DATALOGIC™

THE ART OF THE CODE

YOUR RESOURCE GUIDE FOR COMMUNICATING WITH BAR CODE SYMBOLOGIES

THE ART OF THE CODE - DIRECTORY

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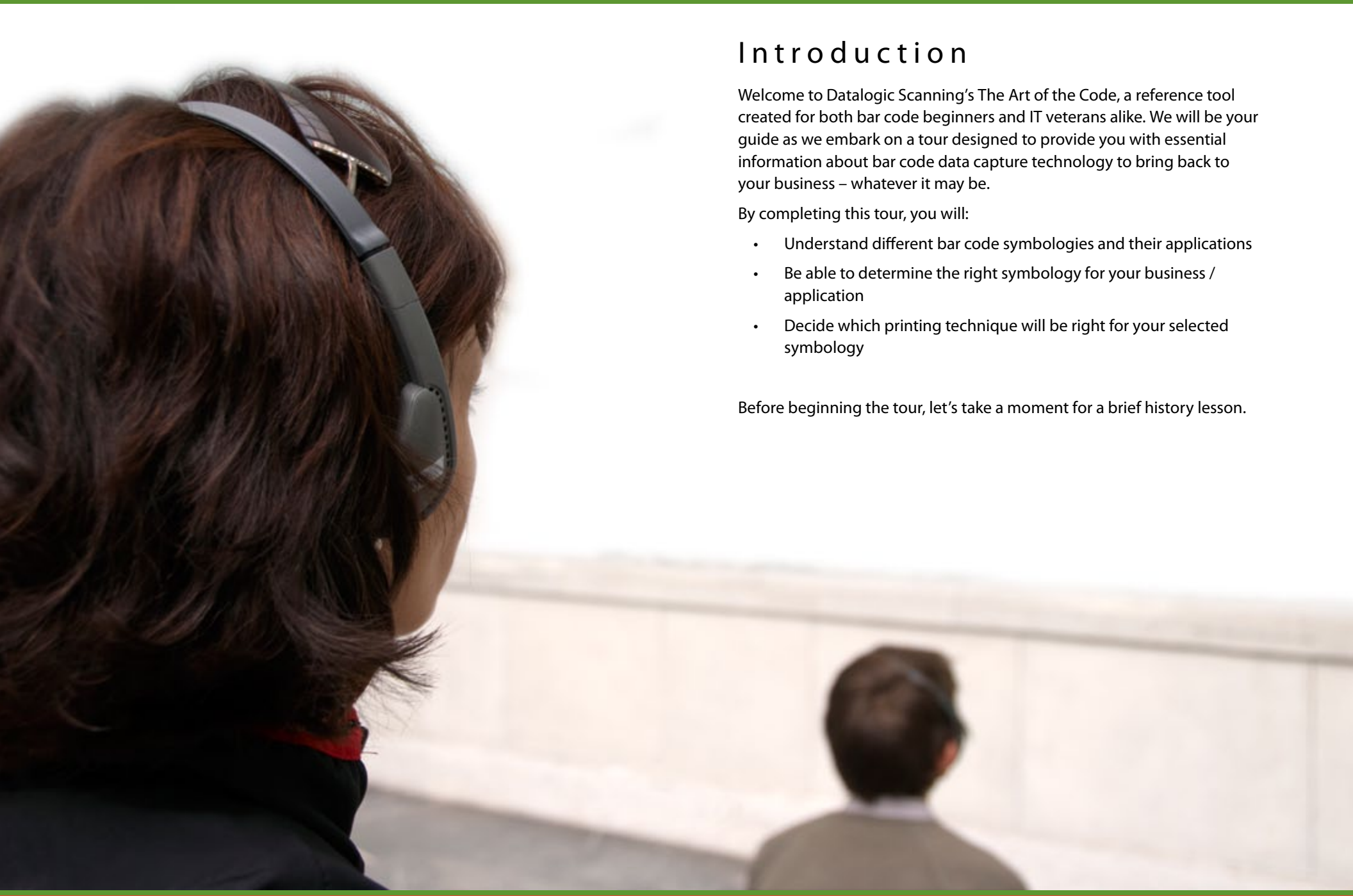


Introduction

Welcome to Datalogic Scanning's The Art of the Code, a reference tool created for both bar code beginners and IT veterans alike. We will be your guide as we embark on a tour designed to provide you with essential information about bar code data capture technology to bring back to your business – whatever it may be.

By completing this tour, you will:

- Understand different bar code symbologies and their applications
- Be able to determine the right symbology for your business / application
- Decide which printing technique will be right for your selected symbology

Before beginning the tour, let's take a moment for a brief history lesson.

