CONSIDERATIONS IN CHOOSING BETWEEN LASER AND IMAGING BAR CODE SCANNING TECHNOLOGIES FROM A RETAILER'S PERSPECTIVE

Bar code technology has increased efficiency and accuracy in a wide variety of retail, manufacturing, service, logistics and warehouse applications over the past four decades. Scanning technology, price and performance have all evolved rapidly over this period. The first laser scanners consisted of large helium neon gas filled tubes whereas modern lasers use miniature solid state diodes; the initial imagers were only capable of reading bar codes on flat surfaces and had to remain physically in contact. In some sectors, newer bar code standards have been developed requiring the use of imaging scanning.

The aim of this White Paper is to explain the differences between these two competing technologies, analyse the pros and cons of each one and clarify those applications where one each is best suited.

Introduction to bar coding

Traditional linear bar codes are created using the familiar series of black bars and white spaces. These bar codes — such as the common EAN/UPC bar code found on items in the retail sector — are termed one-dimensional (or 1D) codes, as the bars are presented along only the length of the code. They act in the same way as a car's registration number, in so far as reference to a database is required to add significance to the data.

Two-dimensional (2D) codes consist of a much wider variety of patterns (squares, dots, hexagons and other geometric shapes). Because data is encoded in both the height and width of the symbol, 2D codes can store a much larger amount of data than is typically found in a one-dimensional symbol — anywhere from 93 to as many as 2,500 characters or, approximately 25 times the amount of data found in a 1D code. Common 2D codes include PDF417, Data Matrix, MaxiCode, QR Code, Macro PDF and Aztec Code. Therefore, 2D bar codes can act as miniature databases with no access to an external database required in some specific applications.
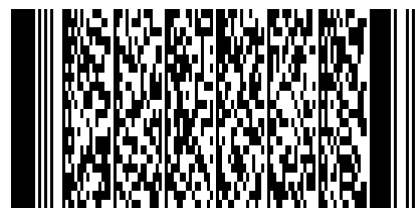
Laser and imager bar code scanners – how they work

Unlike the laser scanners used to read linear bar codes, 2D codes are usually read with (camera-based) imagers that take successive black and white images of the code, isolate and decode it, then relay that information to the application. The process is very much similar to taking a photograph although lack of image stabilization can make it difficult to read bar codes on items which are not entirely stationary. Unlike a camera, the imager can sometimes struggle to focus/adjust to different scanning ranges and will only register a correct decode over a quite narrow reading range. As the imager does not generate any light source itself, a secondary LED (or laser) is needed to simulate approximately where the user is attempting to aim.

Today's laser scanners generate their light source from a solid state component such as a diode. The resultant laser light is moved bi-directionally over the surface of the bar code by a prism at high speed, typically over 100 scans per second. This is a highly effective way to decode a bar code since only one of these scans needs to be used to register a good scan. The red line effect is simply the laser being manipulated at high speed. As it is the same line physically scanning the bar code it is a 100% accurate representation of where the scanner is being aimed.

Generally, lasers are faster and more tolerant at reading 1D bar codes than imagers. For starters they have a much wider range of reading distances making it easier to scan the bar code without fiddling with the proximity of the reader. This flexibility extends to the angle at which the scanner can be aimed at the bar code.

Choosing between laser and imager bar code scanners in a retail environment

1D bar codes predominate in the retail sector. In fact, these are the only type of codes currently in use and likely to be in used in the foreseeable future. The EAN/UPC format has been the universal standard for article marking since the early 1970s. In 2014 GS1, who administers the global retail standards, are allowing for another higher density bar code (GS1 DataBar) as an optional replacement for EAN/UPC (see separate White Paper on this subject). This date itself has already been put back several times as there is currently little retailer support for this newer symbology (not surprising, considering the change to EPoS scanners and mobile terminals required and the increased costs). All GS1 DataBar codes have been designed to be read easily by either laser scanners or imagers.

For traded units at retail DC level, a further 1D bar code type (ITF14/UPC Shipping) has been in use since the 80s. Typically, these codes need to be scanned at much greater ranges than EAN/UPC codes and can only be effectively read by long range or standard laser scanners.

