BAR CODE SYMBOLOGIES

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There are over 50 different bar code symbologies each having their own symbol interpretation. Currently, there are only a few code symbologies in wide spread use. Code symbol density ranges from low to mega-density. Low-density symbols have fewer than 3 characters per inch. High-density symbols can contain 100s of characters per square inch. Code symbologies are classified as linear (1D) or two-dimensional (2D). Two types of symbology structure, discrete or continuous, define all bar codes.

LINEAR CODES (1D)

Linear codes are those in which characters are grouped, one next to another, in one linear direction. Simply put a single row of parallel bars and spaces. While linear bar codes are two dimensional, having both width and height, they are one dimensional in scanning. Only the widths of bars (and sometimes spaces) are measured to interpret the symbol. The height of the code is simply redundancy to enable scanners to more easily scan the symbol. These are most commonly known as "bar" codes. These include UPC, Code 39, Codabar, Code 128, Interleaved 2 of 5, and 2 of 5 code.

DISCRETE BAR CODES

There are three main discrete bar codes used in North America: Code 39, Codabar, and Code 2 of 5. Characters in these codes begin and end with a bar. This construction creates spaces between characters that are not part of a character. This inter character gap should be approximately equal to the narrow bar width. Codes with this inter character gap are called discrete since each character is separate and independent from other characters in the same symbol. Because of this inter character

gap, impact numbering machines can be used to print bar codes since the space of the inter character gap can be used for ratchets for the individual number wheels in a numbering head. These ratchets are essential for impact numbering devices.

CODE 39

Code 39 was the first alphanumeric code and is the most common non-retail symbology. It is a 43 character alphanumeric binary code (most other discrete codes are not alphanumeric). This bar code is capable of representing all capital letters, numbers, seven special characters (./+%$- and space), and can easily be printed by a variety of technologies.

Code 39 is a two-width symbology; meaning all bars and spaces are either wide or narrow. Each character is composed of nine elements; five bars and four spaces. Three elements are wide (two bars and one space) and six are narrow. Each code begins and ends with an asterisk, which is this symbology's start/stop code. Code 39 is self-checking; meaning any element erroneously printed or scanned will not result in bad data input. An optional check character is available. Code 39 is the standard symbology for the federal government, automotive industry, and the material handling industry. It is the code of choice in most situations that require alphanumeric coding. It is bi-directional. The maximum density is 9.8 characters per inch. Minimum bar ratio is 2.0:1. If the "x" dimension is less than .02 inches, the minimum ratio should be 2.5:1. Maximum bar ratio is 3.0:1.

Although there are only 43 data characters in Code 39's character set, it is possible to encode all 128 ASCII characters using Code 39's full ASCII feature. If a reader is in its full ASCII mode, the symbols $ / % and + are used as precedence codes with the 26 letters.

CODABAR

Also known as USD-4, NW 7, and Code 2of 7, Codabar is a self-checking, numeric only code. It is a bi-directional code. There are 16 characters in the set, 10 digits plus special characters ($-,/ and +). The start/stop characters A,B,C,D,E,*,N, or T must be used in matching pairs and may appear elsewhere in the bar code. Each character is coded independently by means of four bars and three intervening spaces, totaling a fixed width but employing a complex set of individual bar and space widths. It was originally designed for use in retail price labeling. It was one of the original proposed symbologies for the UPC. Instead, it found a niche in several diverse, non-retail applications. It is the code required by the Department of Defense. Other applications include inventory control, libraries, blood banks, photo finishing, and air bill applications. The maximum density is 12.8 characters per inch. The minimum bar width is .075".

Its specifications allow it to be printed with wide quality tolerances. That is why it was used for package tracking. There is no checksum defined as part of the Codabar standard, but some industries (libraries, for example) have adopted their own checksum standards.

CODE 2 OF 5

In use since the late 1960's and is supported by several equipment suppliers. It is used less that Code 39 or Codabar. It is a numeric, discrete, self-checking bar code originally developed for automated warehouse sorting and Photo-finishing envelopes. 2/5 encodes information in five bars, two of which are wide with the remaining three narrow. All spaces separating the bars are about the same width and carry no data, so the code has a much lower information density than

the interleaved 2 of 5. Its only advantage is a shorter impression length compared to Code 39 and Codabar.