The Beep Heard Around the World

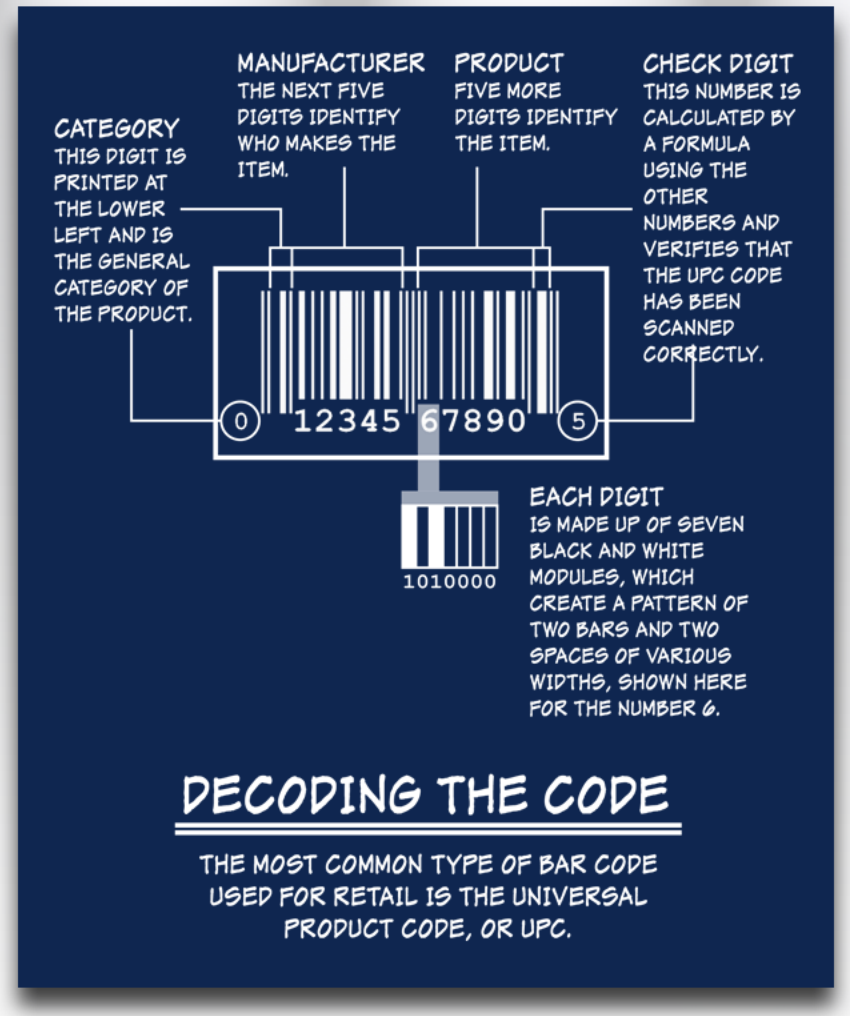
On June 26, 1974 at a Marsh Supermarket in Troy, Ohio USA, a clerk passed the UPC bar code on a 10 Pak of Wrigley's chewing gum over the scan window of a Datalogic Model A bar code scanner.

Datalogic made history that day by producing the first commercial bar code scan, and the now infamous good-read 'beep'.

This first 'beep' signaled the beginning of the automatic data capture industry.

Since its first scan, the bar code has revolutionized the retail industry and caused rapid adoption of bar code technology to improve productivity and advance inventory management while, at the same time, reducing pricing errors and the physical strain on cashiers.

The same benefits have been realized upstream through the supply chain, from the factory floor to the retail outlet, while also creating huge waves in other industries such as manufacturing, healthcare, finance and entertainment.



Bar Coding 101

A bar code symbology is best described as an “optical Morse code”; a series of black bars and white spaces of varying widths printed on labels to uniquely identify items. The information encoded in the bar code is decoded by a scanner, which measures reflected light and interprets the code into numbers and letters that are passed on to a computer.

Simple, right?

There are many commercial programs available for encoding data into a bar code. Most are fairly easy to use for activities such as building text strings into certain types of bar codes or printing a series of incremental numbers. Decoding the bar code and passing the data along to where it is needed is more complicated. Sophisticated scanners and support software, however, have made this relatively easy since the hardest part (decoding) is completed by the scanner, not the user.

The primary benefit bar codes provide is rapid, simple, and accurate reading and transmission of data for items that need to be tracked or managed. Since bar code labels are easily affixed or can be directly printed onto virtually any material (i.e. mailing tubes, envelopes, boxes, cans, bottles, packages, books and more), they are the most cost-effective and accurate solution for capturing data.

When bar codes are used on a widespread public basis, such as printed on an internationally sold item, it is important to register the symbology in order to protect the data, especially from product / code copiers. However, if the bar code is for ‘in-house’ use it does not need to be registered. An example could be a patient’s unique bar code obtained during hospital admittance and used throughout the duration of their stay. Registering a bar code is a simple process that can be performed through third party online sites or through bar code global organizations such as GS1.

Automatic Identification

Bar code data collection is part of a broader category called Automatic Identification, or Auto ID. Auto ID encompasses the automatic recognition, decoding, processing, transmission and recording of data. This is most commonly achieved through printers, scanners and software by reading the information encoded in the bar code and using databases and supporting software to automatically identify and make use of the resulting data. In effect, Auto ID turns data into useful information.

Think of it this way: Anyone can read the 'human readable' numbers printed under a bar code at the grocery store - this is called 'data'. The scanner and associated point-of-sale (POS) terminal, POS software and lookup tables, however, provide the item description and price – this i called 'information', or data that has meaning to the people using it.

The emergence of Auto ID solutions has significantly increased the speed, efficiency and accuracy of data collection and entry. The early applications of bar code scanning such as retail POS checkout, item tracking and inventory management have been expanded to more advanced applications in more industries such as: time and attendance, work-in-process, quality control, sorting, order entry, document tracking, shipping and receiving, controlling access to secure areas – even tracking and identifying farm animals!

These expanded systems have measurably increased productivity by linking production, warehousing, distribution, sales and service to management information systems on a batch or real-time basis. Consequently, opportunities to improve operational efficiencies and customer responsiveness have developed for retailers, transportation and package delivery companies, manufacturers, wholesale distributors and service providers.

New bar code symbologies are enabling users to respond to the requirements of 'chain of custody' tracking, the ability to identify where something came from and every step of progression along the way. For example, blood banks need bar codes to track and identify the blood donor, the collector, the site of collection, the test lab where the blood went to, where it was stored, and finally, where the blood was sent. Another example is customer loyalty cards at grocery stores. Auto ID is making it possible for retailers to target specific customers with coupons and special discounts or rewards; a capability long dreamed of, and only now, being realized.

Data Collection is Essential

Imagine this...

A child falls seriously ill with E. coli in Traverse City, Michigan USA. Investigators from the State Health Department search the child's home and find an empty meat container in the garbage. The investigator pulls out a bar code scanner, reads the label into a laptop and quickly identifies not only what store sold the item, but the packing house where the meat originated. A quick phone call results in items being pulled off the shelves in half a dozen stores in the area and FDA inspectors are sent to the packing house.

