Guide to Scanning Technologies

Intermec®

Introduction

Scanning technology has been changing dramatically. Laser scan engines, once considered the workhorses for most scanning applications, have been surpassed by new imaging scan engines – linear imagers and 2D imagers – that are more powerful and reliable. It has also enabled the convergence of scan engines into a wider variety of devices.

When the question arises as to which technology is best in handheld scanners, the debate polarizes. The laser camp will argue "it's a laser so it must be better," where as imaging advocates tout its unmatched reliability, versatility and value.

In reality, all scanning technologies are exceptionally good at what they do, as long as they're used in the correct environment for the proper application. Both laser and imaging technologies have been around for many years and continue to improve, although recent advances in imaging technology, which make it superior in reading many types of bar codes, have changed the playing field considerably.

The question then arises: "How do I choose the best scanner for my application?" This guide is designed to help you do just that. As a leader in barcode technologies as well as emerging data collection technologies such as RFID, Intermec is uniquely positioned to guide you through technical information and different scanning applications so you will be able to make informed choices about what will work best for you.

Linear Imagers

The underlying technology of a linear imager is called a charge-coupled-device (CCD). These solid state components are found in a wide variety of products from simple scanners and image capture devices, such as fax machines, to highly sophisticated devices, like linear imagers, video cameras, and digital cameras. In a linear imager, the CCD captures different levels of reflected light from a bar code's bars and spaces and converts them into a video signal.

For optimum performance, linear imagers need their own light source, which is provided by low-power, long-life LEDs (light emitting diodes). Their low power consumption and long life means that the light can be on all the time, eliminating the need for a trigger, although some scanners do incorporate triggers and sleep/wake modes for power saving, especially when connected to battery operated devices.

Since linear imagers are solid state they are inherently more reliable than laser scanners, which use fast-moving mirrors to move a beam across the bar code. To read a bar code, a linear imager illuminates it with light from the LED and uses a lens to focus the image of the bar code onto the CCD component. The simplest reading process identifies the peaks and troughs in the signal and applies one or a number of decode algorithms to get the bar code data. This is done by the scanner's analog-to-digital converter and by software running on the processor. The speed of the processor and efficiency of the software largely determine how fast this happens and how "snappy" the scanner feels to the user.

While linear imaging capability has been around for many years, recent advances in the technology have dramatically improved the performance of this type of scanner. Manufacturers of these next-generation linear imagers have developed advanced ways of reading the video signal and special decode hardware/software to improve speed, depth-of-field and read success rates. These refinements, coupled with faster scan rates (up to 5-10 times faster than a laser scanner) and faster processors, help explain why linear imager scanners are better or snappier than others when it comes to reading poor quality or laminated bar codes.

Laser Scanners

Laser scanners read bar codes with a laser beam in conjunction with oscillating mirrors to automatically move the beam back and forth across a bar code. Laser engines come in a variety of configurations (e.g. standard range, wide angle, high density, long range and high visibility) to meet the needs of different scanning applications. The major advantage to lasers is their scan range; they can read bar codes from several feet away. In fact, if the symbol is printed large enough, the laser can read it from as far away as 35 feet (11 meters). For applications such as scanning from a forklift in a warehouse, the ability to read a bar code without having to constantly get off the forklift is a distinct advantage.

Another advantage of lasers is that they can be focused to a very small beam. Because the light is coherent (a single frequency), the beam will not spread much over a given distance. Therefore the diameter of the beam will remain small enough to resolve the wide and narrow bars of the bar code even if the reading distance varies. That property allows laser scanners to read bar codes over a wide scan range.

