Two-Dimensional Bar Code Overview

What is a bar code?
A bar code is simply a series of stripes (usually black) on a light background (usually white) that can be scanned and read directly into a computer. They are interpreted virtually instantaneously and without errors by a bar code reading system. The elements (bars and spaces) in a bar code symbol must be of a consistent, proportional thickness and thinness. The widest element could be as thick as a pencil or as thin as a business card, as long as the corresponding thin bars and spaces in the bar code remain proportionally thin.

Bar codes are read the same way that people read text from a page; the reflectance and absorption of light. A light of a given wavelength is beamed and moved across a bar code at a consistent speed. The reflected light is measured with a photoreceptor, tuned to look for light of the given wavelength. The off-and-on (white and black) pattern of the bar code creates an electrical wave that is sent on to a computer chip called a "decoder." The decoder then deciphers the signal into something the waiting computer understands. Imager and CCD (charge coupled device) bar code scanners read somewhat differently in that they "take a picture" of a bar code symbol, analyse it, and create a conditioned electronic signal that basically mimics that from the reader types described in the paragraphs above.

The bar code "symbology"
In other point of view, a bar code "symbology" is to bar codes in much what a particular alphabet is to language. Different symbologies of bar codes use different combinations of bars and spaces to represent different characters. Bar code symbologies, like languages, are given different names, like Code 39, UPC, Codabar, PDF417, DataMatrix…

There are different symbologies developed in order to satisfy various application requirements. Each has a set of characteristics tuned to these various situations. Recently, there has been a trend toward standardization of symbology selection both within and between user groups and in specific industries.

The factors that should be considered when choosing a symbology are mainly two. First, it has to be determined whether or not a particular symbology is required to comply with an existing industry or organization standard. If no standard exists, it is wise to consult with other businesses like your own, in order to determine whether any standard is forthcoming. The second factor is the type and amount of data that needs to be encoded. Some codes allow full alphanumeric encodation, but usually do so at the cost of the symbol taking up more space. Also, the size of the article or label being encoded must be taken into account, keeping in mind that the density of the characters varies greatly between symbologies and printing method. Finally, compatibility with available reading and printing equipment must be taken into account.

One dimensional vs two Dimensional barcodes
Before beginning a discussion on two-dimensional bar code symbols, some clarifications must be made regarding one-dimensional symbols...

Typical bar code symbols obviously have both height and breadth. To most people, they'd be considered a two-dimensional object.
So, why do we refer to them as one-dimensional bar code symbols? Because, when read, it is only the *width* of the bars and spaces that is taken into account—the height of the bars is only to give the symbol some built-in redundancy. Typical bar code symbols, therefore, are only read in one dimension.

One other important aspect of one-dimensional bar code symbols is that they seldom represent more than a dozen characters. Therefore, the bar code does not contain any data, per se. Rather, the bar code represents the *key* to a record in a database, where related information is stored. The best example is a car licence plate which, by itself, doesn't mean much but, when entered into a motor vehicle database, can access all sorts of information regarding the car it is attached to.

In the Two-dimensional (2D) symbols, data are encoded in both the *height and width* of the symbol, and the amount of data that can be contained in a single symbol is significantly greater than that stored in a one dimensional symbol. In fact, *over thousands alphanumeric characters* can potentially be placed in a single symbol the size of a large postage stamp! Obviously, the main advantage of using 2D bar codes is that possibly a large amount of easily- and accurately-read data can "ride" with the item to which it is attached. There are new applications being created for 2D bar code technology every day. A few examples are at the conclusion of this document.

One of the amazing (and beneficial) aspects of two-dimensional symbols is their potential durability. To sabotage the readability of a conventional 1D symbol, one only has to add another bar to the beginning or end of the symbol or draw a line through the symbol, parallel to the stripes. This throws off the checks and a balance built into the decoding algorithms of a 1D bar code decoder and makes the symbol unreadable. By comparison, many degrees of redundancy can be built into a 2D symbol. While it makes the symbol somewhat larger, the remaining symbol is remarkably secure. We have experimented with vandalizing 2D symbols with holes, black marker and tearing. The symbol has remained readable through all of this abuse!

Two-dimensional scanners were far more expensive than 1D scanners when were introduced. Recent microprocessor developments have brought the cost of 2D scanners down to about 125% of the cost of a comparable 1D scanner. Also, advancing decoding algorithms have made scanning quicker and easier and provided even greater readability of excessively-damaged symbols.