The Result? No other sick children, quick corrective action and consumer confidence in the food industry. This is a fictional scenario, but fast, accurate data collection makes such a story possible.

Similar to this story, data collection is solving major concerns in product safety and security as industries are faced with new regulations or product issues. This can be noted with new laws issued by the FDA, which require all businesses to track their entire chain of custody as a result of global health concerns such as mad cow disease, salmonella and contaminants in medicines. A modern data collection system using bar codes can easily ensure that businesses are meeting these safety standards.

The need for data collection also extends into healthcare, where bar codes are being used for to update and track a patient's electronic medical records (EMR) and prescriptions. By using a bar code based system, medical facilities can quickly and accurately update EMRs, instead of relying on a doctor's hard-to-read handwritten notes for patient safety.

Reasons Why Bar Codes Exist Today

It might be hard to conceive of going back to the days before bar codes. Imagine having to wait in line while a cashier looks up and types in each item by hand! Aside from retail, how many other ways are our lives impacted by bar codes? Think about that the next time you board an airplane, send or receive an overnight package, clip a coupon, or hand your driver license to a police officer. There are thousands of places where bar codes play an invisible role in every facet of our daily lives!

Today any business that buys, sells, ships or manufactures products can gain operational efficiencies and competitive strength through the application of bar code technologies. Bar codes and the related technologies can also improve operations in healthcare, package delivery, maintenance and customer service. By using bar codes as a solution, you may gain the following benefits:

- **Fast and Reliable Data Collection:** A bar code scanner can record data significantly faster with better accuracy than a skilled typist can. In fact, bar codes have 10,000 times better accuracy than manual data entry, which creates an average of one error in 300 keystrokes. For industries such as healthcare or manufacturing, these mistakes could be life threatening and damaging to any business.
- **Reduced Costs and Losses:** Reduced labor costs and losses from data entry errors are the most obvious benefits of bar code data collection. For example, if an employee makes an error on an invoice in the customer's favor, the error may not be discovered. In most companies, it does not take many data entry errors to amount to a great deal of lost revenue. Using bar codes to keep a tight handle on inventory is also a great method to reduce inventory and save on capitol costs.

- **Better Management and Decision Making:** Managerial decision making often occurs as a result of automated data collection. A bar code system can easily collect information that would otherwise be difficult or impossible to gather. By collecting data automatically, managers will benefit greatly from real-time information. With more information, they can make faster, fully informed decisions and respond quickly to new opportunities.

The International Bar Code Gallery

Now that you are convinced of the vast capabilities, applications and benefits that bar codes provide, let us begin the tour of symbologies! As we take you through the different exhibits, you will notice there are dozens of different types of bar code symbologies. Each symbology has its strengths and weaknesses and was designed for specific industries, applications and needs. Many symbologies are preserved for historical or commercial reasons, while others have definite technical advantages.

For those interested in a quick overview, an outline next to each code will take you through the following key points:

- **Character Set/Size:** All symbologies have some limitations on the number (size) and type of characters that can be encoded (set). Bar codes can encode numeric only, alphabetical only or alphanumeric character sets. The values of these digits are determined by standards managed by GS1, Global Standards One, formerly known as the Uniform Code Council (UCC) in North America and EAN International in the rest of the world. GS1 is now the single worldwide origination point for UPC and EAN numbers.
- **Fault Tolerance:** Some symbologies are more fault tolerant than others, which means the symbology will be less affected by damage to the printed code. Generally, those with better readability are more fault tolerant. It is important to always test bar codes by subjecting them to some abuse and making sure the equipment will still read them, especially if you print your own bar codes.
- **Application:** Since all bar codes are created with a unique intended purpose, the selection of a bar code symbology is an important and often complex process. This section will describe the industries or applications that best fit the different symbologies to help you choose the right bar code for your business.

Ready for the tour? Let's begin!

1D / LINEAR SYMBOLOGIES

Linear Symbologies

One-Dimensional (1D) bar code symbologies encode data along the length of the bar code (left and right), rather than in the height (up and down). If you draw a line through a bar code, you will see the single dimension. This is how a laser scanner works when it reads a 1D symbol. The height of the bar code just helps the scanner 'find' the label. Technically, the 1D symbol could be 1/8 inch high and still decode, as long as the operator could align the scan line to the symbol.

EAN/UPC (Universal Product Code)

The EAN/UPC bar code is the most commonly recognized symbology and identifies most consumer items in the world.

When a product number is assigned to an item, a unique EAN/UPC bar code is created for each of the millions of products manufactured around the world. During their evolution, the UCC mandated a 2005 Sunrise date by which time all systems had to be upgraded to scan both variable length company prefixes and product numbers in EAN/UPC codes.

EAN/UPC bar codes consist of characters with two bars and two spaces each. As a multi-width symbology, each bar or space can be one of four widths. Traditionally, EAN/UPC bar codes contain information about the manufacturer and product code. These bar codes also require a check character digit and allows two or five digit supplemental numbers.

The EAN/UPC bar code can exist in the following four formats...

EAN-13

Character Set: Numeric only

Character Size: 13 fixed-length

Fault Tolerance: High

Application: International retail and grocery standard (Europe)

EAN-13 is a numeric only bar code that is very similar to its United States counterpart, UPC-A. Similar to UPC-A, EAN-13 has two 'six-digit' halves and can only encode a relatively small amount of data. EAN-13 differs from UPC-A by being able to encode one additional character and the first two digits of the code identify a specific country. Furthermore, the first digit in this code, which is encoded in the "parity" of the left half of the label, cannot be "0".

UPC-A

Character Set: Numeric only

Character Size: 12 fixed-length

Fault Tolerance: High

Application: Retail and grocery standard (United States)

Likewise, the UPC-A is very similar to its European counterpart, EAN-13. UPC-A is a numeric only bar code, whose first digit is the number system character followed by a five-digit manufacturer number, a five-digit product number and a check character. Due to its limited encoding capabilities, UPC-A is primarily used in retail environment where highly detailed data is not vital to the business.