On the downside, lasers tend to be more expensive than linear imagers and have a moving part, the oscillating mirror, which over time can get out of alignment and degrade scanning performance. Laser safety is also an issue, especially in Europe where concern over high-energy lasers hitting the eyes is already a hot topic of discussion. In the U.S., the move to bring scanners into the home
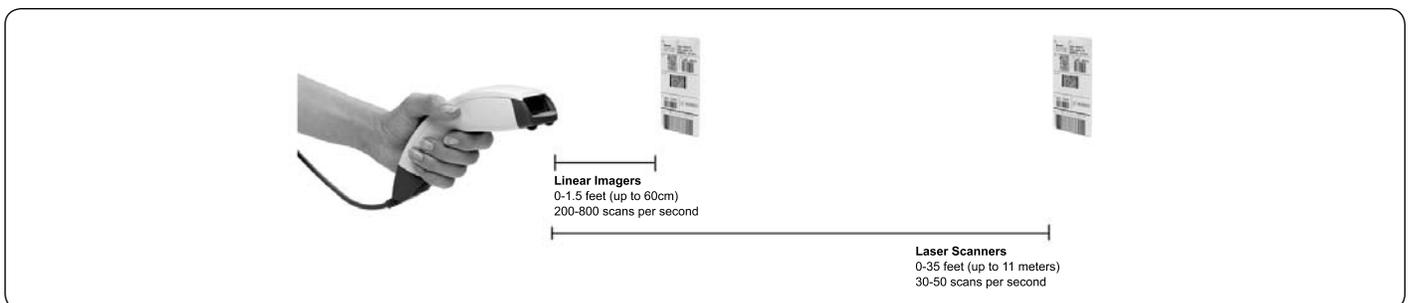
Linear images scan most effectively at shorter distances, but scan at a much higher rate of speed. Lasers are ideal for long-range scanning applications.

for
e-commerce applications is raising the question of laser safety around children.

Laser scanners and linear imagers include handheld or fixed position models. Handheld units generally operate at the lower end of scanning speeds (35-300 times a second) because the symbol being scanned is usually stationary. Fixed position scanners on a conveyor operate at the higher end (600-1800 times a second) to be fast enough to read the label before it moves past the scanning area.

Performance Benchmarks
Intermec's labs have conducted extensive tests over a variety of brands of handheld laser and linear imaging scanners to determine performance characteristics. The data from these key benchmarks illustrates the strengths and weaknesses of each technology.

In general, the most expensive laser scanner and the higher quality linear imagers did well in virtually every category, so the scanner purchase decision must balance price, performance, and specific application needs.

Beam Brightness
Lasers are the clear leader in beam brightness and coherency. Linear imagers' beam brightness is very good within typical scanning range (2-18 inches/40mm-480mm), but tends to diffuse at longer ranges.

Scan Time ("Snappiness")
Scan time tests involved measuring the time a scanner takes to read real-world, poor quality labels – the most effective test for evaluating what the customer experience will be.
Linear imagers and the top-of-the-line laser did significantly better – up to 91 seconds faster than other laser scanners.

Scan Range (depth of field)
Lasers, specifically long range lasers, can scan at a greater distance, but have difficulty scanning at close range. Linear imagers have a better overall read range, especially on 2.5 mil Code 39 bar codes.
For larger codes (55–100 mil) at a greater distance, long range lasers are the only option.

Substitution Resistance
This tests the scanner's propensity to substitute characters when it can't read the barcode – in other words, how well does it resist substituting bad data. Scans are taken over various distances, as substitution tends to occur more often at longer scan ranges.

In the test, only linear imagers did not generate any substitutions.

Decodability
A decodability test determines the scanner's ability to read extremely poor quality and damaged codes, including bar codes under several layers of clear plastic wrap.

Both the most expensive laser and the higher quality linear imagers performed well on virtually all poor quality and overlaminate codes and read low contrast codes down to 20-25%.

Considerations For Selecting A Scanner
For applications requiring scanning of linear bar codes, both lasers and the linear imagers are excellent technologies and while there are some overlaps in their appropriate applications, each technology has characteristics that make it better for specific uses.

The criteria used to decide which technology to use – or how to mix the technologies within your enterprise – should be based on the scanning application (from what distances will scans be made, what is the condition of the bar codes being scanned, what is the work environment, etc.) as well as price/performance considerations.

The chart below summarizes the characteristics of the most recent generation of linear imaging and laser scanning technologies.

What is the reading distance and item to be scanned?
Linear imagers work exceptionally well at standard range of less than 18 inches (45cm), so if the scanner can be brought close to the label (or vice versa), a linear imager would be a good choice. However, if the labels are more than 18 inches (45cm) away, laser scanners are the best option.

What type of code will be used?
Most scanning technologies read the same common set of bar code symbologies, including EAN/UPC, Code 39, and Code 128. The latest generations of linear imagers work best on these codes at higher code densities, in the region of X-dimensions (narrow bar width) between 2 and 5 mil (0.05 and .1mm) and with code widths up to 8 inches (200 mm) for X-dimensions between 10 and 20 mil (0.25 mm and 0.5mm).

