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GS1 US

2D barcodes enable traceability and authentication for modern commerce, but they require strong data foundations, from supplier to consumer.

Delivering the next-generation barcode

Key takeaways

1. 2D barcodes create a new way of capturing and sharing robust product data, unlocking unprecedented opportunities to connect suppliers, businesses, and customers.
2. Realizing the full potential of these barcodes hinges on an enabling data ecosystem – one that can supply accurate, standardized, and interoperable data across the supply chain.
3. New barcode use cases will supply individual consumers with information they need, personalized to what matters most – from real-time product use instructions to full materials traceability.

The world's first barcode, designed in 1948, took more than 25 years to make it out of the lab and onto a retail package. Since then, the barcode has done much more than make grocery checkouts faster – it has remade our understanding of how physical objects can be identified and tracked, creating a new pace and set of expectations for the speed and reliability of modern commerce.

Nearly eighty years later, a new iteration of that technology, which encodes data in two dimensions, is poised to take the stage. Today's **2D barcode** is not only out of the lab but "open to a world of possibility," says Carrie Wilkie, senior vice president of standards and technology at GS1 US.

2D barcodes encode substantially more information than their 1D counterparts. This enables them to link physical objects to a wide array of digital resources. For consumers, 2D barcodes can provide a wealth of product information, from food allergens, expiration dates, and safety recalls to detailed medication use instructions, coupons, and product offers. For businesses, 2D barcodes can enhance operational efficiencies, create traceability at the lot or item level, and drive new forms of customer engagement.

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Leslie Hand, Group Vice President, IDC Retail Insights

An array of **2D barcode types** supports the information needs of a variety of industries. The GS1 DataMatrix, for example, is used on medication or medical devices, encoding expiration dates, batch and lot numbers, and FDA National Drug Codes. The QR Code is familiar to consumers who have used one to open a website from their phone. Adding a **GS1 Digital Link** URI to a QR Code enables it to serve two purposes: as both a traditional barcode for supply chain operations, enabling tracking throughout the supply chain and price lookup at checkout, and also as a consumer-facing link to digital information, like expiry dates and serial numbers.

Regardless of type, however, all 2D barcodes require a business ecosystem backed by data. To capture new value from advanced barcodes, organizations must supply and manage clean, accurate, and interoperable data around their products and materials. For 2D barcodes to deliver on their potential, businesses will need to collaborate with partners, suppliers, and customers and commit to common data standards across the value chain.

Driving the demand for 2D barcodes

Shifting to 2D barcodes – and enabling the data ecosystems behind them – will require investment by business. Consumer engagement, compliance, and sustainability are among the many factors driving this transition.

Real-time consumer engagement: Today's customers want to feel connected to the brands they interact with. Information is a key element of that engagement and empowerment. "When I think about customer satisfaction," says Leslie Hand, group vice president for IDC Retail Insights, "I'm thinking about how I can provide more information that allows them to make better decisions about their own lives and the things they buy."

2D barcodes can help by connecting consumers to online content in real time. "If, by using a 2D barcode, you have the capability to connect to a consumer in a specific region, or a specific store, and you have the ability to provide information to that consumer about the specific product in their hand, that can be a really powerful consumer engagement tool," says Dan Hardy, director of customer operations for HanesBrands, Inc. "2D barcodes can bring brand and product connectivity directly to an individual consumer, and create an interaction that supports your brand message at an individual consumer/product level."

2D barcode use cases – present and future

Today's 2D barcodes harness the power of product data to enable a wide array of use cases across the supply chain. Read on to discover some innovative examples.

To reduce physical waste: Some retailers, says Carrie Wilkie, senior vice president of standards and technology at GS1 US, are using 2D barcodes to replace "the huge packet of cardboard tags that you see on outdoor items that tell you what the product is made of, what conditions it's meant to be used in, how you clean it, and how you store it. Being able to consolidate all of that information so it can be accessed from one QR code, and eliminating all of that paper, is a huge boost for sustainability and really exemplifies what a brand believes in."

To aid the visually impaired: Zapvision is a free mobile application designed to help brands provide product information to blind and partially sighted people. An Accessible QR code on product packaging allows app users to scan the product from an extended distance and receive audio information about it, while also functioning as a standard 2D barcode.

To fight theft: Integrating 2D barcodes and Radio Frequency Identification (RFID) tags with security systems can trigger an alarm if a customer exits a store with an item that has not been paid for. "By marrying together the 2D barcode with RFID technology, sales associates can scan the 2D barcode with a mobile device, automatically triggering a lookup file that indicates whether a serial number has been scanned," says Wilkie. Items that have not been scanned contain an active RFID tag that triggers an alarm, letting store associates know that a theft is in progress.

