, telecommunications industries. Some of the best-known examples include SPEC 2000 in aerospace, AIAG B-11 in automotive, UID from the U.S. Department of Defense, and numerous electronics standards from the Electronics Industry Association (EIA) and the Semiconductor Equipment Manufacturer's Institute (SEMI).

Many of these standards and marking initiatives are driven by the desire to provide cradle-to-grave traceability of parts, assemblies and components. Make-to-order and just-in-sequence manufacturing require more than basic identification and often need components to be marked with serialization, sequence or configuration information. Organizations throughout the supply chain, including suppliers, product manufacturers, service providers, packagers and distributors can all take advantage of the standardized information to exchange information and create their own records management applications – *with no central database access required*.

For example, a supplier that needs to provide uniquely identified parts to a manufacturing customer could scan the 2D part ID during the picking and packing processes to validate the right items were included in the order and packed in sequence. 2D bar code verification is often preferred and more accurate than relying on EDI data in these situations, because shipments often move ahead of when their corresponding EDI transaction is processed.

The implementations, standards and initiatives referenced above, together with the ever-increasing need for more information and traceability, are nevertheless not enough to explain the explosion in 2D use. The final development driving increased 2D adoption is improved reading technology.

Technology Advances

Until very recently, technology limitations with area imaging often made it impractical for organizations to transition from legacy 1D bar code applications to use 2D symbols. Laser scanners cannot read all 2D formats. Area imager scanners, which excel at 2D reading, couldn't read 2D codes at distances greater than an arm's length. Selecting a scanning technology for two dimensional bar codes has historically required making tradeoffs, because no single scanner was able to provide all the symbology support, range, reliability and speed required in real-world environments. Would-be users faced a choice of supporting multiple scanning technologies, or a single bar code technology. 2D adoption lagged as a result and its perception as a niche technology lingered.

"The market expects to witness a considerable level of convergence and co-existence in the short and medium term between 1D and 2D barcode applications depending on the application in focus."

– Frost & Sullivan Research Analyst Priyanka Gouthaman[2]

Area imagers read bar codes by capturing a full image of the symbol and using image processing software to decode it. They provide excellent performance for bar code reading, because they can read traditional linear, stacked and matrix symbologies in any orientation – which is a major difference from other reading technologies. Omnidirectional (orientation-independent) scanning capability means users don't have to arrange or align bar codes to read them, which results in more successful first-time reads, improved throughput, less operator fatigue and reduced chances of injury.

Area imagers can also be used to take pictures, and in fact share many components with digital cameras. These imaging capabilities also set them apart from other types of bar code readers and enable new applications, such as documenting the condition of goods delivered, inspection/quality control, form/signature capture, damage recording and more.

Despite this flexibility, area imagers have had limited adoption because of their traditional range restrictions. The same scanner used to read a 2D part mark couldn't also read the location code of the warehouse shelf the part was picked from. That limitation led to application tradeoffs that stifled adoption.

With the development of a new generation of area imager scanners, these tradeoffs are now going away. Newly released area imagers are now available that can read both linear and 2D bar codes at distances ranging from a few inches to more than 50 feet, which opens up a whole new set of opportunities.

Area imagers are gaining the performance and price benefits resulting from the competitive innovation and economies of scale that have been driven by advances in digital photography, particularly from the explosion in cell phone photography. New generation area imagers are leveraging autofocus optics that enable cell phone cameras to be used at short, medium and long range, allowing them to meet or exceed the range of laser scanners, while providing support for more bar code types. Intermec, a long-time innovator in scanning technology[3], has leveraged some of these developments in its R&D to produce the first area imager capable of long- and short-range reading on the market.

The Intermec Intellibeam™ EX25 Area Imager

The Intermec Intellibeam EX25 is the first area imager scan engine capable of reading stacked 2D, matrix 2D and 1D bar codes in any orientation at both close and long range. For example, it can read a Data Matrix 2D storage slot label from 50 feet away, a linear bar code product label from six inches, and numerous other symbology types at all distances in between. Long distances are even attainable without costly retro-reflective material. This feature results in lower operating costs because standard label and tag materials can be used instead of expensive retro-reflective material. Figure 1 shows how the Intellibeam EX25 compares to long range lasers for reading various sizes of 1D and 2D symbols at close, intermediate and long distances.