EAN-8

Character Set: Numeric only

Character Size: 8 fixed-length

Fault Tolerance: High

Application: Small packages in retail (Europe)

EAN-8 is composed of two 'flag digits', five 'data digits' (assigned by the Country Coding Authority), and one 'check digit'. This numeric only code is commonly used for marketing small retail items sold in Europe due to the limited character size and set of the code.

UPC-E

Character Set: Numeric only

Character Size: 6 fixed-length

Fault Tolerance: High

Application: Small packages in retail (United States)

UPC-E is a compressed bar code with an implied number system of '0'. This code is also well suited for small items due to the limited encoding possibilities, similar to its European counterpart, EAN-8.

Code 128

Character Set: Alphanumeric (uppercase/ lowercase), punctuation, controls

Character Size: Any

Fault Tolerance: High

Application: Best for full ASCII character set

Code 128 is best known for its generic code availability, compact size and diverse encoding capabilities. Code 128's full ASCII character set can be encoded without double characters, which means two code characters are not required to represent letters, like Code 39. If the bar code has four or more consecutive numbers, the numbers are encoded in double-density mode, which means the two characters are encoded into one character position.

Code 128 also has five special, non-data function characters, which set reader parameters or return parameters. Code 128 has three different character-code subsets, where two of its forms are for error checking, which make it a very stable bar code. Like EAN/UPC, the individual bars and spaces can be multi-width, versus being just wide and or just narrow such as in Code 39.

Code 39

Character Set: Alphanumeric (uppercase only), punctuation

Character Size: Limited by reader

Fault Tolerance: High

Application: Military, government

Code 39 (Code 3 of 9) is the most common bar code used for custom applications. Its popularity is driven from its ability to support alphanumeric characters and punctuation as well as its ability to support any number of characters that the reader can scan. This ability makes it a very flexible code for the user, especially for government and military applications where codes should have fewer limitations. Code 39 can also be read by almost any bar code reader in its default configuration, which saves installation and set-up time.

Code 39, a binary or 'two-width' bar code, is one of the oldest of modern bar codes. These bar codes are also self-checking and are not prone to substitution errors. Generally, Code 39 does not require a check character, but it is recommended.

Extended Code 39 (Code 39 Full ASCII)

Extended Code 39, a derivative of Code 39, is a symbology that uses combinations of two standard Code 39 characters for every character in the ASCII character set (0-127). Extended Code 39 allows for special characters, such as lowercase letters and control characters (i.e. a Carriage Return (CR), Line Feed (LF), ACK, BEL or unprintable ASCII characters) at the expense of size. Generally, the more special characters that are used, the longer the bar code will become.

Most bar code readers in their default configuration will not read Extended Code 39. If you want to use this symbology, you will need to configure the reader. If you need to read both uppercase and lowercase, Code 128 is the better choice.

GS1 DataBar Omnidirectional

Character Set: Numeric only

Character Size: 14 fixed-length

Fault Tolerance: High

Application: GTIN in small format

Formerly known as RSS-14, this relatively new symbology is a fixed length code with a built in check digit designed to encode a GTIN (Global Trade Identification Number). The symbology was designed to encode information in a smaller space than the traditional UPC-A/EAN-13 labels. Like UPC/EAN and Code 128, GS1 DataBar uses multi-width bars and spaces to encode characters. Most modern scanners are now capable of decoding GS1 DataBar codes, but some older equipment does not. This symbology can be stacked to create GS1 DataBar Stacked Omnidirectional Codes, described in the 'Stacked' section of this document.

GS1 DataBar Expanded

Character Set: Numeric only

Character Size: Variable-length

Fault Tolerance: High

Application: GTIN, applications in ID fields

An extension of the GS1 DataBar symbology, GS1 DataBar Expanded was designed to encode Application Identifiers (AI) with the data (similar to GS1-128). Application Identifiers are fields within the bar code data that mean specific things to specific applications (programs running on a computer). For example, a combination of numbers in a specific location of the bar code may indicate the country of origin, or manufacture date, or carton/container number, etc. This symbol allows users to encode detailed information about the product as per the GS1 specifications. For example, this code could be used to include a product GTIN, use-by date, and manufacturer and/or supplier data. Like GS1 DataBar Omnidirectional code, GS1 DataBar Expanded can be stacked or combined with other codes to create composite codes or coupons.

Interleaved 2 of 5

Character Set: Numeric only

Character Size: Variable-length

Fault Tolerance: Moderate

Application: Dense numeric codes

The Interleaved 2 of 5 bar code, also known as ITF, is a unique because it only encodes an even number of digits. If an odd number of digits are necessary, a leading zero is added. Since the ITF bar code is prone to substitution errors, a check character is always recommended. This code is used primarily in warehouse and distribution systems. It is a denser, more compact variant of Standard 2 of 5 symbology.

GS1-128

Character Set: Alphanumeric

Character Size: Variable-length

Fault Tolerance: High

Application: Many uses in supply chain; lots, containers, batches, retail.

Formerly known as UCC/EAN-128, GS1-128 code is a special version of the C128 symbology, which encodes the user data and also the context or meaning of the data as defined by the UCC/EAN-128 standard. This is done by encoding the values for one or more Application Identifiers (AIs) as defined by the EAN/UCC-128 standard. The AIs tells the application what the data means; if the data is a shipping container number, expiration date, product weight, size, or many other possible values.

The standard describes a large number of two or four digit AIs that have specific meanings. In addition, the structure of a UCC/EAN-128 bar code is very specific; it contains a C128 start character, a 'Function Code' 1 character, the AI, the data packet (length depends on the AI) and the C128 check character. It is important to note that this bar code is not really a separate symbology, but just a C128 label with a very specific data format. A bar code scanner that is configured to read C128 labels can read UCC/EAN-128 labels without modification.