Emerging legislation: To improve supply chain transparency, the European Union is implementing new legislation that will require nearly all products sold in the region to have a Digital Product Passport – a digital record that provides important information about a product and its entire value chain, from materials used to environmental impact. Similarly, section 204 of the **FDA Food Safety Modernization Act (FSMA)** establishes recordkeeping requirements for certain foods to protect public health. For many organizations, 2D barcodes will play a crucial role in meeting these requirements by storing traceability data.

Greater sustainability: As organizations increasingly recognize the business value of **sustainability**, many are looking to 2D barcodes to help track their environmental impact. By making it easier to capture and share robust data about products and events, and to continue to add to the story over time, 2D barcodes can improve supply chain transparency and traceability. As a result, in addition to helping quantify a company's carbon footprint, they can help reduce waste and enable more efficient business operations, such as by providing insights about product movements for optimizing transportation routes.

Better traceability leads to better inventory management. "Sustainability comes down to managing your product well," says Hand. "If I can accurately forecast what I need to make or sell, then I can avoid producing the wrong items or sending them to the wrong places." The additional transparency 2D barcodes can provide, she adds, also "enables me to better perform carbon tracking and reduce energy and water usage, and to measure these metrics against my sustainability targets."

A field guide to 2D barcodes

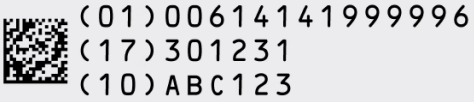
2D barcodes encode more information than their 1D equivalents by storing data in a grid or matrix pattern.

QR Code barcode

QR Codes are commonly used to encode a URL and are familiar to consumers who may have scanned them to access web pages, menus, sign-up forms, and other information online. QR Codes can also contain product identifiers and other data that make them scannable at checkout.

Data Matrix barcode

Data Matrix barcodes can convey a great deal of information compactly, and thus are often used to mark small items. The GS1 Digital Link format allows Data Matrix barcodes to encode URLs, but unlike QR Codes, they are not natively scanned by all devices to connect to the web. For use cases in which a purpose-driven app is appropriate, Data Matrix barcodes may be used.



GS1 DataMatrix barcode

The barcode type primarily used in health care, GS1 DataMatrix is similar to Data Matrix, but lacks the ability to support a GS1 Digital Link.

Source: Compiled by MIT Technology Review Insights, based on data and images by GS1 US, 2024

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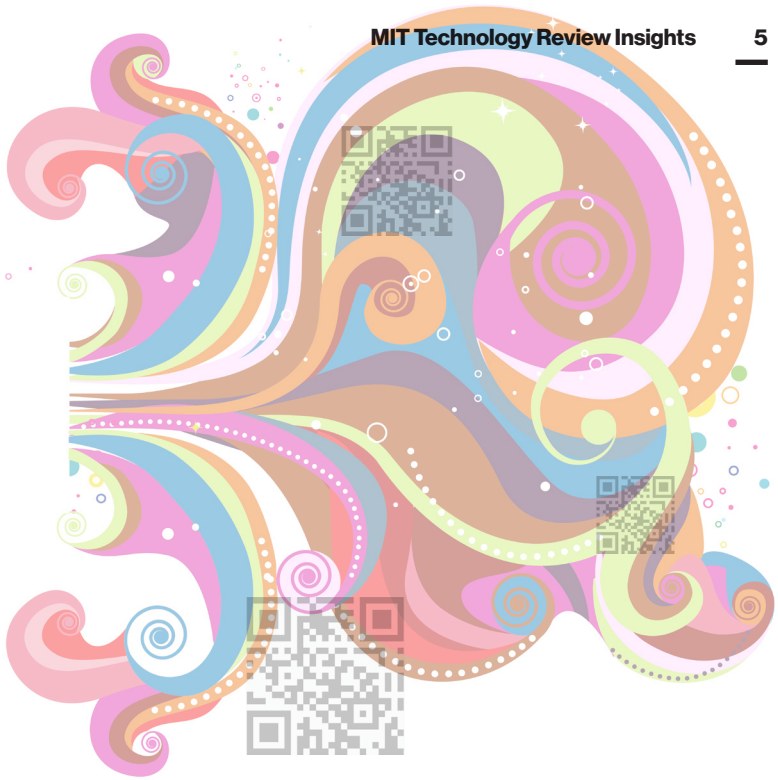

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Businesses increasingly understand that a company's commitment to sustainability can increase consumer trust, and 2D barcodes can also help by relaying sustainability data to the customer. At Hanes, Hardy is exploring using the technology to provide more detailed sustainability information directly to consumers. "I'm interested in how we can utilize 2D to help facilitate more granular traceability, helping us to provide visibility and linkage to product production components throughout our supply chain," he says. Currently, Hanes provides information on its website about its sustainability efforts – "a broad-based view of our supply chain and where components come from," says Hardy. With 2D barcodes, however, that information could become far more granular and product-specific.

