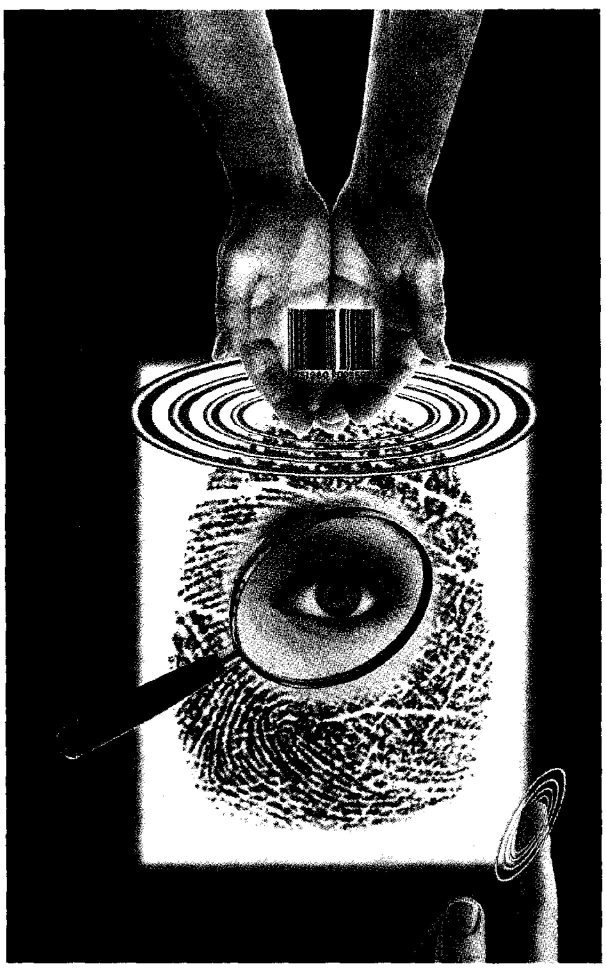
From BARCODES, to BIOMETRICS, and BEYOND, the future holds exciting challenges and opportunities for the field of Auto ID

The Growing *"MAGIC"* of **Automatic Identification**



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by JEROME SWARTZ

Automatic identification represents a set of technologies that (to the uninitiated) seems to work like magic. It's knowing instantly what's in a crate from 30 feet away; talking or looking into a machine that will automatically unlock a door; "laser zapping" a simple stamp-sized paper-and-ink symbol that describes an entire truck's contents; or instantly identifying a fingerprint—an unalterable and unique personal key to secure banking (virtually any place, any time).

Diverse Auto ID technologies have, in fact, become so seamless and transparent to the end user that they do perform business magic for countless corporations and institutions around the world, reducing errors and speeding up processes and delivery times, resulting in major cost savings up and down the supply chain, and really providing "tools" that allow people to do their job more effectively.

The fundamentals of total quality management and continuous process improvement (as competitive advantages in every business) require participants in the supply chain to pursue cycle-time (and variance) reduction as well as defect elimination, really defining attributes of Auto ID technology. I like to call it "blue collar" computing for today's mobile work force.

An appropriate insight came from a *Wall Street Journal* technology editor, who called Auto ID, "embedded stealth technology." Even "simple" linear barcode theory (and practice) is rather complex and sophisticated, at least if you want to read every barcode (including the dozens of substrates and printing processes) first time, every time.

That's what's demanded today, and what's delivered. To get a scanning device to "beep," there's a robust orchestration of

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optics, analog and digital electronics, mechanics, software (pattern-recognition algorithms and computer-interface connectivity) as well as low power consumption, miniaturization, and device ruggedness—all in a familiar "aim-and-shoot" form factor (like a gun; a telephone; or even a Captain Midnight ring and Dick Tracy wrist radio). And no mean engineering feat!

Core Technologies

There are six core Auto ID technologies—one- and two-dimensional barcodes, optical character recognition, magnetic stripe. radio-frequency identification, and automatic speech recognition—that are perhaps the most mature the industry has to offer in terms of technological development and market impact.

Performance capabilities of the core Auto ID technologies are being pushed forward aggressively.

Traditional 1D barcode-based systems shine in terms of speed, flexibility, cost, accuracy, and reliability. They offer many printing and reading choices and eliminate manual entry.