Code 93

Character Set: Alphanumeric (uppercase/lowercase), punctuation

Character Size: Variable-length

Fault Tolerance: High

Application: Higher density than Code 39

Code 93 is a compressed version of Code 39 and Extended Code 39. Code 93 supports the same characters as Code 39, but in a smaller character width and is secured with two required check characters.

MSI/Plessey

Character Set: Numeric only

Character Size: 3 to 16 fixed-length

Fault Tolerance: High

Application: Grocery

The MSI/Plessey bar code is generally used in grocery stores for shelf labels or in environments with significant wear and tear. The MSI/Plessey bar code requires a check character, which can be generated in several different ways. Designed in the 1970's, this symbology has been replaced by more modern codes for most of its original applications.

Codabar

Character Set: Numeric, punctuation

Character Size: 6 (punctuation characters) variable-length

Fault Tolerance: High

Application: Library

The Codabar is a unique bar code, capable of encoding numeric characters, up to six punctuation characters (i.e. -$:/.+) and spaces. There are also four special 'start and stop characters', which include A, B, C and D. Naturally, Codabar is a popular symbology for encoding dollar figures and mathematical figures with its ability to encode punctuation. It is also a self-checking bar code.

Code 32

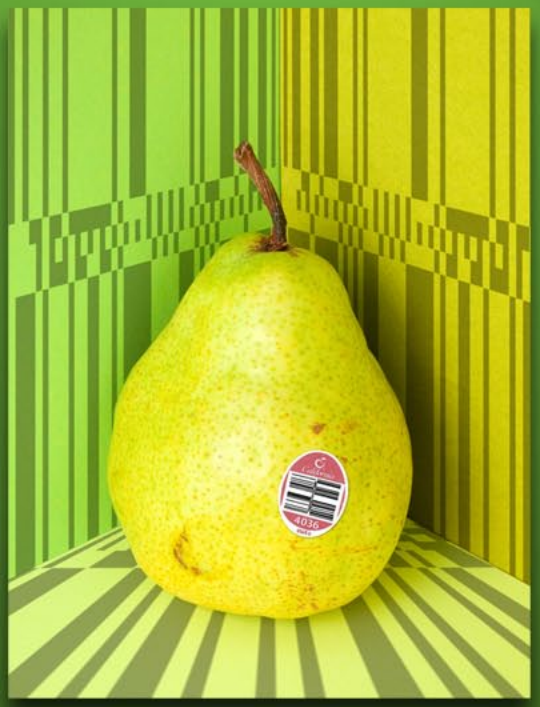
Character Set: Numeric only

Character Size: 8 digit (plus one check character) fixed-length

Fault Tolerance: High

Application: Pharmaceutical industry (Italy)

Code 32 is a bar code with limited applications as it was designed to encode pharmaceutical products in Italy. Since this symbology is used only in Italy, many scanners do not decode Code 32 by default and require programming to enable decoding.



2D STACKED SYMBOLOGIES

2D Stacked Symbologies

Two-Dimensional (2D) bar code symbologies contain information in both the X and Y axis of the symbol. In other words, there is different data encoded in the horizontal and vertical dimensions of the code. To properly decode the data, a scanner must read the entire symbol, in both dimensions simultaneously. This can be done by sweeping the scan line (in the case of a laser or linear imaging scanner) over the symbol, or by using a 2D array equipped scanner, which acts as a camera.

Since the data can be stored in two dimensions, 2D bar code symbologies allow vast amounts of data to be stored. A great example of potential data storage of these codes is that of a 2D code no larger than a standard UPC bar code that can contain the entire Gettysburg Address, a document consisting of 246 words.

There are two kinds of 2D bar code symbologies: ***stacked codes*** *and* **matrix codes**. *Stacked codes consist of multiple layers of linear bar codes and matrix codes encode data using cells within a matrix.*

PDF417

Character Set: Alphanumeric (uppercase/lowercase), punctuation, controls

Character Size: Variable-length

Fault Tolerance: High

Application: Driver licenses, transportation, inventory management, government

The PDF417 (Portable Data File) bar code is a stacked linear bar code that consists of 3 to 90 rows, each of which is like a small linear bar code. The PDF417 is capable of linking other bar codes scanned in sequence, which allows more data to be stored. It also has user-specific dimensions. This lets the user decide how wide the narrowest vertical bar (X dimension) and the height/quantity of the rows (Y dimension). The PDF417 bar code has a Public domain format, which means that anyone can implement systems using this code without a license.

PDF417 can be used in many applications in differing environments, such as a substitution for paper boarding passes. The PDF417 is the standard bar code selected by the airline industry's Bar Coded Boarding Pass standard (BCBP) as the official symbology, and by the Department of Homeland Security in the United States for machine readable zone technology for RealID compliant driver licenses.

Codablock F

Character Set: Numeric only

Character Size: Up to 5,450 characters variable-length

Fault Tolerance: High

Application: Healthcare

Codablock F is an extension of the Code 128 symbology and provides encoding for the full ASCII table. Codablock F allows a Code 128 label to be cut into pieces and stacked, which makes it perfect for environments that need a more compact format. A Codablock F label can have from 2 to 44 rows with 4 to 62 characters per row, thus encoding up to 5450 numeric characters. Now that's a lot of data!

GS1 DataBar™

Emerging as the replacement for the restrictive and continuously limiting EAN/UPC codes, GS1 DataBar has been approved for marking trade items in the retail supply chain. GS1 DataBar is a family of linear 1D and stacked 2D bar codes. It is a more compact symbology than UPC/EAN and it has the capability of encoding much more information.

GS1, the global retail standards-setting organization formerly known as EAN International and Uniform Code Council, set January 1, 2010 as the sunrise mandate for global adoption of this new bar code type. As of 2010, all manufacturers around the world have the option of marking their packages with GS1 DataBar codes as an alternative, or update, to the EAN/UPC bar codes still used today.

Retailers must be ready to scan these packages at the point-of-sale, on the shelf, in the stockroom and elsewhere within their logistics systems. This change is a critical step that enables future standards improvements for several important retail applications, such as coupons and marking of fresh foods.

