White Paper

How To Choose The Best Data Capture Technology

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Intermec PartnerNet

Barcoding Incorporated

In 1974 when Intermec invented Code 39, data capture technology was pretty simple: print out a linear bar-code label and read it with a batch laser scanner.

As bar codes became commonplace, companies realised the advantage of carrying more data, leading to new symbologies such as PDF417 and matrix codes that convey far more information, and now radio frequency identification (RFID), which can serve as a portable, dynamic database attached to a pallet, case, or single item.

Along with the proliferation of new symbologies to convey data, there has been a significant change in scanning technologies. The workhorse laser scan engines have been supplemented with—and often surpassed by—new imaging scan engines. These linear and area imagers are more powerful and reliable than laser scanners. Add to that RFID interrogators and you have a much more complex data-capture landscape to navigate.

While it might be logical to ask which technology is best, the better question to ask is, "What is the optimal suite of data-capture technologies for my specific set of applications?" All scanning technologies are exceptionally good at what they do, as long as they're used for the proper application. With numerous applications in use, a combination of scanning technologies is needed.

Both laser and imaging technologies have been around for many years and continue to improve. Recent advances in imaging technology have changed the playing field considerably, making them superior for reading many types of codes. And the newest technology, RFID—which has actually been in use for decades—is well on its way to broad industry adoption.

The first step in choosing the technologies that will best suit your environment is to understand the advantages and disadvantages of each and how they support key applications.

AVAILABLE DATA CAPTURE TECHNOLOGIES

Standard Laser Scanners

Pluses:

- Excellent for long range scanning
- Very bright, coherent spotting beam

Minuses:

- Oscillating mirrors make them less reliable
- Not as effective in reading damaged or poorly printed labels

Best Applications:

- Scanning linear codes on high shelves in warehouses and distribution centres

Standard laser scanners read bar codes with a laser beam in conjunction with oscillating mirrors to automatically move the beam back and forth across the 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 applications. The major advantage of laser scanners is 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 as 35 feet (10.7 metres). For applications involving a forklift operator in a warehouse, the ability to read a bar code without having to repeatedly get off the forklift is a distinct advantage.

Another advantage of lasers is that they can be focused to a very narrow beam. Because the light is coherent (a single frequency), the beam will not spread much over a given distance. Therefore the diametre 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 variety of depths of field.

On the downside, lasers tend to be more expensive than linear imagers and have moving parts (the oscillating mirrors) that wear out, often necessitating the replacement of the entire scanner.

Laser scanners are available in handheld or fixed-position models. Handheld units generally operate at the lower end of scanning speeds (35-100 times a second) because the symbol being scanned is usually stationary. Fixed position scanners for conveyors operate at higher speeds (600-1,800 times a second) and are fast enough to read the label before or as it moves past the scanning area.

MEMS Laser Scanners

Pluses:

- More compact and reliable than standard laser scanners
- Very bright, coherent spotting beam
- Five times faster scanning rate than standard laser

Minuses:

- Inferior to imagers for reading damaged or poorly printed labels

Best Applications:

- Standard range (arm's length) scanning in retail, healthcare, and warehouse applications

Laser scanners built on Micro Electro Mechanical System (MEMS) technology have a performance advantage over standard laser scan engines due to faster scan rates and improved reliability because the oscillating mirrors of the standard laser are replaced by a silicon chip.

MEMS devices are manufactured using silicon semiconductor batch-fabrication techniques similar to those used for integrated circuits. MEMS technology has been proven reliable in some of the world's most difficult environments, including use in sensors for automobile air-bag systems and antilock brakes, and in optical switches for fibre-optic communication.

MEMS technology produces a laser scan engine with entirely new capabilities, including faster scan rates, miniaturisation, improved durability and frictionless mechanical parts for longer-lasting performance. Initial scan rates are five times faster than current mechanical motor-based laser scanners, with the capability to increase to thousands of scans per second in future product generations. This speed will allow precise high-speed scanning in two dimensions and provide omni-directional reading of 1-D and stacked bar-codes, as well as 2-D raster scanning for matrix codes.

Intermec's EL10 scan engine is the first laser-scan engine based on MEMS technology.

Linear Imagers

Pluses:

- Reliable, solid-state performance
- Excellent for reading poorly printed and damaged labels

Minuses:

- Cannot scan at extremely long ranges

Best Applications:

- Retail POS
- Inventory management and order picking
- Production line replenishment

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

A linear imager's light source is provided by 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 with no moving parts, they are inherently more reliable than laser scanners, which use fast-moving mirrors to move a beam across the 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 decode algorithms to retrieve the bar code data. This is performed by the scanner's analog-to-digital converter and software running on the processor. The speed of the processor and efficiency of the software largely determine how fast this happens and how "snappy" or responsive the scanner feels to the user.