Two-dimensional barcodes store millions of bytes of data quickly, efficiently, and error free. With their capability to re-enter long data streams without manual key strokes, 2D portable data files fill a conceptual gap, which can redefine the working relationship between people, computers, and documents.

Barcodes belong to the class of Auto ID technologies where the identified object is a "cooperative target"—content is derived from a predetermined set of characters. OCR and speech recognition deal with "noncooperative targets," hence, their performance is generally somewhat less reliable and more computation-intensive. However, they employ the same printed or spoken languages as their human operators—an advantage in some cases, especially in those involving the need to capture random inputs.

Optical character-recognition systems are beginning to broaden their capability and offer simultaneous human- and machine-readability at the lowest cost of "carrying" data, but they do require major CPU power.

Magnetic-stripe systems are widely standardized in financial services and security-control applications. They offer relatively inexpensive read/write solutions, but suffer from robustness problems and provide limited information density.

Radio-frequency ID tagging systems deliver noncontact, read-only and read/write capabilities, often with large data capacity, offering a wide range of cost/performance characteristics.

Automatic speech-recognition technology excels due to its natural human interface and nonintrusive, hands-free operation. It works without tags or labels, enabling the user to enter additional information, but it requires clear speech and tolerable background noise.

These core Auto ID technologies are all broadly supported by multiple manufacturers, well introduced into a variety of application contexts, and solidly proven in terms of their capabilities. And yet all are the subject of exciting new developments, holding great promise for the future.

Beyond the Core Technologies

There are other Auto ID technologies that, beyond the core set, have more indistinct boundaries and overlap into the broad field of remote sensing and controls. All of these technologies have important applications, often adjacent to the core Auto ID technologies.

Global-positioning systems, for example, keep track of the whereabouts of trucks on the highway and ships at sea. Infrared systems detect the presence of bodies moving into and through controlled areas. A wide variety of environmental sensors monitor temperature, humidity, shock, and other parameters related to goods in manufacturing and the distribution/logistics pipeline. Electronic article-surveillance tags (a go/no-go single-bit version of RFID) keep shop-lifters at bay. And the rapidly developing field of biometrics is at the heart of solutions in security and finance applications.

Even this list isn't complete. It will grow over time and should serve to remind us of what a rich and exciting technology landscape Auto ID has developed into.

A New Framework for Converging Technologies

Over my 20-plus years in the industry, I've noted a gratifying maturation in the way we look at the relationship between the various Auto ID technologies. Not long ago, I recall the heated debates about which technology was best—which would bring the most benefits, prove to be the most reliable or the cheapest. The implied question was, "Which will emerge as the real winner at the end of the day?" I believe that "competitive" framework asked all the wrong questions and clouded a better understanding of how the technologies could exist side-by-side.

Today, many of us see Auto ID technologies as "complementary," with each filling a space in the market defined by the fit between its strengths and weaknesses, and the requirements of target applications. And looking forward, I believe we'll evolve from a "coexistence" model to one that leverages the many converging opportunities around the intersections and in the gaps between those technologies.

The idea behind today's developing complementary model is to identify the best fit between application requirement and technology capability.

First, the computing and systems environment must be taken into account. Information capacity, bandwidth and memory, density and resolution, are at issue. Access to descriptive databases allow the use of license-plate schemes. Remote applications without this access are better served by a technology capable of supporting a "portable data file" model.

And real-time, two-way electronic commerce may relieve some demand on accuracy (since it can support closed-loop transaction verification).

The physical environment must be considered: Will the technology (and reader) be put to use in harsh conditions? Temperature, humidity, ambient light, RF interference, ESD, and drop-proof ruggedness are among the considerations.

Will the data carriers (tags, symbols, and so on) be subject to abuse? And what about "feeds and speeds" and working-distance practicalities?

It will be possible in some applications to eliminate the need for attaching or printing a barcode on an object.

Operator requirements are another important driver. Must the user have both hands free during equipment use? Will she have to carry the reading equipment for long periods of time? Will there be an operator present at all?

Naturally, economics will be taken into account for both the reader and the data carrier. It makes no sense to mark a one dollar box of cereal with a tag costing five dollars. But that same high-performance tag might be just the answer to carrying a machine-readable manifest of what's contained in the trailer of a truck hauling groceries from a distribution center to a retail store. There are other relevant economic questions. How many data carriers are needed in the application? Can they be recycled?