What is the condition or source of the bar code?
Linear imagers are not only excellent at higher densities; they also read poor quality codes and bar codes through laminates exceptionally well. Generally, linear imagers can read codes with low contrast between bars and spaces (caused by the color or poor printing/fading). Some linear imagers can also cope well with

damaged codes. The faster scan rate of linear imaging engines plays a significant role in reading these, as do the methods used to decode the complex video signal information provided by the linear imager. This is, in turn, dependent on the investment the supplier has made in decoding techniques.

Test your scanner
Linear Imagers can read very poor quality bar codes that lasers can't.

What are the environmental conditions?
Linear imagers are solid state without any moving parts. Because

of that, they tend to be more reliable than lasers, which use moving mirrors to make a laser spot travel across a code. However, it's the casing of the scanner that dictates its suitability for certain environments. In retail, for example, a linear imager in a standard ABS plastic case will provide a durable, long-life solution, whereas a more durable casing would be needed for the same scanner in a warehouse or industrial application.

Do you need to read bar codes off computer screens?

Application	Linear Imager	Laser Scanner
Scanning distance less than 18 inches (45cm)	✓	
Scanning distance up to 35 feet (11 meters)		✓
Higher bar code densities	✓	Requires special scan engine
Poor quality/damaged bar codes	✓	
Over-laminated bar codes	✓	
Linear bar code labels	✓	✓
2D stacked bar codes – PDF 417, Code 49 (requires special software)	✓	Requires special scan engine
Matrix codes (Datamatrix, QR code)	(see "Other Scanning Technologies")	
Reliability	✓	
Scan rate: 30-50 scans per second		✓
Scan rate: 200-800 scans per second	✓	Fixed position only
Very bright spotting and scanning beam		✓
Fast scanning in fixed positions	✓	✓
Retail Price (with cable): US$150 - $700	✓	
Retail Price (with cable): US$500 - $2000		✓

**Most recent generation of linear imaging
and laser scanning technologies**

One unique application for linear imagers is reading bar codes off computer screens. This is extremely helpful in configuring the devices via bar codes, especially if you have a large number of devices to configure. Instead of printing out a series of bar codes, you simply display them on a computer monitor and scan them directly.

How important is performance?

If a scanner, regardless of its technology, reads a code, then the performance differences between it and another will be judged on issues like "snappiness", scan range and definition of reading zone. Within its scan range, a linear imager can provide exceptional performance. Scan rates of 100 scans per second are common and top-of-the-line scanners offer up to 800 scans per second.

Some linear imagers are contact readers and will only read if the scanner's nose is touching the code. This is appropriate for flat surfaces, but can give problems if the code is on a curved surface. Long-range linear imagers are better for curved surface scans. Other linear imagers can read out to 2 inches (40 or 50 mm) while extended or "long" range linear imagers, like Intermec's ScanPlus 1800 Vista, can read up to 18 inches (460mm).

As the reading distance increases, it becomes more important to know where the scan line is. With laser scanners this is clearly marked by the laser line, but linear imagers depend on the illumination of the LEDs. As a result, the scan line for linear imagers becomes more difficult to see as the reading distance increases or in high ambient light conditions such as direct sunlight.

How much do I want to pay?

Linear imagers are generally less expensive than lasers. With U.S. retail prices between $150 and $700, linear imagers are easy to justify. However, the range in price is still quite wide (and even wider with lasers), which can be an issue for some buyers, particularly when high volumes are being considered. If price is an issue, take care not to compromise on the following features, particularly if the purchase is intended to improve productivity.