CONTINUOUS BAR CODES

Other codes are called continuous and will not allow an inter-character gap. Consequently they cannot be used in impact numbering equipment.

INTERLEAVED 2 OF 5 (I 2/5, ITF)

Interleaved 2 0f 5 is a numeric-only, bi-directional, self-checking code. It's the most popular numeric only bar code in non-retail distribution. Its main advantage is its density. Each character is five elements...two wide and three narrow. There must be an even number of characters in this code.

If there are an odd number of digits, a zero must be added in the most significant position. Bars represent odd-numbered digits and even-numbered digits are represented by spaces. This "interleaving" process, in which bars and spaces encode numbers independently, gives the code a higher density. I 2/5 is usually printed with a top and bottom border to prevent a partial scan being interpreted as a complete scan. I 2/5 is often used with a MOD 10 check digit. The standard ITF contains 14 digits, with an optional 6-digit suffix. The IT outer case code with the human readable characters at the base of the code, grouped into country code, supplier code, product code, and check digit.

It is a recommended symbology for corrugated shipping containers and has been selected for use on other shipping containers in the grocery industry. It is used in this application to identify the trade selling as opposed to the consumer-selling unit in retail trade. It employs a data format standard identical to that of the regular UPC A code but with two additional digits at the front. The first is an assortment indicator used to indicate the type of selling unit (e.g., case or pallet) or for a single case where the five-digit item code portion matches the five-digit item code of the consumer selling units inside. Quite commonly, the five digits match. This is not possible when there is more than one trade-selling unit for the same consumer item, or where the trade-selling unit contains an assortment of consumer selling units. The second extra digit is always a zero, provided to make the format compatible with EAN.
The code value, as specified by the data format standard, is more widely used than is the bar code symbology. In distribution, sorting and shipment control are usually exercised according to shipment number ID rather than stock keeping unit (SKU) ID. On the other hand, the UPC shipping container code number is the standard way to identify items in a purchase order, shipping advice, invoice, etc. when transmitted between parties using UCS, the grocery industry's EDI standard.

Though its major application is considered warehouse inventory, it has been accepted in airline ticketing and baggage and cargo handling.

N,K CODE

N,K codes are a different type of continuous bar code symbology, which provides greater symbol density. N,K code is proportional, allowing elements to have multiple widths, not just two widths. These

symbologies divide the region occupied by a character into N modules. Each bar and space may occupy one or more modules. K refers to the total number of bars and spaces in a character.

UPC (Universal Product Code)

UPC has been successfully employed in the supermarket industry since 1973. It is the most familiar N,K code. It is used in static applications for product identification. UPC is a coding system as well as a symbology; it is designed to uniquely identify a product and its manufacturer. It is important to differentiate between the UPC coding scheme and the UPC symbology. UPC is a fixed length, numeric, continuous symbology employing four element widths. There are three versions of the UPC symbol:

Version A is a 10-digit code: the first five digits represent the manufacturer of the labeled item, and the next five digits are a unique product identifier code. This 10-digit code is preceded with a "number system" digit. Most products will either have a "1" or "7" in this position. It signifies that the product is of a fixed weight and size, as opposed to a variable (i.e. apples) or a product coupon. A Mod 10 DR check digit that is based on the preceding 11 digits of data follows the UPC code. To make matters more complicated, the publishing industry has added a supplemental 2 and 5 digit symbols to the end of the UPC-A symbol. This supplemental symbol contains date-of-issue information or a price.

UPC-E is a shortened and more complicated for of UPC-A, representing a full ten digits using only 6 characters. UPC-E was developed to aid manufacturers who could not fit an entire 12-digit symbol on their small package. A limited number of these symbols were issued, the last of which was given out years ago.

UPC-D is a version used for variable length messages. It is very seldom used.

The UPC code currently used will be replaced by EAN. EAN, initially known as "European Article Numbering", is gaining worldwide retailing acceptance. In the US its use is largely limited to the encoding of books, though all retailers will adopt the symbology by 2005. EAN-13 encodes 13 digits, one more than UPC. For more information, contact the UPC Code Council at (513) 435-3870 or http://www.uc-council.org. This Council issues the manufacturer and product code numbers used in this symbology.