At time of writing there are no plans by the international standards authority to issue any other new bar code standards for the future, so the retailer is perfectly free to choose between laser or imager safe in the knowledge that neither is likely to become redundant over its working life.

Having established that existing EAN/UPC and the newer GS1 DataBar codes can be read either by laser or imager scanners, which scanning technology offers the best advantages to a retailer? First of all, be sure to get unbiased advice rather than the view of a manufacturer who has a vested interest in one technology over another. Datalogic Mobile is scanning technology agnostic. Our most popular retail mobile devices offer a choice of either laser or imager and additionally we are integrating cameras into our latest devices.

Over the last four decades, the retail industry has voted with its feet and laser scanners have been used almost exclusively for reading bar codes. The reasons behind this are cost and productivity.

Imagers have reduced rapidly in cost over the last few years, however, they are typically more expensive than lasers. This is determined by supply and demand – retail and transportation sectors comprise the majority of sales in the Automatic ID industry, with the greater volume of sales driving down the price of lasers over four decades. In contrast, imaging is a relatively new technology used mainly for niche applications and so does not have the critical mass needed to reach the same price points as laser.

It is not all about the initial purchase cost as the Total Cost of Ownership is the key critical factor when selecting hardware, so it is important to factor in service costs as well. In terms of reliability, there is little difference between each technology. The latest laser scanners use frictionless elements and imagers use solid state technology with no moving parts. In the mobile computing world both types of scan engine are normally protected from physical abuse by being integrated within sealed, ruggedized enclosures. Consequently, service costs are very similar between the two and it is more important to check the manufacturer's specific drop testing, IP rating and service program regardless of technology type.

Great strides have been made in the reading performance of imagers over the last few years. The first imagers needed to be in contact with the bar code, but now they are capable of much greater reading distances. However, for reading bar codes in a store systems' mobile computing environment, laser scanners still offer higher productivity and performance advantages. There are several reasons behind this:

- Physical properties – lasers can be projected over long distances since the beam is highly concentrated and does not spread out as is the case with other light sources which are typically used in imagers. Therefore, an imager possesses a much more limited range which hampers productivity as the user really has to experiment to get the right "sweet spot". Reading diagrams for area imagers may claim similar maximum reading distances when compared to a laser, however, their scan width is much more limited meaning that the actual real practical reading range is reduced

- Fine tuned for retail codes – with over four decades of real world usage experience laser scan engines and decode algorithms have been refined to produce the optimum first time read rates for reading EAN/UPC and ITF14 bar codes

- User tolerant – every operator users a scanner differently. Again, lasers achieve higher productivity rates as they have greater skew and pitch angle incident to the bar code. With an imager the angles are more acute making the "sweet spot" depending upon not only the scan range but the angle too

- Motion sensitive – lasers are not affected by movement or shaky hands. This is vital in mobile computing applications which are typically aim and shoot. In contrast, Imagers can be prone to shaky hands

There is one attribute of imaging where it can outperform a laser. Bar codes can be read omnidirectional, whereas a laser can only read a bar code bi-directionally. So a laser can read a bar code in the correct orientation and upside down, whereas an imager can additionally decode a bar code presented at 90 or 180 degrees to the incidental. This can offer improved ergonomics for

the user in some instances. However, this advantage is minor when compared to the greater performance and costs benefits of laser scanning as outlined above.

Digital camera bar code scanning technology

Increasingly, mobile device manufacturers are integrating digital cameras, either as a standard feature or extra cost. These have been designed first and foremost to take photos and not to read bar codes. Certainly, given suitable application software these can scan bar codes but their performance is simply not up to the scan intensive requirements of a retail store. The performance of digital cameras is nowhere near comparable to even that of a bar code imager. The scanning range is far more sensitive and it can take seconds (rather than milliseconds) for a bar code to scan. Digital cameras simply do not offer the scanning productivity needed for rapid gap analysis, stock taking or shelf edge label verification.

Mobile computing vs Point of Sale (PoS) bar code scanning

Mobile computers tend to be used in store for applications such as inventory control, price management, replenishment and many other areas. Unlike at the PoS, the required scanning range and depth of field are typically very diverse. This is because the scanning process and operation are completely different – the user takes the mobile computer to the item, whereas at the PoS the item is brought close to the scan window. In mobile computing, the operator can stand either right up close or at some distance to the item to be scanned (the latter for hard to reach items to avoid discomfort from bending down or over reaching). Consequently, a much greater depth of field is required. For this reason, laser scanning is considered to be a far more productive and user friendly technology for retail mobile computing applications.