1. Is the scanner's scan range suited to the application? Is there a "comfort zone" (scan range on the actual code of at least 0.4 inches/1cm) to make reading intuitive and allow curved labels to be read? Does the user need to see the scan line on the bar code?
2. Is the resolution range of the scanner suitable for the application? The scanner should read the codes with some comfort zone.
3. Does the scanner read all the possible qualities of code the application will present?
4. Is the scanner easy and comfortable to use? Can it be picked up and set back down easily? Is the scanning plane and zone suitable for the operator's position and placement of the coded items? If the scanner has a trigger, is it easy to use?
5. If an extended scan range is necessary, does the scanner have adequate scan depth on the actual codes?
6. Does the scanner read all codes easily or does it take time to read? A good test is to check the time it takes to read 10 or 20
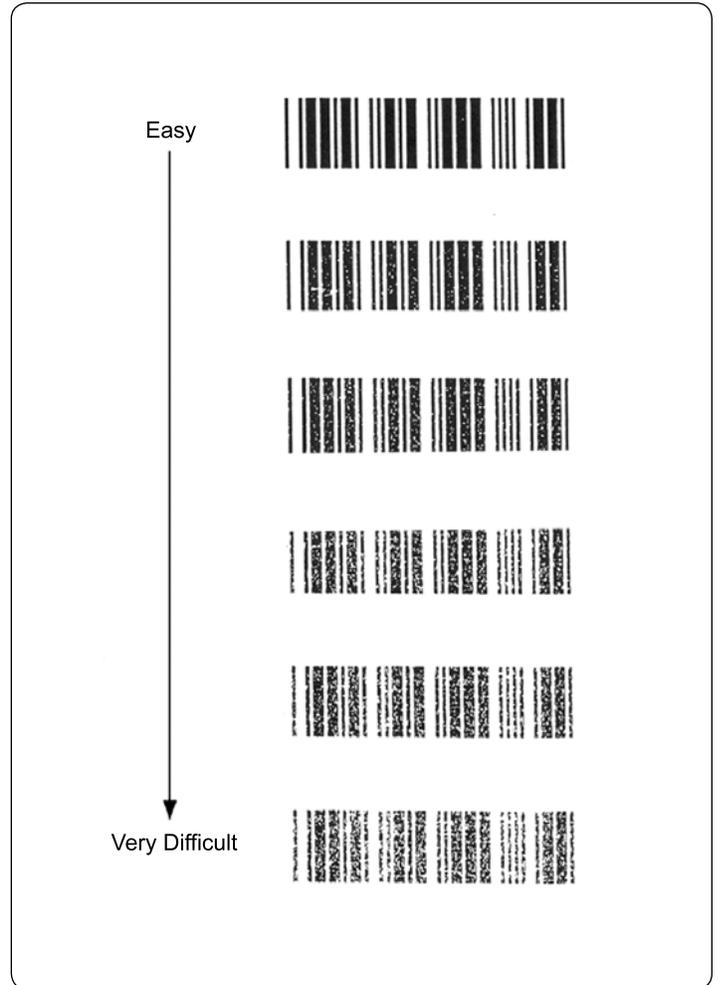
Fuzzy Codes

real-world codes rather than just testing on one sample.

7. Is the scanner suitable for the environment, i.e. ruggedness, style, cable strength and length, sealing against water, dust and vibration, ambient light, temperature, etc.?

8. Check that the most obvious requirements are actually met, including symbology type, data formatting needs, etc.

Other Scanning Technologies
APS CMOS Sensors

Active Pixel CMOS Sensors (APS), like Intermec's EV10 scan engine, are a new form sensor that replaces the CCD used in many of today's linear imagers. The new APS sensor combines the light detector and the digital signal processor all into one ASIC. This new APS sensor allows for linear imagers to have the same performance as those that used CCD sensors but these new linear imagers are smaller, lower power, more reliable, and offer many other advantages over conventional CCD based linear imagers.

2D Image Readers

2D imagers capture a "picture" of two-dimensional or linear codes and process them using advance decode algorithms. For linear codes, 2D imagers provide omnidirectional reading of linear bar codes, so orientating the code for scanning is unnecessary.

2D codes carry much more information in a smaller space than linear bar codes, making them ideal for applications like printed circuit board manufacturing, healthcare/clinical and retail.

2D imagers can be produced using either CCD technology or the more sophisticated CMOS technology, which uses dramatically less power while providing advanced performance. CMOS-based 2D imagers are ideal for applications where changing or recharging batteries in mid-shift reduces productivity, like portable data collection in warehouse, manufacturing, and distribution applications.

For more detailed information on 2D imaging, read the whitepaper *Sizing Applications for 2D Symbols* available at www.intermec.com (go to the "About" navigation and then "whitepapers").