For a complete discussion of GS1 DataBar, see the Additional Resources section at the end of this book to download the Datalogic Scanning White Paper 'GS1 DataBar 2010 Sunrise: An Explanation from a Retailer's Perspective'.

GS1 DataBar Stacked Omnidirectional

Character Set: Numeric

Character Size: 14 fixed-length

Fault Tolerance: High

Application: Grocery (Produce)

A variant of GS1 DataBar Omnidirectional code, the stacked version uses the same data character set and size. The stacked version was created to provide a compact way to mark small items, specifically produce. Most people are now familiar with this bar code on apples, bananas, and other produce items; however, not all stores are currently reading these bar codes on produce. In this version, there are only two rows containing the data with a separator pattern between the two data rows. This narrow separator contains no data, but helps the scanner decode the two parts.

GS1 DataBar Expanded Stacked

Character Set: Numeric

Character Size: Variable-length

Fault Tolerance: High

Application: Coupons

This variant of GS1 DataBar Expanded contains the same data and format as the Expanded version, but allows stacking of the code to make it more compact, in terms of being narrower and higher. This bar code can have anywhere from 2 to 11 rows, each up to 20 segments long. The most common use for this symbology is currently for coupons, but it can be used anywhere. Similar to the Stacked Omnidirectional version, the data rows are separated by a narrow non-data row.

Code 49

Character Set: Alphanumeric

Character Size: Up to 49 alphanumeric characters or 81 numeric characters

Fault Tolerance: High

The Code 49 bar code is a multiple-row bar code that can encode the full ASCII character set below ASCII 128. The characters in this code are encoded into two to eight rows, where each row is divided by a separator bar. The top and bottom of the symbol also have separator bars that extend to the ends of the minimum quiet zones.

All characters are encoded in double-density mode, or that two characters are encoded into one character width, making the size of the bar code smaller. For example, sequences of five digits are represented as three code characters. Code 49 bar codes also have three forms of error detection. Parity is checked for each character to ensure each row contains a check character as the last row character. Two to three check characters are always attached to the end of the bar code.

Code 16K

Character Set: Alphanumeric

Character Size: Up to 77 full ASCII characters or 154 numeric characters

Fault Tolerance: High

Application: Healthcare

The Code 16K bar code is a multiple-row bar code that was created to resolve Code 49's memory problems for encoding and decoding tables and algorithms. Code 16K bar codes can encode the full ASCII character set below ASCII 128 and uses existing UPC and Code 128 character set patterns, where characters are encoded into 2 to 16 rows. Each row is divided by a separator bar. The top and bottom of the symbol also have separator bars that extend to the ends of the minimum quiet zones.

Code 16K is similar to Code 128 as a choice can be made between three subsets of Code 16K directly or you can choose Code 16K Auto for auto switching mode. When choosing Code 16K Auto, it is important to note that if the bar code has four or more consecutive numbers, the numbers are encoded in double-density mode. Code 16K bar code has three forms of error detection. Parity is checked for each character to ensure each row contains a check character as the last row character. Two to three check characters are always attached to the end of the bar code.

Composite Bar Codes

Composite bar codes, a special type of stacked bar code, consists of a linear part and a 2D part. The linear portion can be either EAN-13, EAN-8, UPC-A, GS1-128, or GS1 DataBar. Above the linear code is the 2D portion, which is a form of PDF417 (including a variant called Micro PDF417). The linear portion contains the usual product code, while the 2D portion may contain additional data, like the expiration date or manufacturer information. The linear component is generally readable by any scanner, but the 2D portion may require an advanced decoder. Special characters within the 2D portion prevent a scanner from reading the 2D component without reading the linear code.

2D MATRIX SYMBOLOGIES

2D Matrix Symbologies

Another form of a 2D symbology is called a 'matrix code'. Some define a matrix code as simply a 'code' rather than a 'bar code' because the data elements aren't simply bars and spaces. For simplicity, most still refer to such 2D symbols as bar codes.

In a matrix code, the data is encoded in black elements within the symbol and each element is the same size. At first glance, these bar codes look a little like a cross-word puzzle.

There are many benefits to using a matrix code such as the ability to encode a lot of data in a small space, high readability, resistance to poor quality printing/damage to the label and support of the full ASCII character set, with some able to encode Kanji characters. On the downside, it requires a 2D imager rather than a laser scanner to read them.

Data Matrix

Character Set: Alphanumeric, Uppercase/Lowercase Letters, Punctuation, Controls

Character Size: Up to 2,335 characters fixed-length

Fault Tolerance: High

Application: Marking small items, printed on labels and letters, industrial engineering for marketing components

Data Matrix code, a 2D matrix bar code, consists of black and white cells arranged in either a square or a rectangular pattern. The code has two solid dark edges in an 'L' shape, used as a 'finder pattern'. It also has alternating dark and light patterns on the other two edges, which is used to identify the location and number of rows and columns, called a 'timing pattern.' Inside these borders are rows and columns of cells encoding information. As more data is encoded in the symbol, the number of cells (rows and columns) will increase.

Data Matrix can encode up to 3116 numeric digits per symbol. Error correction codes are added to increase symbol strength, which ensures the code can still be read despite damage. Data Matrix codes can be quickly read, and because the data is encoded in the center of the cell, it is highly immune to printing errors such as ink spread. Data Matrix is an infinitely scalable code, with commercial applications as small as 300 micrometers and as large as a 1 meter squared.

QR Code

Character Set: Alphanumeric, Uppercase/Lowercase Letters, Punctuation, Controls. Includes Kanji characters

Character Size: Up to 7,000 numeric characters or 4,296 alpha characters variable-length

Fault Tolerance: High

Application: Automobile manufacturing, mobile phone codes

Named QR for 'Quick Response,' QR Codes are square codes that can be quickly read due to their design. QR Codes are square symbols, containing three distinctive 'finder' squares embedded in three corners of the symbol. A fourth smaller alignment square is near the lower right corner of the symbol. When read by a QR-enabled reader linked to a browser, the code can direct a user to a web site. The QR code also has a variant symbology known as the Micro QR Code, which can hold 35 characters in a small space.