Laser scanners provide a much more defined reading beam – the aiming and reading beam are one and the same, so it is very easy to see which bar code is actually being scanned. Nowadays, the imagers installed in mobile computers are area imagers which project a square reading pattern. Consequently, it is sometimes not possible to clearly see which bar code is being scanned. This can present mis-scan errors where two bar codes are very close together as is the case in shelf edge bar code price validation or inventory control where smaller items are displayed very closely together. Furthermore, the user may appear to be scanning the top or bottom of the bar code with an imager but actually obtain no decode at all. For these reasons the omnidirectional reading pattern is actually often counterproductive.

Imagers use aiming illumination LEDs which come out as independent squares and these will pretty much only scan when the overlap area encompasses the entire bar code. So as the bar code gets wider, the minimum range goes up significantly and the user loses the ability to scan codes up close which is the most common usage requirement in store system mobile computing.

Imagers also consume very high amounts of battery power, typically up to 450mAh which is more than five times more than laser scanners. As mobile computers become more sophisticated with complex, power hungry operating systems and backlit displays, conserving battery power to

ensure a full shift and beyond is a key factor to consider when evaluating which scanning technology to use.

PoS scanning takes place either at checkout or countertop. The bar code scanning range tends to be quite narrow being either contact or near contact. Bi-optic/flatbed (in counter) and presentation (on counter) scanners are now available in either laser or imager formats. Owing to very recent improvements in imaging technologies, these can now duplicate the speed and wide short range field of view of high performance omnidirectional laser scanners. Performance improvements are particularly noticeable when capturing hard-to-read bar codes such as truncated (short), out-of-spec, and poorly printed codes. An imager can also scan bar codes from a mobile phone display which may become a standard way in the future for manufacturers to transmit their promotional discounts and offers to consumers.

PoS laser scanners use far more complex scanning arrays such as polygonal mirrors to manipulate the laser to produce an omni-directional scan pattern (laser scan engines use a much smaller and simple oscillating, bidirectional laser diode). PoS laser scanners use motors to drive the mirrors which increase costs in comparison to PoS imagers. Furthermore, as PoS scanners draw their power ultimately from the main power supply (and not from a battery), it is not an issue that the imager itself consumes more power than the laser. Therefore, in a PoS environment imagers offer better scanning performance at similar cost.

So why all the fuss about 2D scanning?

Although 2D bar codes and imaging scanners previously were just a small part of the automatic data collection market, the technology has increased in usage in certain (non-retail) industry sectors over the past few years and according to industry analyst VDC is expected to grow 18% annually through 2012, albeit from a low base. Despite the fact that 2D bar codes have not been embraced or standardized by the retail community, 2D bar codes have been adopted within the aerospace, automotive, electronics, semiconductor, sanitation and telecommunications industries, as well as by government agencies in the US like the Department of Defense and NASA.

The combination of 2D bar codes and high-quality imaging scanners has produced a number of benefits for these enterprise users, including:

Increased data capacity: Because they can provide a larger amount of data in a much smaller footprint, 2D bar codes enable a wide variety of track-and-trace and other applications. With more information about a marked item, scanning the code can auto-populate forms in a number of field service, maintenance, inspection and customer applications; provide valuable traceability data; and improve data access for remote applications. Their relatively small size means these codes can be directly marked on everything from delicate electronic circuit boards to automotive parts with uneven or curved surfaces.

Omni-directional scanning: Imagers can also read codes regardless of the orientation of the scanner or the label, a critical capability for manufacturing, logistics and maintenance applications where workers may need to scan hard-to-reach codes on packages, meters, heavy equipment, or within an engine chassis. Once the code has been read, the scanner typically generates an audible "beep" so that the end user knows it has successfully been decoded. In noisy

environments (such as in a manufacturing facility, for example), a visual indicator can provide confirmation. Datalogic, for instance, provides a patented "Green Spot" technology in its imaging scanners that uses a separate LED to provide visual confirmation of a successful scan. The same technology can be used for applications in hospitals, doctor's offices and libraries, where silent scanning may be preferred. The Green Spot can also help users target a single code from a group of codes or to position a single code inside the reading area — an especially helpful feature in logistics and package tracking applications, where one label may include several 2D and linear bar codes.