Reliability and accuracy requirements must also be considered. What's the cost of an all-too-common transposition error? How critical is it that a data-capture event happen first time, every time? Can errors in data capture exceeding 100 ppm (i.e., 99.99 percent accuracy) be tolerated?

Finally, in an "open" system environment, applicable standards must be thought through. Many transactions involving trading partners or government applications are already fully specified on the Auto ID end. And no standard presents its own daunting barrier to customer utilization.

These points are simply an example of the application analysis required to optimally select an Auto ID technology. It's a pretty complex picture.

The More Things Change...

In thinking about how today's application-technology match might change over time, let's start by recognizing that some fundamental facts are not likely to be much different tomorrow than they are today.

- Even taking into account the most aggressive extrapolation of Moore's Law, ink-on-paper will continue to be a much less expensive data carrier than silicon chips (at about 15 cents per square millimeter). The ratio will change, but a significant cost difference will persist for the foreseeable future.
- Humans will continue to be fallible. Systems that depend on their power to read, write, hear, speak and process information will suffer from our built-in shortcomings.
- Auto ID systems tied to remote databases can go down due to service interruptions, since complex networks do not (and can not) operate with 100 percent up time.
- Human eye resolution won't change either, so the size of today's fonts and displays (interfacing the computer) will stay about the same.
- Human operators have two arms and hands available—not easily exceeded when accounting for the appendages required to do the application task!
- Visible light can't pass through opaque objects (ballistic photon imaging and X-ray lasers aren't quite around the corner), so optical systems must accommodate line-of-site data capture.

However, some important marketplace factors impacting our technology choices are subject to change. New standards come into existence, outdated ones pass from the scene, and the popularity and support of a given technology can change dramatically over time. That's what happened some years ago when barcoding became the de facto standard of choice (in retail), pushing aside OCR and magnetic ticketing in the process. Important Auto ID standards often evolve from such beginnings, driving technology selection as a matter of compliance. The last 15 years have seen many examples of this in industries ranging from the Department of Defense to automotive to health care to DMVs.

We all work in an economy that is becoming increasingly interconnected by the supply/demand chain and by strategic business partnerships that serve to direct Auto ID technology choices in a given direction. The technology I use on my shipping dock should optimally match that used by my customer on her receiving dock.

If anything, the pace of change in technology is accelerating. And the performance capabilities of the core automatic-identification technologies are being pushed forward aggressively. Barcode scanners read symbols at distances past 10 meters and as close as a few centimeters; voice recognition systems understand 60,000 word vocabularies; and 50 RFID tags within a volume can be read nearly simultaneously. These emerging capabilities not only can shift the fit equation toward one choice and away from others, they also open up new application opportunities not previously conceived.

Ongoing value-engineering progress will also alter the balance of the technology/application fit. Volume learning curves, combined with breakthroughs, can lead to significant shifts: In the mid-80s, the sub-$500 barcode scanner created strong momentum at retail point-of-sale, and the sub-25 cent high--performance RFID tag may have comparable dramatic impact.

As we all know, the computing environment into which automatic identification systems capture and transact data is moving forward at a dizzying rate. Increases in portable com-

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Voice-recognition systems may become much more attractive if the processing can be done on a high-performance server, communicating wirelessly with mobile, thin client devices using voice-over-IP technology now emerging.

And OCR and 2D barcode technology might team up to yield a secure replacement for the postal mark, by uniquely tying a postage "stamp" to address information.

My last observation relates to the expansion of Auto ID from today's commercial and industrial environments to mass-market consumer applications. We can already see the beginnings: the use of RFID tags at automatic toll-collection booths and barcode-based consumer self-scanning in supermarkets.

And, if portable self-checkout in stores is an evolution, then the true revolution is the use of Auto ID technology in home automation. The first application may be home shopping, perhaps starting with emergency half-hour delivery of a barcoded prescription from the local chain drugstore, or Internet access and ordering of commodity items via a machine-readable URL, direct from the manufacturer.

So where does this all lead? There is no question in my mind that the future holds many exciting challenges and opportunities for the field of Auto ID and its cutting-edge practitioners.

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