White Paper

Image-based Barcode Readers Transforming the Logistics Industry

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The high volume and frequency of orders placed over the Internet combined with a multitude of available products from retailers make automated scanning at logistics centers more important than ever. This paper will analyze the current state of barcode scanning applications and investigate potential for improvement, focusing on the most common applications performed by distribution centers today.

The state of logistics scanning

The logistics barcode-scanning market breaks down into three segments. At the entry-level, a mix of conventional area-array imagers and laser scanners read codes on slow moving or stationary objects. At the high-end of the scale, fixed line scan image-based systems handle high-speed, multi-sided barcode tunnel applications. Situated between these two extremes lies an entire range of applications that currently rely on an increasingly challenged generation of laser-based scanners.

Retail distribution centers require meticulous stock control, which includes careful management of purchasing, shipping and warehouse inventory. Laser systems provide high read rates with good-quality printed barcodes when labels are undamaged, but they have difficulty reading codes under less than ideal conditions. Image-based readers can provide improved read rates, but their cost and complexity have limited their use to high-volume distribution centers... until now. A new generation of image-based readers is poised to revolutionize the market, offering sufficient speed at a price point equal to or lower than that of laser-based alternatives.

A laser scanner reads a barcode by measuring the size of printed modules using light reflected from the code. One of the method's most potent advantages is its simplicity. Its popularity stems from the fact that it is easy to set up, connect and aim, and can read codes fast enough to accommodate high speeds. These systems also achieve a large scanning area and working range. Excellent vendor-supplied service and support ensure that the equipment's performance will always meet published specifications.

Unfortunately, the laser method itself tends to limit the read rate (i.e., the percentage of codes that a scanner reads correctly). Printed barcode quality can vary dramatically depending on the amount that the package is handled, the printing technology, label geometry, point of origin and a host of other factors. A laser scanner may fail to read poorly printed codes. Insufficient contrast, for example, may not provide enough difference between a printed and unprinted module to permit an accurate read. Because a laser scanner attempts to decipher the code along a single laser line, light or specular reflections or damage to the portion of the code being scanned may dramatically reduce the scanner's ability to read the code successfully. Some laser scanners attempt to solve this issue by stitching multiple scan lines together to reconstruct a damaged code. This method works well in some cases, but not when damage is severe.

An unread code requires diverting the package to a manual station where an operator either directs the package to its destination, or replaces the defective barcode, and resends the package back through the sorting system. This failed condition increases the labor and material costs and reduces the efficiency of sorting equipment because packages are handled more than once. Rework means increased overhead and lost margins.

To cope with these limitations, the logistics industry has designed special labels that maximize read rates and equipment specifically optimized to handle high numbers of no reads. Nevertheless, with rapid growth, distribution centers must handle escalating package volumes, an increasing number of sources and destinations and a greater package mix, all of which exacerbate the need for better efficiency and higher read rates.

Distribution centers that struggle with no reads can upgrade to line scan-type, image-based readers. Line scan readers assemble a high-resolution image of a package surface containing a code one line at a time as it passes, analyzing that image to locate and interpret a valid code regardless of its orientation or its placement on the package.

Image-based barcode reading systems offer several advantages over the laser-based variety. First, because a picture is worth a thousand scans, image-based readers begin with more information about the barcode. This advantage allows them to successfully read codes degraded by damage, orientation or distortion. To compensate for damage to the code or light reflections from the package, the analysis software can reconstruct the data of interest from any legible portion of the image.

Image-based systems can also store images for later retrieval and analysis. Archiving this information helps a distribution facility to determine the root cause for any unread barcodes and implement corrective actions, reducing the number of subsequent misreads and thereby improving process efficiency. For example, consider a distribution facility that achieves read rates of only 98%. Reviewing the images of unread packages might reveal that package handling issues caused half of the no-reads. With this information, supervisors can modify the operators' procedures for loading packages onto the sorting conveyor and thereby improve the read rates to 99%. The resulting reduction in the number of packages that the system must re-read following a failure reduces the number of packages manually sorted by hundreds or even thousands per day.

Despite their advantages, however, significant barriers remain that prevent the widespread adoption of line scan image-based systems. The systems are bulky, expensive, hard to set up and difficult to maintain. Calibration during setup becomes critical to the method's success because the movement of the object under the camera must be synchronized with the system's image-acquisition activities. Any aberration in that movement—an unexpected bump or vibration, for example—will cause distortion, compromising the resulting image and therefore the effective read rate.