Improved Error Correction: When 1D bar code labels are damaged, ripped or faded, they can be difficult if not impossible to decode. In order to read a partially damaged 1D code with a laser scanner, the scanner must be carefully aimed at an undamaged portion of the label. Since 2D codes feature enhanced error correction (and in some cases provide data redundancy within the code), they can still be read even if significant portions of the label are damaged or missing. Imaging scanners present pictures of the entire code to the decoding library. Logic is used to piece the images together, much like a puzzle, and compare those pieces to codes in the library. This allows even damaged 1D codes to be read by compiling different parts of the same code.

Investment Protection: Many of the industries that have adopted 2D bar codes still use a mix of 1D and 2D codes. Using imaging scanners allows end users to read a wide variety of codes, as well as perform other functions.

Non-retail applications for 2D bar codes

2D bar code technology provides many advantages to end users, but it is not suitable for every project; for items that only have to be marked with a simple serial number or SKU (such as retail scanning), 1D bar codes are still sufficient. Where 2D technology excels is in applications that require a higher degree of functionality, and where the bar code has to accommodate a much larger amount of data. In track-and-trace applications — where users must maintain an up-to-date location history of items like parcels, shipping containers, pharmaceuticals and other goods — 2D codes can be used to provide a wider variety of item-specific data, such as lot number, a date code, manufacturing location, routing numbers, and other information. A few non-retail vertical industry sectors have widely deployed 2D codes for certain traceability systems.

Manufacturing

Manufacturers in the automotive, aerospace, pharmaceutical, electronics and other vertical segments have deployed 2D bar codes. These industries rely on the larger data capacity of the 2D codes for assembly and process control, work-in-process, anti-counterfeiting, asset tracking and other applications. In some industries, manufacturers utilize direct part marking of 2D codes to provide part traceability for items that are either too small for traditional labeling or that operate in harsh environments (within an aircraft engine, for example) where labels would rapidly deteriorate. In these applications, 2D bar codes can be printed or etched on parts with complex or curved surfaces. Because the codes can contain a variety of data — serial numbers, batch numbers,

material information, service history, etc. — they can aid in a number of post assembly service and safety applications. In the aerospace industry, for example, 2D codes can be used to track the repair history and hours of service for airplane components that have to be regularly maintained and replaced per government safety guidelines. In the automotive industry, manufacturers can utilize the tracking information on each component to better target safety recalls. In related field service applications, 2D codes can provide model and serial numbers to field technicians, and can automatically link those technicians to repair information held in electronic manuals or on the Internet. The technicians can also update service history data so that the information can be accessed even if employees are unable to access offline databases.

Several industries have mandated use of 2D bar codes. For example, the U.S. Department of Defense requires that certain of its assets be permanently marked with Data Matrix codes as part of its Unique Identification (UID) initiative, and the Air Transport Association's (ATA) Spec2000 traceability standards include 2D codes.

Healthcare

In addition to tracking pharmaceuticals, the healthcare industry has adopted 2D bar codes to improve patient safety within hospitals. Bar code technology is heavily used within healthcare facilities to ensure the "five rights" of patient safety — that the right patient receives the right drug, at the right time and the right dosage, in the right form. In these applications, bar coded patient ID bracelets are scanned and matched to pharmaceuticals, intravenous medications and even blood bags. Other facilities are using 2D codes to track assets within the hospital, and even to process valuable surgical tools in the operating theatre. Several hospitals have piloted systems using 2D codes to track everything from anesthesia equipment to scalpels as they move from the OR through the sterilization process and back into storage.