RFID

Radio **F**requency **ID**entification is similar in concept to bar coding, but instead of a printed label with static information that requires line-of-sight scanning, RFID tags contain an application-specific integrated circuit (ASIC). The ASIC acts as a dynamic portable database that can be read and/or written to every step along the supply chain. RFID does not require line of sight to read tags, speeding the process of data collection and RFID devices, such as a tag or label, can be attached to virtually anything – from a vehicle to a pallet of merchandise. In addition, because the technology is difficult to counterfeit, RFID provides a high level of security.

RFID is currently a complementary technology to bar codes, but has the potential to replace them in certain supply chain applications. In the short term, combination bar codes scanners/RFID interrogators, like the Intermec 1555, allows workers to work with either technology using one device.

Intermec Technologies' Scanning Solutions

Intermec offers a full range of linear imagers, CMOS-based 2D imagers, laser scanners, scan engines and RFID interrogators to meet virtually every application requirement along the supply chain. From industrial to retail to healthcare applications, Intermec has a product designed specifically to meet virtually every environmental, scanning and ergonomic need.

For more information on Intermec scanning solutions, contact Intermec Technologies Corp. at 1-800-347-2636 or visit Intermec's Web site at www.intermec.com.

Glossary Of Terms
APS

Active Pixel Sensors often fabricated using Complimentary Metal Oxide Semiconductor (CMOS) technology. APS enables individual pixels on the sensors to be programmed, making it easier to read a variety of different symbologies from the same device.

Bar Code Symbol

A sequence of rectangular shapes and intervening spaces used to encode a string of data. A bar code symbol typically consists of five parts: 1-a leading quiet zone, 2-a start character, 3-data character(s) including an optional check character, 4-a stop character and 5-a trailing quiet zone.

Bi-directional

Characteristic of some bar codes that allow decoding of the symbol regardless of whether scanned in a forward or backward direction.

CCD

Charge-Coupled-Device, the solid state component found in a wide variety of products from simple scanners and fax machines, to highly sophisticated devices, like linear imagers, video cameras, and digital cameras.

Close Range

Contact to 5 inches (12.7 cm)

CMOS

Complementary Metal Oxide Semiconductor (pronounced see-moss). CMOS is a widely used type of semiconductor. CMOS semiconductors use both NMOS (negative polarity) and PMOS (positive polarity) circuits. Since only one of the circuit types is on at any given time, CMOS chips require less power than chips using just one type of transistor. This makes them particularly attractive for use in battery-powered devices, such as portable computers.

Long Range

2 feet (61 cm) to 35 feet (11 meters)

Laser

Light Amplification by Stimulated Emission of Radiation. Laser scanners read bar codes with a laser beam in conjunction with oscillating mirrors to automatically move the beam back and forth across the symbol.

Linear Imaging

Linear imagers are solid state scanners which use a charge-coupled-device (CCD) as their underlying technology. Linear imagers have generally better performance and reliability at a lower price than laser scanners.

LED

Light Emitting Diodes are special diodes that emit light when connected in a circuit. They are frequently used as "pilot" lights in electronic appliances to indicate whether the circuit is closed or not.

Matrix Codes

An arrangement of regular polygon shaped cells where the center to center distance of adjacent elements is uniform. The arrangement of the elements represents data or symbology functions. Matrix symbols may include recognition patterns that do not follow the same rule as the other elements within the symbol.

RFID

Radio Frequency IDentification. The use of radio frequency signals to provide automatic identification of items. RFID uses a reader (or interrogator) and special RFID tags that can be read and written to hundreds of times.

Standard Range

2-9 inches (5-23 cm).

Stacked Code

A long, multi-row symbol that is broken into sections, which are stacked upon another in a fashion similar to sentences in a paragraph.

Symbology

Bar code language, i.e. Code39, UPC, EAN, including linear, stacked matrix and matrix bar codes.

Two-dimensional Symbology

A machine-readable symbol composed of rows of encrypted data arranged in a rectangular or square pattern. The rows of data may be composed of bar code strips, "stacked" to form the two-dimensional block pattern or arranged as a checkerboard "matrix" of typically square elements.

X-dimension

The nominal dimension of the narrow bars and spaces in linear and 2D stacked codes. In 2D matrix symbols, the X-dimension is the height and width dimension of the smallest element because each module is square, except for MaxiCode modules, which are hexagonal.

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