CODE 128

Code 128 is an N,K code, one specifically designed to encode the entire 128 character ASCII set. This character set includes special control codes necessary for computer communication. The symbology is denser than Code 39 and includes a check character instead of the optional check for Code 39.

Each character is encoded by means of three bars and three spaces with a combined width of 11 modules or units. The total length of 11 modules is made up of an odd number of bar modules and an even number of space modules. The bars and spaces may be 1,2,3, or 4 modules wide. This coding system provides 106 different print characters. Four bars and three spaces define three stop/start characters. Each character requires only 68% of the space required in Code 39 characters.

The symbology provides for three different character sets that are identified by distinct start characters: A, B, or C. 128 C consists of the 100 two-digit pairs 00 through 99. This allows the effective density of 128 to be doubled when printing all numeric data. This provides a maximum density of 24 characters per inch. 128 A and 128 B cover the entire 128 ASCII character set, with a considerable amount of redundancy. 128 B includes both upper and lower case letters as well as numbers and some special characters; 128 A emphasizes the full set of special characters but excludes the lower case letters. As a result, the code can be quite compact when expressing numbers only, yet fully capable of providing all needed ASCII characters as and when needed.

CODE 93

Code 93 is a specially designed code incorporating nine "n" modules, each having 3 bars and 3 spaces. The bars and spaces may be one to four "N" modules wide. Code 93 as designed by Intermec (designers of Code 39) to address density demands by users. Code 93 normally utilizes the same character set as Code 39, but special versions use the complete ASCII file. Code 93 utilizes 2 check digits and has a higher density and Code 128 versions A/B.

TWO DIMENSIONAL BAR CODES

WHY TWO DIMENSIONAL (2D) BAR CODES?

Bar codes became widely used because they increased productivity and were significantly more accurate. Standard linear codes have been primarily used for identifying items. They are typically 20 characters or less. Identification has traditionally been through a "license plate" concept of assigning bar coded numbers to documents or assets. This process has largely remained an intra-organization system, because the data base behind the bar coded identifier is within the organization. As such, the assigned bar code numbers have no meaning to others who may scan them.

As with any technology with widespread appeal, users wanted the ability to do more: store more data, scan it more accurately, store it in a smaller footprint, read it faster, and read it from further distances. While the capability of traditional bar codes improved (i.e. 128C has a higher density capability than Code 39 and an inherent check digit for higher scan reliability), such improvements were relatively marginal in hindsight. Despite some of these improvements other issues arose; for example, if more data was added in a code it meant more space was taken. If the code was compressed to fit in the original footprint, it may be too dense for a scanner to read. These problems may be solvable as a new generation of bar code technology slowly emerges.

WHAT ARE 2D CODES?

2D bar codes were developed in response to the evolving constraints of traditional linear bar codes. Two dimensional (2D) bar codes are printable PDBs (portable data bases). They are stored on paper instead of flash cards or CDs. These formats both used modules to create a vertical and horizontal pattern of data storage (matrix), hence the two dimensional (2D) description. This was a paradigm shift in code symbology as traditional linear codes only store data in one dimension. Some 2D symbols can carry 7000 characters of data as compared to a regular or linear bar code capacity of 20 characters. 2D symbols can also carry binary data, which can be made to run a computer program or generate photographs and drawings, such as passport photos, fingerprints, and signatures. Two-dimensional bar codes are defined as stacked or matrix (pattern). DataMatrix can be used like traditional bar codes as a "license plate" number that accesses a specific file of information on a computer. However, the symbol

can also contain that information rather than just a number that “accesses” that information on a storage device (hard drive). Each square in the symbol is a data cell.

2D STACKED CODE

Stacked codes are constructed of rows of individual characters (that can be individually recognized) including stop/start characters that are stacked upon one another. It also contains an element telling the scanner where it is when it's reading the code. Stacked code is easier to print and read than matrix code. Like standard linear bar codes, the scanner looks at the width of bars and spaces to read the code.