QR Codes were invented in 1994 by Denso-Wave in Japan to support the automobile manufacturing industry. Despite its trademark, the format is open, which allows royalty-free use of the symbology. Today, QR Codes are still widely used in Japan for many applications including encoding URLs in signs and publications.

Aztec Code

Character Set: Alphanumeric, Uppercase/Lowercase Letters, Punctuation, Controls

Character Size: 3000 characters

Fault Tolerance: High

Application: Part marketing in manufacturing, large capacity for small items, transportation and logistics and government

Aztec Codes are general purpose bar codes that were formally published by AIM International in the fall of 1997 after being created by Welch Allyn Inc. Despite its patent, the code has been released to the public domain. With a square shape and a distinctive concentric square pattern (bulls-eye) in the center, Aztec Codes can be thought of in two basic formats: A compact symbol will display a 2-ring bulls-eye and the full range symbol will display a 3-ring bulls-eye.

Together, the two formats create a sequence of 33 distinct symbol sizes. This enables the Aztec Code to encode small to large amounts of data, despite its small size (13 to 3832 numeric characters or 12 to 3067 alpha characters). The Aztec character set includes the entire ASCII and extended-ASCII set (character 0 – 255). The symbology utilizes a Reed-Solomon error correction technique, with user-selectable levels of security.

Maxicode

Character Set: Alphanumeric, Uppercase/Lowercase Letters, Punctuation, Controls

Character Size: 93 alphanumeric characters or 138 numeric characters fixed-length

Fault Tolerance: High

Application: Sorting, tracking

Designed with the intention of encoding postal information, Maxicode is a unique bar code array of hexagonal dots, rather than rectangular bars, and distinctive center target of concentric circles. Although Maxicode encodes far less data than other matrix codes, it has the perfect amount of data store for encoding most package addressing.

Maxicode was developed by United Parcel Service of America, Inc. (UPS) and since has been adopted by AIM and ANSI as the suggested symbology for product sorting and tracking. Although this is a widely used code, creating properly formatted Maxicode labels for use in the UPS system is complex because of the application-specific requirements of the UPS system.

Postal Codes

Postal Code symbologies are another type of bar code symbology that cannot be described as purely a 2D or a 1D linear bar code, but somewhere in between. Typically, these codes do not contain data in the bar and space width, but instead, in the position and height of the bars.

There are nearly as many different Postal Codes in the world as there are countries, where each has developed codes to suit their needs. In recent time, however, there has recently been some movement toward standardization. Some Postal Codes, such as China Post and Italian Post, are variants of standard 1D bar codes. In the US, the old POSTNET and PLANET codes are being replaced by a code called Intelligent Mail Bar code (IMB), which allows more data to be encoded than the old codes.

The majority of postal codes are numeric only, but some do encode letter characters as well. For example, the UK's Royal Mail 4 State Customer Code (RM4SCC) was the first postal code to use a 4-state system, which in their case is used to encode alphanumeric data. IMB, UPU (Universal Postal Union), Japanese Post, and Australia's Post Address Bar code are implementations of a 4-state bar code.

CREATING BAR CODES

Creating Bar Codes

Preprinted Bar Codes

Using preprinted labels is the most economical way to get high-quality bar codes. This solution is not very flexible because the information in the bar codes must be determined in advance. Preprinted bar codes are used where very durable, high-quality labels are necessary to withstand the environment (such as on a fork truck pallet), or where high-volume packaging or labeling is done.

There are several companies that can print stickers, pallet tags, item tags, or other types of very high quality bar code labels to identify a particular item as unique. Tags can be printed in any required sequence on a variety of media, even reflective medial for extra long range applications. This solution works very well when bar codes can be assigned beforehand. Randomly numbered bar codes can be accommodated with the extra step of manually associating the bar code data with a record in a database as a control number.

Direct Part Marking is a method of encoding machine readable data in the form of a bar code directly on the part with no label, tag, or packaging. Typical methods for marking include laser etching the data into the surface of the part, dot peen impact marking, or engraving the markings into the mold or tooling that makes the part. This type of mark is inherently difficult to scan because the contrast between light and dark areas is very low. Specialized readers with sophisticated illumination schemes are needed to read these codes. These marks are more permanent than adhesive labels, but if the surface becomes contaminated with dirt or grease, the marks may become unreadable.

Origin	Typical Use	Benefits	Limitations
Printed on Packaging	Retail	Economical	Lack of control
Stickers, Print on Demand	Retail, Manufacturing, Supply Chain	Flexible, inexpensive	Not permanent
Tags	Supply Chain	Durable, selection of media	Inappropriate for item level marking
Direct Part Marking	Manufacturing	Free	Difficult to read

Printed On-Demand Bar Codes

When the bar code must contain information that is only available at the time the bar code is generated, it is common to use an industrial printer to generate the bar code. This is common occurrence in manufacturing when a serial number is created for a specific work piece or in healthcare when a new patient is admitted to the hospital.

On-demand bar codes can be produced in small quantities for less money than preprinted bar codes and in less time. They can be printed with dedicated bar code printers that produce very rugged bar codes. Dedicated printers come in several varieties, including thermal and thermal transfer. The best can produce bar codes that are not bothered by acids, rain, sunlight or similar factors. These printers can easily produce a single tag or sticker and remove the label backing automatically.

Laser and Ink Jet Printers can also be used to generate on-demand bar codes. The bar codes they print are comparable to those printed on dedicated label printers. In fact, the print quality is almost as good as on preprinted bar codes. The downside is that laser printers are not as rugged as dedicated label printers and only print a full sheet of labels at a time.

Avery™ and Costar™ make small, thermal label printers that can print bar codes. These printers work well for occasional use but may not be the best choice for high-volume printing.