[2]Ibid.

[3]In 1981 Intermec invented the first portable, non-contact, non-swipe linear imager. Years later the company also introduced the first fully automatic digital camera for non-contact image capture, invented the first handheld two-dimensional matrix symbology scanner, and coined the term "Imager."

The Intellibeam EX25 scan engine is integrated directly into the company's handheld computers and scanners. These products also support non-bar code image capture, which can be used to document the condition of goods delivered and received, record signature images for proof of delivery, create a photographic record of environmental or usage conditions and much more.

Taking Advantage of New Capabilities

These advances have made it possible to use a single scanner for picking and product ID operations that require near- and long-range scanning regardless of the symbology being used. The same scanner can be used during one shift for work-in-process tracking and other close-range scanning, and used again by another shift for picking and putaway operations.

It is now practical for manufacturers to encode lot codes, serial numbers, configuration data or other variable information on the products they are packaging to supplement traditional 1D bar codes used for inventory and shipping applications. For example, a leading auto parts manufacturer took advantage of the Intellibeam EX25 to improve parts traceability and preserve some legacy bar code operations. The manufacturer switched from marking individual parts with 1D linear bar codes to 2D Data Matrix symbols that encode more specific variable information.

The manufacturer captures individual part data with the same scanners it uses to receive incoming materials, track work-in-process and scan outbound shipment labels. The various applications include numerous linear, stacked and matrix bar code symbologies including, UCC/EAN, Code 39, Code 128, PDF417 and Data Matrix to be read. Bar code sizes range from very small product ID symbols read at close range to large location labels that are read from 25 feet away. The Intellibeam EX25 is the only device the company needs to read all these different symbologies at various distances.

The optics in the Intellibeam EX25 can successfully read bar codes from angles as small as 12°, which gives users tremendous flexibility for reading symbols and improves first-time read rates. In a head-to-head test to measure how quickly a worker could scan 50 bar codes, which were applied to packages at different 90° angles, volunteers using a handheld computer equipped with the Intermec Intellibeam EX25 area imager completed scanning 66 percent faster than those using laser scanners. The test was designed to determine how much impact omnidirectional scanning has on total scan time, because in real-world conditions there are often inconsistencies in the location and alignment of bar code labels on items. Not having to align the bar code symbol adds up to significantly improved worker productivity.

Omnidirectional reading capability is very helpful for overcoming these inconsistencies, and the wide range of supported scanning angles gives users many ways to conveniently read bar codes without reaching, squatting, bending or stretching. For example, a paper and packaging manufacturer selected Intermec's autofocus imagers because they enable workers to reliably scan and read bar codes on paper rolls that are stacked 40 feet high, despite the fact that the labels are curved and covered by shrinkwrap packaging.