A revolution in logistics scanning

Distribution centers face a difficult choice. They can select laser scanners for an easy-to-use affordable system that unfortunately offers limited reading capability and no data for process improvement. Alternatively, they can choose an expensive and complex line scan image-based system. A far better choice would be a system that combines the performance of image-based equipment with the cost and ease of use of laser scanners. But what would it take to build such a reader?

Conceptually, a high-speed, area-array, image-based reader could provide the solution. Area-array imagers, like digital cameras, capture an entire image in a single snapshot. By taking snapshots, area scan eliminates the need for precise encoder input or very bright, always-on illumination. Also, area scan technology is not susceptible to distortion or other undesirable image artifacts. Historically, however, area scan image-based readers could not keep pace with the speeds required by package conveyors and could not handle the package size variations seen in logistics applications. However, several advances in the technology have enabled area scan readers to overcome these limitations.

In a conventional image-based reader, the imager, A/D converter and image processor all exist as discrete components interconnected via narrow communication buses. This configuration typically permits a maximum image-acquisition speed of only 60 frames per second (fps). In one innovation—called Vision System on a Chip (VSoC)—the components all reside on a single piece of silicon. As a consequence, VSoC technology can acquire and analyze images at up to 1,000 fps and process them in real time, so the reader can adapt to wide variations in package size.

Also fundamental to this new generation of area scan image-based readers is a new autofocus implementation based on *liquid lens* technology. Liquid lenses focus much more quickly and with greater range than the mechanical variety can—with no moving parts. Modeled on the way the human eye changes focus, such a lens contains two immiscible liquids with different refractive indices—a conductor like water and a non-conductor such as oil. As Figure 1 shows, applying an electric field to the lens changes the surface tension at the boundary between the two liquids, which alters the curvature at the boundary and therefore the focal length of the lens. Varying the electric field strength can make the originally convex liquid boundary flat or even concave. Therefore, the position of a package on a conveyor need no longer compromise either throughput or read accuracy. Also, liquid lens technology simplifies installation, setup and maintenance by allowing focal-length adjustment without the need for anyone to touch the lens.

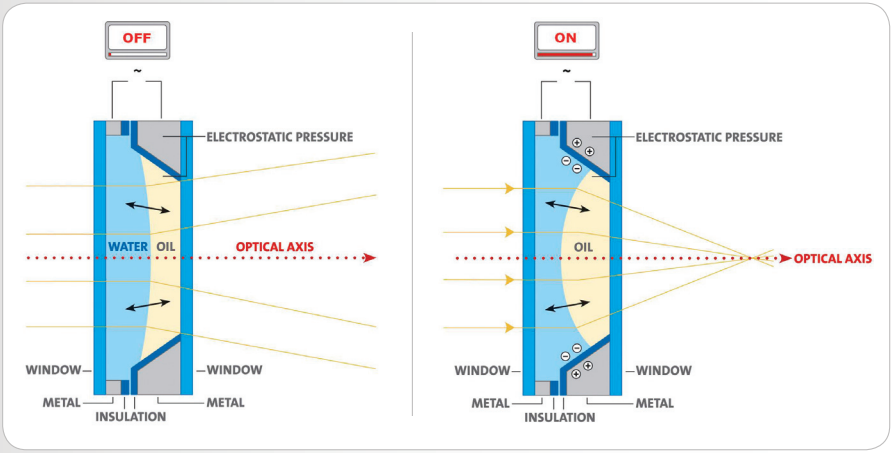

Figure 1

Making the transition

Area-array image-based scanners and laser scanners are easier to install and set up than are line scan systems. However, area-array imagers offer additional setup advantages over lasers. For example, when setting up a laser scanner to maximize read rates, users cannot see the image that the scanner is attempting to read. They have difficulty determining whether the scanner is positioned optimally, especially in omnidirectional applications where the rotational position of the code is unknown. During operation, laser scanners provide no information to help the user determine why a read was unsuccessful. Data from the scanner indicates only the number of packages that were not read successfully, making any attempts to respond reflect pure guesswork rather than data-driven corrective action.