There are a number of two-dimensional symbologies in growing use today. They fall into two categories: matrix and stacked. An explanation of each is best done visually through the examples below—the difference is obvious. Two-dimensional bar code symbologies represent one of the biggest advances in
the market of Automated Data Collection in the past few years. With advancements in technology, with smaller and faster processors, it can only get better. However, when analysing any potential data collection system, the advantages must be weighed over the added costs. 2D bar code technology should be thought of as one that is complementary to the traditional 1D scanning technology, not its
replacement.

Some example applications for 2D technology:

Tax Return – In every nation around the world, there comes that time of the year when tax returns must be filed and, unfortunately, taxes must be paid.

The taxpayer could use some tax software, enter the relevant data, and allow the program to perform all needed calculations. When the task is completed, the tax form can be printed out the data and the 2D barcode symbol using any ink jet or laser printer for mailing to the tax authority.

The benefits are obvious: when the form arrives at the tax authority, the data can be captured from the symbol in seconds using a scanner. The data is not only captured quickly, it is captured with 100% accuracy – no errors are introduced by the scanning process. Not only is the direct cost of paying someone to key the data eliminated, but the indirect costs – to both taxpayers and the government - of the errors introduced by manual key entry are done way with. Since studies show that professional key entry can result in up to 1 error every 300 keys, we know these errors exist.

Moreover, this application has clear potential outside the income tax arena – any situation in which companies or individuals are supplying information to a government in paper form could benefit from this idea. This includes company excise/sales tax returns, the submission of company employment information, and the collection of government economic statistics from business enterprises, among others.

Just by adding a 2D barcode symbol to a form, you create what is, in effect, an "intelligent document", one that can be read by human beings, but that can also be automatically and accurately entered into a computer whenever was required.

Packing List - Trading partners agree on a standard methodology for encoding shipping information in a 2D symbol, attached to a shipped order. Order data (PO number, shipping date, product codes, quantities, etc.) can automatically be entered into the receiver's receiving computer terminal in a couple of seconds.

Driver's Licence - The driver's name, address, licence number, expiry date and driving restriction codes are encoded in a 2D symbol that is printed on the operator's licence. Police officers, car rental agencies, hotels (you name it!) can easily enter in information regarding the licence holder, with the possibility of adding any mis-keyed data.

Patient Record - On a hospital patient's chart record is a 2D symbol, encoding their name, health care number, doctor's name, date of admission, allergies, etc. When direct care is given to the patient, the caregiver or doctor records the action by scanning the bar code. Also, the bar code is scanned when medication is administered and the possibility of giving a patient the wrong medicine is virtually eliminated.

2D Stacked Symbologies – Examples

PDF417 is a high-capacity two dimensional bar code developed by Symbol Technologies, Inc. A PDF417 symbol can hold approximately 2000 characters of information, whereas a traditional linear bar code has difficulty holding more than 30 characters. The key characteristic of PDF417 is its large information capacity. This also explains its name. "PDF" stands for Portable Data File. PDF417 is designed with enough capacity to contain an entire data file of information. With traditional linear bar codes, the bar code contains only a key or "license plate".

With PDF417, no external database access is needed, because the PDF417 symbol can hold all the information needed an entire portable data file.

PDF417 is used today in a wide variety of applications, including logistics & transportation, retailing, healthcare, government, identification, and manufacturing.

2D Matrix Symbologies – Examples

DataMatrix is a two-dimensional barcode that can store from 1 to about 2,000 characters. The symbol is square and can range from 0.001 inch per side up to 14 inches per side. DataMatrix is being used to encode product and serial number information on electrical rating plates; to mark of surgical instruments in Japan; to identify lenses, circuit boards, and other items during manufacturing.

MaxiCode is a fixed-size code that holds up to 93 data characters. The symbol is composed of a central bulls-eye locator and offset rows of hexagonal elements. Created by United Parcel Service (UPS), the MaxiCode symbol was designed for quick automated scanning of packages on high-speed conveyor lines (special cameras can read a MaxiCode on a carton travelling at up to 500 feet per minute).

The QR Code (Quick Response Code) It can encode up to 2509 numeric or 1520 alphanumeric characters and offers three levels of error detection. The smallest QR Code measures 21 X 21 cells (each cell encodes one bit) and can grow in increments of 4 cells to a maximum size of 105 X 105 cells. The squares in the bottom left, top left, and top right corners are locator patterns. The QR Code was developed in Japan by the Nippon Denso Company.

This paper has been composed with information extracted from the following sites :

www.pdf417.com/2d
www.aurorabarcode.com
www.symbol.com