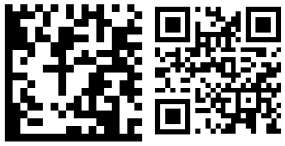
PDF 417

PDF 417 was the first 2D code. It is a continuous type stacked symbology. Each stacked row contains start/stop patterns and data units called "words." In each row of a symbol, the first and last words are row indicators. The height and width of PDF 417 is variable. Because rows can vary in length, and the number of rows can be variable, users can define the share or aspect ratio of the symbol, the X and Y dimensions of the elements, and the mode of the symbol. Symbols may be stacked upon one another for almost unlimited data acquisition or truncated for smaller symbols. PDF 417 can encode ASCII, binary or numeric data and can communicate with any operating system. It can be bi-directionally scanned and can be decoded by the computer system and automatically do the document verification either on-line or locally.

2D MATRIX CODES

Data matrix symbols are rectangular in shape (usually square). They are made of cells that represent data bits. Matrix codes have a checkerboard appearance, with each uniformly spaced square or polygon shaped cell corresponding to a binary bit. They are constructed of a mosaic of light and dark elements that must all be read before any characters can be recognized. Matrix codes contain bars having only one width, so the scanner must read the center of each bar to interpret the code. Matrix codes can store more information per unit area than stack code. Matrix symbols are encoded with a binary code requiring a special scanner.

To an untrained eye, all data-matrix codes look much the same. There are actually several different types of data-matrix codes. The best known include QR Code and DataMatrix Code.



DATAMATRIX CODE

A DataMatrix Code is composed of two solid adjacent borders known as the "finder pattern" and two other borders consisting of alternating black and white modules known as the "timing pattern". Within the borders are even numbers of rows and columns of cells encoding information. Algorithms contained in each cell identify the information that has been encoded. Upwards of 3000 ASCII characters may be encoded in a symbol. This code is very popular for applications that require a very tiny symbol size. A typical matrix code can be made to hold 60 characters of information in a .12" square symbol. A special 2D CCD reader or cell phone is required to read the code.

QR CODE

QR codes were developed by and originally used in a factory where there was significant likelihood of damage to the code. Because of this issue, it was designed to include data restoration up to 30%, meaning 30% of the code could be damaged or stained and still provide complete data recovery. It has 3 position detection patterns in 3 of the 4 corners with black and white data modules within. A special 2D CCD reader or cell phone is required to read the code.

WHY USE 2D CODES?

2D codes are capable of storing significantly greater data than conventional bar codes. A traditional linear bar code carries one line of data (linear). It is limited by the length of the sequence of bars that will fit in a given space, typically a maximum of 20 characters. A 10 digit conventional bar code would be approximately 2.8 inches long by .375 inches tall, or about 1 square inch. Data matrix symbologies can store 30 times as much data in the same space. A QR code could contain 600 characters with 25% correction capability.

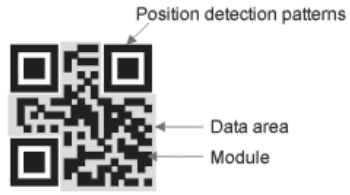
While traditional bar codes have a bit of redundancy (the height of the bars simply repeat the same data) and/or there is a check digit included, but there is no redundancy should 25% the bar code length be torn off. Probably the most fascinating thing about 2D symbologies is that most can accommodate advanced data redundancy and "error correction methods" (error correction can be defined by the user). By mathematical formulas embedded in the code, data can be mixed in predetermined ways, so the information from a single input/output character is distributed along with other data over pixels scattered over multiple locations. As a result, when the code is damaged "error correction" will "reconstruct" missing portions of the symbol and recreate the missing data. Up to 30% of the label can be destroyed or damaged and still retrieve 100% of the data contained in the symbol when it is scanned. Damage can include worn out and scratched areas, horizontally and/or vertically cut areas, hole punched areas, and folded areas. This is very beneficial for use in environments where symbol damage is likely. 2D bar codes generally have an error rate of less than 1 in 10 million characters scanned. The advantages of 2D codes are:

- More information: A traditional linear bar code carries data one line of data (linear). It is limited by the length of the sequence of bars that will fit in a given space, typically a maximum of 20 characters. By adding more information, you add to the length. By contrast, a data-matrix code is a square or rectangle of 2 dimensional information, packing 30 times as much information in about the same relative space.
- Fewer errors: While traditional bar codes have a bit of redundancy (the height of the bars simply repeat the same data) and/or there is a check digit included, there is no redundancy should 25% the bar code length be torn off. 2D codes have options for multiple levels of error correction by means of built in redundancy.