On the other hand, an image-based system can display the scanner image on a monitor or industrial display in real time. As the user sets the system up, the display shows exactly what the scanner sees, ensuring that the images will be in focus and that the image will include all codes on any package that comes down the conveyor. Both initial setup and later adjustments to improve the scanner's read rate require little specialized knowledge, minimizing setup and maintenance times.

As a result, image-based readers are easier to maintain and support than are laser scanners. Vendors provide support, of course, but with easy review of "no-read" images users can quickly and easily identify and rectify problems and support the systems themselves with little training. Or, they can provide most of the support themselves and call in the vendor only when absolutely necessary. The convenience of not needing to schedule, wait for and pay for vendor-supplied service can significantly reduce downtime and the accompanying costs.

Area-array image-based readers also offer better uptime because laser scanners use motors and other mechanical mechanisms to "move" the laser spot across the code. These moving parts wear out over time, thereby limiting the system's useful life. In contrast, area-array image-based readers contain no moving parts, typically resulting in a useful life that is two to three times longer than that of laser scanners.

LOGISTICS SCANNING TECHNOLOGY COMPARISON					
Features	**Entry Level Laser Scanners**	**Entry Level Area-Scan Imagers**	**Laser Scanners**	**Next Generation Area-Scan Imagers**	**Line Scan Imagers**
Easy to set up	✔	✔	✔	✔	✘
High speed	Limited	✘	✔	✔	✔
Large scanning area	✔	Limited	✔	Multiple cameras	✔
Large working range	Limited	✘	✔	✔	✔
Performance feedback via image capture	✘	✘	✘	✔	✔
Read rate performance (damaged codes)	Limited	High	Limited	High	High
Omnidirectional	Multiple scanners	✔	Multiple scanners	✔	✔
Mounting flexibility	Limited	Limited	Limited	✔	Limited
Read 2D symbologies	✘	✔	✘	✔	✔
Bottom scan through conveyor gaps	✘	✘	✘	✘	✔
Price	$	$	$$	$$	$$$
No PC required	✔	✔	✔	✔	✘
Does not require precisely controlled motion	✔	✔	✔	✔	✘
Application Complexity	**Entry Level**		**Middle Range**		**High End**

Preparing for the future

The continued consolidation of distribution operations will strain the capacity of reader systems, while the diversity of sources and destinations continues to escalate. Most companies are struggling to reduce capital costs. They want to invest for the long term. They do not want the equipment that they buy to become obsolete prematurely. In this environment, image-based systems' longer life represents a considerable advantage.

Another future trend in the logistics industry is the introduction of two-dimensional (2D) codes like Data Matrix. Vertical industries such as pharmaceutical will be required to start using these codes for unit level serialization to combat drug counterfeiting within the supply chain. Although not yet as ubiquitous as the old faithful bar codes, the amount of information that 2D codes can store makes them very attractive for a wide range of applications and image-based scanners are required to read these symbologies.

Perhaps most important, as large retailers and Internet fulfillment centers consider capital equipment purchases to add capacity or increase throughput, raising barcode read rates by just 1 percent can significantly shorten payback schedules and increase ROI. Capital equipment acquisitions that improve read rates—such as this new generation of high-speed area array image-based readers—enjoy short payback times that can be measured in months, not years. So, the future belongs to the area scan image-based technology. To learn more about how making the transition to this new technology will help distribution centers prevent falling read rates from eating away at profit margins, download our whitepaper, *"When 99% Just Isn't Enough: Benefits of Improved Read Rates in Logistics Scanning"* or visit us at www.thelaserkiller.com/.

About the Author

Jorge Schuster has nearly 20 years of diversified logistics industry experience and now specializes in Automatic ID and Data Collection (AIDC) serving the postal, parcel, and retail distribution markets. He joined Cognex in 2010 as the Director of ID Sales, Americas. Formerly, he has held positions such as Vice President of Logistics Sales and Vice President, Worldwide Sales and Services at leading Auto ID companies. He managed all postal efforts at Cinetic Sorting Corporation (formerly Sandvik Sorting Systems) and managed all business development activities for Bowe Bell & Howell (formerly Bell & Howell, Postal Systems, Inc.), a leader in postal automation solutions. He holds a bachelor of science degree in mechanical engineering from Villanova University and an MBA from Temple University.

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