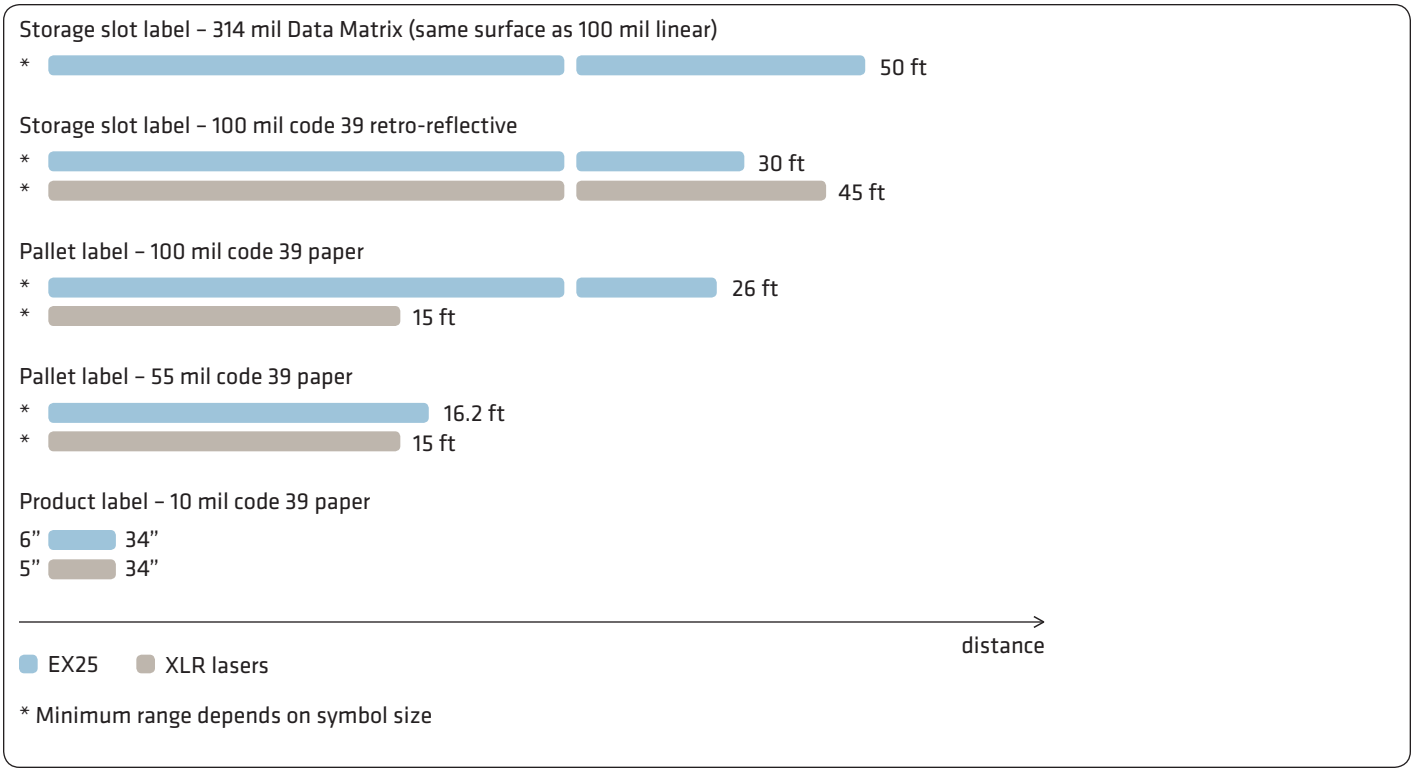

Figure 1: Reading Distance Comparison Between Intellibeam EX25 and Extended Long Range (XLR) Laser Scanners

Conclusion

Two-dimensional bar codes have long given users more information and traceability than 1D bar codes, however long-held perceptions about 2D bar coding limited their use. These perceptions are no longer true. 2D bar coding is far from a niche technology and usage is exploding, in large part because of recent technology advances that have made 2D reading more flexible, practical and reliable. Now users don't have to give up long-range scanning and efficient legacy bar code processes to get the benefits of 2D. Autofocus area imagers eliminate the tradeoffs between symbology support and read range that users have historically faced. Bar coding revolutionized many operations, two-dimensional technology later revolutionized bar coding, and now long-range area imaging is revolutionizing 2D. These changes are dramatic, but they are making 2D common. Millions of parts and products are already identified and tracked with 2D symbols, and millions more soon will be because of new standards, business requirements, and improved 2D readers.

Intermec Inc. (NYSE:IN) develops, manufactures and integrates technologies that identify, track and manage supply chain assets, including a full range of bar code readers, including area imagers, linear imagers, laser scanners and scan engines to meet virtually every bar code reading requirement. Intermec's other core technologies include RFID, mobile computing and data collection systems, bar code printers and label media. The company's products and services are used by customers in many industries worldwide to improve the productivity, quality and responsiveness of business operations. For more information about Intermec, visit www.intermec.com or call 800-347-2636. Contact Intermec Investor Relations Director Kevin McCarty at kevin.mccarty@intermec.com, 425-265-2472.

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