- Broader reading capability. 2D bar codes cannot be read by traditional linear bar code scanners, BUT they can be read by cell phones with built in digital cameras.
- Higher security. Data can be encrypted in 2D codes making it more secure.

HOW DOES IT WORK?

Data matrix codes are readable by 2D scanners and cell phones with a camera and an appropriate "app." QR Codes have detection patterns located in 3 corners that let the scanning device orient the code and hence read from any orientation (omni directional). The omni directional capability guarantees stable high speed reading. DataMatrix Codes have a finder pattern that is used to locate and orient the symbol while the timing pattern provides a count of the number of rows and columns in the symbol.



BIFOCAL BAR CODES

Bar code scanners have a specific scanning range called the "depth of field". A near range scanner may have a "depth of field" range of 0-6". A long range scanner may have a "depth of field" scan range from 3 feet to 30 feet. What that means is that it cannot scan less than 3 feet or more than 30 feet. A specific bar code size must be used to work within the specific "depth of field" range of the scanner. Some optical scanners have a wide scanning range but need a different size bar code to scan close up versus further away (i.e. one bar code size for under 3 feet and a different bar code size for 30 feet). This becomes a particular issue in settings like a warehouse where you may want to scan an upper storage rack label from the floor, but later scan it up close when a cherry picker goes to that storage space. This may also occur with labels/tags marking dock doors. You would want to provide a long range scanning capability for forklift drivers so they don't have to dismount from the forklift to scan the dock door label. In this way they do not have to stop the forklift and walk over to the bar code door bar code tag to scan it. Conversely, if you make the bar code too big, you can't scan it if you are standing next to it.

What to do? Pointil has developed a **BIFOCAL 2D Bar Code**. Much like bifocal glasses, this bar code can scan at different distances to accommodate different types of scanners simultaneously. This allows you to scan from short range with a standard scanner or all the way up to the maximum distance scannable by your long range scanner with the same bar code.

WHO WOULD USE 2D?

DataMatrix Code has its roots in the US and has, to date, been the predominate data matrix symbology used here, primarily in industrial applications. That is beginning to change. QR Code was originally intended for tracking vehicle parts, but innovative marketers have learned it's power and it has now morphed into a much broader consumer context through the use of cell phones as scanners. Virtually all cell phones in Japan, where the code was developed, have built in QR scanner capability. QR code use is common place there. For phones like the iPhone and the Android, there are reader applications available. In the US, the technology is still largely unknown, but that will change rapidly as people learn the power and convenience it provides.

WHERE WOULD 2D BE USED?

In an industrial business setting, data matrix symbologies have substantial power to increase data transmission, particularly for processes that cross company lines. Historically bar code was an internal business application tied to an internal data base. A number in the code would act as a "look up link" to date in the internal data base. Such a code (look up link) would not translate to another company's internal data base. Now documents with around 1000 words can be transmitted via 2D code. This will change the dynamics of tracking and shipping. The constraint is that conventional bar code scanners in place don't have the capability to scan this type of code. Until the supply chain upgrades scanners throughout, its use in this capacity is limited. On the consumer side, there will be vast and immediate use due to the widespread use of cell phones.

HOW IS 2D USED?

Consumers with a camera equipped cell phone and the correct reader application can scan the image with the camera function to display the contents of the code symbol. The information in the scanned symbol can be redirected to connect to the web via the phone's web browser. This is called "hard linking." The iPhone supports this by means of an app available on iTunes. The Android operating system is capable of providing this and its web browser supports the URL redirection. The Nokia operating system also supports QR Code.

WHY WILL CONSUMERS USE 2D?

Consumers can instantly learn more about companies and their products. They could "hard link" from codes on products, billboards, display posters, business cards, magazines, or newspapers, for example. You could "hard link" from the milk carton at breakfast to get more nutrition facts; the poster at the metro station for the train schedule; download a coupon from a product billboard; link to a movie trailer from a code in the newspaper; do a virtual tour of an apartment for rent via a newspaper ad; scan a clam shell of salad to see if it has been recalled; scan a code on a bottle of wine at dinner to learn about the vintage. The application opportunities for information, entertainment, business, and safety are endless.

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