Linear imagers provide better code-reading performance for many reasons.

1. Faster scanning at 200-500 scans-per-second.
2. "Thick beam" technology reads a much thicker portion of the bar code than laser scanners so that it can piece together the good parts of the label while ignoring the imperfections.
3. Its broad spectrum of light (a.k.a. incoherent light), provides 300 times more opportunities to differentiate light than a laser's coherent beam.

Imagers are an increasingly popular choice due to their smaller size and lower cost. According to Venture Development Corp., the market for linear imagers is expected to grow at an 11 percent compound annual growth rate and 2-D imagers at 20.8 percent, while the overall scanner market will grow at 8 percent.

Application Note

Warehouse Management Systems

WMS include all the activities within a warehouse or distribution centre that manage and track reception, inspection, storage, inventory control, and picking and shipping of items. A suggested WMS suite of scanning technologies includes:

- **Area Imagers** for shipping and receiving cartons from 3PL companies using matrix codes. Area imagers are also ideal for reading linear codes without having to reorient cartons for proper label alignment. And they provide the unique benefit of taking pictures of damaged cartons to be used in proof-of-condition claims.
- **Linear Imagers** for arm's length scanning during inventory management and order picking. Linear imagers usually deliver snappier performance and are superior for reading bar codes that have been damaged during storage, retrieval, or transit.
- Long-range **Laser Scanners** for scanning high shelf and carton labels. Long-range lasers allow workers to scan up to 35 feet with a sharp scanning beam, eliminating the need to climb ladders or step off a forklift to scan labels.
- Fixed **RFID** Readers for labour-free scanning of tags as they pass through warehouse/DC doors. For cross-docking applications, the forklift driver can immediately receive orders indicating where to deliver pallets via a wireless vehicle-mounted computer, eliminating downtime and misplaced goods.

Area Imagers

Pluses:
- Provide omni-directional reading of codes (eliminates the need to reorient labels to read them)
- Reads virtually any symbology, including 2-D codes
- Captures signatures, proof of delivery
- Can take pictures of damaged cartons for proof-of-condition claims

Minuses:
- Cannot scan at extremely long ranges

Best Applications:
- Shipping and receiving from 3PL carriers
- Work-in-progress
- Field service and parcel delivery
- Insurance

An area imager captures a “picture” of two-dimensional or linear codes and processes them using advanced decode algorithms. Area imagers provide omni-directional reading of linear bar codes, so reorienting the label for scanning is unnecessary Additionally, area imagers are the appropriate scanning technology for reading two-dimensional (2-D) codes. Two-dimensional codes carry much more information in a smaller space than linear bar codes, making them ideal for space-limited applications like printed circuit board manufacturing, healthcare, and parcel delivery.

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

Active Pixel CMOS Sensor (APS) imagers, like Intermec’s EV10 scan engine, are a new form of solid-state scanning technology that enables individual pixels on the sensors to be programmed. This makes it easier to read a variety of different symbologies from the same device. For example, to read PDF symbols, a square pixel is better than a rectangular one.

Because area imagers capture an actual picture (e.g. a signature or damaged cartons), they are ideal for field service, proof-of-delivery, and shipping/receiving applications.

RFID

Pluses:
- Delivers truly automated, hands-off data capture
- Does not require line-of-sight to read tag
- Acts as a portable, dynamic database that can be read and updated anywhere along the supply chain

Minuses:
- Cost of tags

Best Applications:
- Cross-docking
- Inventory management
- Tracking along the supply chain
- Parts traceability/product genealogy
- Asset management
- Access control

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-code scanners/RFID interrogators allow workers to work with both technologies using one device.

RFID is similar in concept to bar coding, but instead of a printed label with static information that requires line-of-sight scanning, RFID tags acts as a dynamic portable database that can be read and/or written to at every step along the supply chain. RFID does not require line of sight to read tags, speeding the process of data collection. Also many tags can be read with one sweep of the read field. RFID tags/labels 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.

Application Note

Parts Traceability/Product Genealogy
Parts traceability records changes, including date and location of origin, for every component or to every element of a product throughout its life—in other words, it documents a product’s genealogy, or history. This can include material sources, production locations, personnel involved, storage locations and durations, transportation means and providers, after-market upgrades, maintenance and repair—virtually every part and action that affects the product. Two technologies may be used, separately or jointly, to manage parts traceability:

- **Area Imagers/Linear Imagers** – Depending on the symbology being used, either an area imager or a linear imager can be used to scan the part’s code and feed the genealogy information into a central database.
- **RFID** – Much, if not all, of a product’s genealogy data can be stored on an RFID tag versus being housed in a central database. This allows the data to travel with the product so that it may be accessed and updated at any point in time. RFID is ideally suited for a large number of traceability applications, especially on more complex products and assemblies.