Mobile Bar Codes

Mobile Ticketing: *a process whereby customers can order, purchase and obtain tickets from any location and at any time using a mobile device*

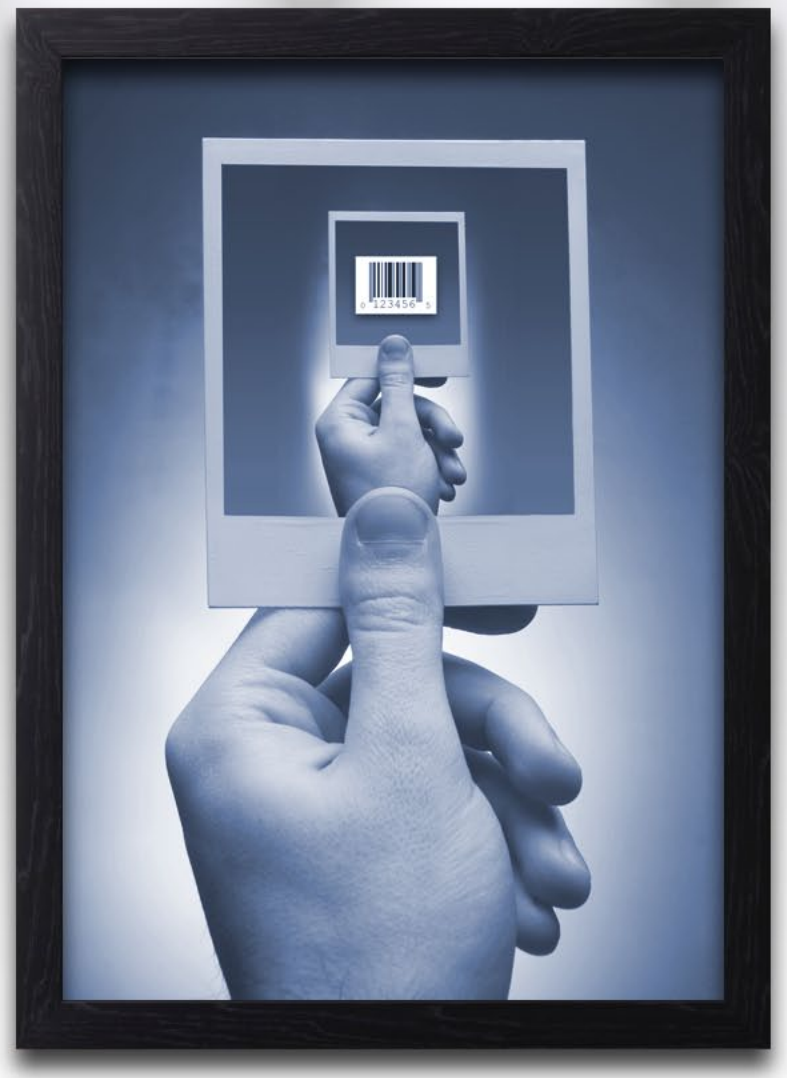
Mobile Marketing: *the use of a mobile device (cell phone, PDA or smart phone) as a new means of marketing communication, promotion or advertising*

Bar codes are not always printed. In fact, printed bar codes are becoming less of a demand in the retail and entertainment industry with the introduction of mobile marketing and mobile ticketing, where an electronic bar code is sent to a consumer's mobile device via a SMS (Short Message Service) / MMS (Multimedia Messaging Service) message. A text message is the simplistic form of a mobile ticket, coupon, loyalty card, etc. that can be sent on any type of mobile phone and is currently a preferred method in many countries.

Mobile Marketing has become a widely accepted means of communication with over 3 billion active mobile phone users worldwide. This form of marketing opens up two-way communication channels for companies to directly engage with customers with fewer costs than ever before.

Utilizing electronic bar codes is simple. As you've already learned, 2D codes have the ability to store more information in equal or less space; thus, these codes are often chosen for mobile ticketing and mobile marketing applications. Once a symbology is selected and the program is defined, engaging with customers is easy.

To sign up for a marketing offer to purchase a ticket, customers simply send an SMS message containing a short code to a service number and a return message will be sent back containing the mobile offer or ticket and a unique bar code symbology. With mobile marketing, customers have instant access to the promotion or can store their loyalty card information in their mobile device without the chance of losing or forgetting it, a common reason for low participation. Mobile ticketing at airports enables customers to check-in and board with less effort than ever before.



Additional Resources

Industry Resources

AIM Global – www.aimglobal.org

GS1 The Global Language of Business – http://www.gs1.org/

Ten Steps to Bar Code Implementation

- http://www.gs1.org/barcodes/implementation

Global Electronic Party Information Register (GEPIR)

GEPIR is a distributed database that contains basic information on over 1,000,000 companies in over 100 countries. You can search by GTIN (includes UPC and EAN-13), SSCC and GLN numbers or by company name in some countries.

- http://gepir.gs1.org

From Datalogic Scanning

White Papers

The Growing Requirements for 2D Imaging Technology

- English (US LTR) English (A4) Italian (A4)

GS1 DataBar™ 2010 Sunrise – An Explanation from a Retailer's Perspective

- English (US LTR) English (A4) German (A4)

eBooks

Unleash the Power of Mobile Marketing with Bar Code Technology

- English French German Italian Simplified Chinese Spanish

About Datalogic Scanning

Datalogic Scanning is the worldwide leader in fixed position retail scanning offering both in-counter and on-counter point-of-sale scanners and the best known provider of handheld scanners in EMEA, with the most complete line of general purpose and ruggedized handheld scanners in the world.

A division of the Datalogic Group, Datalogic Scanning is headquartered in the U.S. with a presence in over 120 countries. The company serves multiple industries throughout the retail supply chain and distribution channel as well as manufacturing, government, healthcare, banking and finance sectors. For additional information, please visit www.scanning.datalogic.com.

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