Logistics

Companies like UPS and FedEx have leveraged 2D Aztec Code, Data Matrix, PDF417, and MaxiCode (along with linear bar codes) to track packages throughout their distribution networks. By arming delivery drivers with portable imaging scanners, these companies have also been able to capture digital signatures for proof of delivery and even take photographs of damaged packages. The United States Postal Service uses 2D bar codes for electronic postage metering. The 2D codes in the USPS application can include the amount of postage, as well as a cryptographic digital signature for offline e-postage systems, security information, and data about the postage meter that generated the electronic stamp. 2D imagers are used at mail processing centers to verify postage by reading the bar code and using optical character recognition technology to evaluate printed or hand-written address information.

Possible future niche usages for 2D bar codes in retail

All retail applications (i.e. check-out scanning, price and inventory management) rely on 1D EAN/UPC bar codes, and laser scanners continue to dominate this market because of their relatively lower cost and familiarity. As outlined earlier, the global retail standards have no plans to introduce any new code types which cannot be read by today's laser scanners.

A small number of retailers have experimented with 2D bar codes for limited PoS scanning applications. In the US, 2D imagers have been used in a very limited way at the check-out counter, enabling a number of other value-added applications. For example, the majority of states in the US include a 2D PDF417 code on their drivers' licenses, and these codes could be used by checkers to verify a customer's age when selling restricted items like cigarettes and alcohol. The content in those bar codes (which includes the customer's name, address, and other information) can also be used to automatically complete registration forms for customer loyalty programs or credit card applications, saving valuable time at the check-out. In each case, an imaging-based presentation scanner could be used for both POS and additional applications. This is not relevant to the UK and most European countries as only 1D bar codes are used on drivers' licenses.

Another example is in the pharmacy. Some pharmaceutical manufacturers have begun marking drugs with 2D codes in order to secure their supply chains, retailers could utilize the technology to verify the authenticity of the merchandise and provide additional traceability information. The European Federation of Pharmaceutical and Industries Association (EFPIA) has piloted a system in which pharmacies use 2D DataMatrix codes to validate drug authenticity against a manufacturer database. Several states in the US are also developing "e-pedigree" requirements for pharmaceuticals that would mandate similar traceability requirements.

The Welsh NHS has defined 'ETP' (Electronic Transfer of Prescriptions) as a system designed to automatically transfer a patient's prescription information between a prescribing system (such as a GP) and a dispensing system (community pharmacy). This system is known as '2DRx' (2-Dimensional bar coded Prescriptions) and relies on a 2D bar code embedded directly onto the prescription itself, ready for a Welsh community pharmacy to 'scan in' to their dispensing system. In all these cases it is dumb 2D scanners wedging into PCs or PoS tills which have been used – mobile computers in these applications continue to use 1D laser scanners.

2D codes have also found their way into the produce and meat departments of a few US grocery stores although retailers are not scanning them at PoS level or using them for inventory purposes. In the wake of several high-profile product recalls, 2D codes are being utilized by manufacturers to provide farm-to-fork traceability. With improved visibility into where food was produced and distributed, manufacturers and retailers can quickly respond to any food safety recalls, pulling food out of circulation that might pose a health risk while avoiding throwing out uncontaminated product. However, these 2D codes are currently only used in closed loop systems by the food manufacturer and not the retailer.

About Datalogic Mobile

Datalogic Mobile is a global manufacturer of mobility solutions for retail applications, assisted shopping, warehouse solutions, and field-force automation.

Our diverse product range of rugged mobile computers includes pocket-sized computers, pistol grip mobile computers, and industrial PDAs designed to keep workers connected to their enterprise inside or outside the four walls. Our mobile computers use Cisco® Certified CCX radios for maximum levels of: RF security, data throughput, and efficiency. Datalogic Mobile computers use the latest technologies for voice and data communications giving mobile workers on-the-go connectivity.

Datalogic Mobile has a complete line of rugged mobile computers for retail, warehouse and field force applications.

Datalogic Mobile is the worldwide leader in Assisted Shopping. Over 350 retail stores have implemented Datalogic Shopevolution™ software and the Datalogic Joya™ handheld pod as their assisted shopping solution. Datalogic assisted shopping gives retailers a competitive advantage while reducing their operational costs. Joya makes shopping a multimedia experience that increases consumer loyalty.

Datalogic Mobile has worldwide presence in over 30 countries and over 800 business partners worldwide. A leader in technology, Datalogic has a growing portfolio of over 850 patents, eight research and development centers, and 300 engineers.