SELECTING DATA CAPTURE TECHNOLOGIES

For some applications, one data capture technology might suffice, but for the majority a mix is the most appropriate answer. The criteria you use should be based on your application and objectives:

- What are you trying to accomplish with automation?
- How much data would best support the application?
- What are the specific tasks involved?
- What is the work environment? Does it require more ruggedised equipment?
- What are your compliance-labeling requirements?
- What ROI can you expect by automating?

The chart below summarises the characteristics of the most recent generation of data capture technologies:

DATA CAPTURE TECHNOLOGIES PERFORMANCE & APPLICATIONS					
Application	**Standard Laser Scanner**	**MEMS Laser Scanner**	**Linear Imager**	**Area Imagers**	**RFID**
Distance:					
Read distance no more than 9 inches (23 cm)					
Read distance no more than 18 inches (46 cm)					Range dependent on tag frequency
Read distance up to 35 feet (10.7 metres)					
Tag/Label Reading:					
Does not require line of sight to read data					
Omni-directional scanning					
Read/write capabilities (dynamic database)					
Can read multiple tags simultaneously					
Label/Code Quality:					
Higher bar-code densities	Requires special scan engine				
Poor quality/damaged bar codes					
Over-laminated bar codes					
Symbology/Data Type:					
Linear bar code labels					
2-D stacked bar codes – PDF417, Code 49	Requires special scan engine				
Matrix codes (Data Matrix, QR code)					
RFID tags					
Scan/Read Rates:					
Scan rate: 30-50 scans per second					
Scan rate: 200-800 scans per second	Fixed position only				
Read rate: up to 1,500 tags per second					
Other:					
Reliability of device					
Very bright spotting and scanning beam					
Fast scanning/reading in fixed positions					
Integrated Scan Option:					
Suggested list price: US $0 – $500					
Suggested list price: US $501 – $1,000					
Industry					
Retail POS					
Retail supply chain					
Warehouse/Distribution Centres					
Healthcare					
Work-In-Progress					
Product Traceability/Product Genealogy					
Logistics					
Field Service					
Government/Homeland Security					

What is the reading distance of the item to be scanned?
For average size codes, linear imagers and laser scanners work exceptionally well at a standard scanning range of up to 18 inches (46 cm). Area imagers can capture codes up to 9 inches (23 cm) in range. If the labels are more than 18 inches away, long-range laser scanners are the only option. However, lower resolution (larger) codes allow longer read ranges than high-resolution (smaller) codes across all technologies.

The read distance of RFID tags depends on the frequency of the tag. For example, a 915 MHz tag has a typical read range of 10-13 feet, whereas a 2,450 MHz tag can be read from up to 48 inches.

What type of symbologies will be used?
Most scanning technologies read the same common set of linear bar-code symbologies in a variety of bar-code densities (i.e. the number of characters which can be represented in a linear unit of measure), including EAN/UPC, Code 39, and Code 128. Linear imagers are the best choice on these codes at higher code densities (where more characters are packed into the same space), in the region of X-dimensions (narrow bar width) between 2 mil and 5 mil (0.05 and 0.13 mm), and with code widths up to 8 inches (200 mm) for X-dimensions between 10 and 20 mil (0.25 mm and 0.5 mm). For applications where scanning matrix codes or a wide variety of symbologies is necessary, area imagers are the best option.

Are you required to produce compliance labels?
Some major retailers and the Department of Defense are requiring their suppliers to incorporate RFID tags into their outbound shipment labeling. Fixed RFID readers and RFID handheld devices for exceptions management are the best answer in this application. Other compliance-labeling requirements may dictate that matrix codes be incorporated into a label with linear codes and human-readable information, in which case area imagers are ideal.

Application Note

Work-in-Progress
WIP monitors the flow of products during the manufacturing process, from raw materials or parts through the finished goods stage. A suggested WIP data capture suite would include:

- **Area Imagers** – Small 2-D and matrix codes are increasingly being used in WIP (e.g. in electronics and automotive manufacturing) because of their ability to contain a lot of information in a very small space. Area imagers will read virtually any symbology used in WIP.
- **RFID** – RFID tags can be used on part carts or other containers to help automate the workflow and document movement of parts or assemblies without human intervention.

Do you need non-line-of-sight scanning?
Because RFID is the only radio-based data capture technology, it does not require an optical read of the tag. RFID readers can also read dozens of tags simultaneously, making them ideal for tracking large quantities of goods through warehouses and distribution centres. Handheld scanners that can read both RFID and linear codes are ideal for exceptions management.

What is the condition or source of the bar code?
Poor quality codes or codes that must be read through laminates can be very difficult to read. Linear imagers are not only excellent at higher densities, they also read poor quality codes and codes with low contrast between bars and spaces (caused by the colour or poor printing/fading) exceptionally well. Some linear imagers can also cope well with damaged codes. The faster scan rate of linear-imaging engines plays a significant role in these capabilities, as do the methods used to decode the complex video signal information provided by the linear imager.

What are the environmental conditions?
The working environment will certainly dictate how rugged the scanner needs to be, but even a seemingly "safe" environment like retail can prove a tough environment for scanners with moving parts, which can get jarred out of alignment by rough handling. Linear and area imagers (as well as RFID readers) are solid state without any moving parts. Because of that, they tend to be more reliable than lasers, which use moving mirrors to make the laser spot travel across the code. However, ultimately 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 rugged casing would be needed for the same scanner in a warehouse or industrial application.

Do you need to read bar codes off computer screens?
One unique application for linear imagers is reading bar codes off computer screens. This is extremely helpful in configuring 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.

Application Note

Retail Point-of-Sale/Point-of-Service
POS includes traditional checkout applications as well as the use of portable scanning devices for scanning items prior to finalisation of the transaction.

- **Linear Imagers** – Because of their reliability, snappiness, ideal scanning distance, and ability to read damaged or poorly printed codes, linear imagers are ideal for every POS application.

How important is performance?
If a scanner reads a code, then regardless of its technology, the performance differences between it and another will be judged on issues like speed of reading, scan range and definition of reading zone. Within their scan range, MEMS lasers and linear and area imagers can provide exceptional performance.

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 cause problems if the code is on a curved surface. Long-range linear imagers are better for curved surface scans. Standard-range linear imagers can read up to 18 inches (46 cm).

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. Linear imagers depend on the illumination of the bar code by the LEDs, so the scan line may be 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, area imagers, and RFID readers. With U.S. retail prices between $150 and $700, linear imagers are easy to justify. 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? Typically, most users scan from a distance of 8-12 inches (20-30 cm) away from a bar-code. Does the scanner you're evaluating allow for that? 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 types and qualities of code that the application will present?

4. Is the scanner comfortable and easy to use? Can it be picked up and set 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 depth of field 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 real-world codes rather than just testing 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.

9. Do scanner cables present failure or safety challenges? Cordless Bluetooth®-enabled scanners would solve those problems.

INTERMEC TECHNOLOGIES' SCANNING SOLUTIONS

Intermec offers a full range of linear and area imagers, laser scanners, and RFID readers and tags to meet virtually every application requirement throughout the supply chain. From industrial and manufacturing to retail and logistics 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 **P**ixel **S**ensors, often fabricated using complementary metal-oxide semiconductor (CMOS) technology. APS enable individual pixels on the sensors to be programmed, making it easier to read a variety of different symbologies from the same device.

Area Imaging
Area imagers capture a "picture" of two-dimensional or linear codes and process it using advanced decode algorithms. Area imagers can be produced using either charge-coupled device (CCD) technology or more sophisticated CMOS technology.

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-**C**oupled **D**evice, the solid state component found in a wide variety of products from simple scanners and fax machines to highly sophisticated devices such as linear imagers, video cameras, and digital cameras.

Close range
From contact to 5 inches (12.7 cm).

CMOS
Complementary **M**etal-**O**xide **S**emiconductor (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.

Decode
The process of interpreting scanned or "read" information and presenting it to the computer in a usable fashion.

Long range
From 2 feet (61 cm) to 35 feet (10.7 metres).

Laser
Light **A**mplification by **S**timulated **E**mission of **R**adiation. 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 that use a charge-coupled device (CCD) as their underlying technology. Linear imagers generally deliver better performance and reliability at a lower price than laser scanners.

LED
Light **E**mitting **D**iodes 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 centre-to-centre 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.

MEMS
Micro **E**lectro **M**echanical **S**ystem. MEMS devices are manufactured using silicon semiconductor batch-fabrication techniques similar to those used for integrated circuits. Used to produce laser scan engines, MEMS technology produces an engine with faster scan rates, reduced size, improved durability and frictionless mechanical parts for longer-lasting performance.

RFID
Radio **F**requency **ID**entification. The use of radio frequency signals to provide automatic identification of items. RFID uses a reader (or interrogator) and special RFID tags containing an integrated circuit and antenna that can be read and written to hundreds of times.

Standard range
From 2-9 inches (5-23 cm).

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

Symbology
Bar-code language, including linear, matrix and two-dimensional codes.

Two-dimensional (2-D) 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 2-D stacked codes. In 2-D 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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