Improved safety and public health: By enhancing product traceability and including more precise product data, 2D barcodes can help keep the public safe. Use cases range from including expiration dates on medication to aiding in vaccine distribution via real-time updates on inventory levels.

Industry initiatives: Recognizing the necessity of providing enhanced product information, the retail industry has launched an initiative to transition point-of-sale (POS) and point-of-care (POC) scanners to be capable of reading both traditional barcodes and 2D barcodes by the end of 2027. Referred to as **Sunrise 2027**, the initiative is well underway, and global in scope, with 2D barcode technology being tested in more than 48 countries so far.

Data practices and ecosystems essential to success

As reasons to invest in 2D barcodes multiply, organizations must establish the data practices and ecosystems that will support them. Here are some actions savvy businesses can take to prepare their data foundations today.

Determine what data your barcode should carry. Different types of barcodes encode different types of information, so brands need to identify what data they want to share to determine the best 2D barcode for their business. A QR Code barcode containing a GS1 Digital Link URI, for example, can turn a product's packaging into a web-friendly gateway to product information and online offers. A GS1 DataMatrix barcode, alternatively, is specifically designed to support the health-care industry and might encode medication expiration dates, dosage instructions, and a batch number.

Ensure end-to-end system integration for your use cases. No system is an island. Wilkie offers an example of a grocery store that uses a POS system to flag recalled items at checkout so that customers don't inadvertently purchase them. In this case, she says,

retailers must update their front-end and back-end systems to logically link related events. "There are front-end changes that may be required for scanners and hardware systems," says Wilkie. "There are firmware and software updates that may be required so that recalled items are flagged at point of sale, and back-end changes to catalog systems to uphold these logic rules."

Embrace data standards for richer consumer experiences. GS1 identifiers, such as the **Global Trade Item Number® (GTIN®)**, for example, provide a common global language for identifying, capturing, and sharing key information about products – a critical capability for managing the supply chain. GS1 Digital Link allows organizations to encode identifiers into a URL in a standardized way.

"You can't get it wrong when you use a standard," says Dominique Guinard, vice president of innovation for Digimarc. "The use of standards allows inter-company and even vastly different companies to communicate and exchange data." He gives the example of the **Electronic Product Code Information Services (EPCIS)** standard, used to track events as a product travels through the supply chain – its origins, its shipment, and its chain of custody. When accessed via a 2D barcode, this data could allow for highly detailed item traceability.

Create an industry-wide ecosystem, supported by standards. Businesses must improve data sharing and the interchange of information across their industries and value chains, and standards are the common language for this collaboration. "It takes coordination between players in the supply chain: producers, brands, sellers," says Hand. "There is a lot of work to do to participate in this ecosystem. Some of that work has to do with preparing their internal systems for managing a larger, more granular set of data, which might be utilized or produced by their ERP systems, manufacturing systems, selling systems, and ecommerce systems."

Third-party expertise can give businesses a boost into the 2D barcode ecosystem. At Hanes, says Hardy, "We realized that sophisticated supplier partners play a critical role to help us in this journey – to help us print the 2D barcode on our packages and to encode the correct data into the barcodes so that 2D performs as expected, and in compliance with GS1 Digital Link."

Prepare for batch and item tracking. Despite the increasing need for product identification, Guinard says "most businesses today don't have an item-level tracking or a batch-level tracking of their products." That's a missed opportunity, as tracking individual items or lots is an excellent way to precisely monitor and manage products throughout their lifecycle. This allows businesses to trace the origin, production, and distribution of every item they handle, enabling quality control, regulatory compliance, and improved operational efficiency.

2D barcodes with GS1 Digital Link, Guinard adds, promise to change this by providing companies "with an opportunity to add more data than in a 1D barcode, such as a serial number or a batch number, which can lead to new optimizations and use cases. There's a real chance for businesses to up their game and start achieving batch tracking and serial tracking."

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Enhance and augment product data for use in 2D barcodes. Today's organizations should use 2D barcodes for more than a simple redirect to a website. "If all you do is drive consumers to an online experience that gives them exactly what they have on the physical package – or even less – it isn't compelling," says Guinard. "Companies connect with consumers when they provide them with useful information that they don't already have on-pack. With 2D barcodes, brands can enhance and augment on-pack product data to deliver value to consumers." This will require companies to ensure that their product data is as complete, accurate, and relevant as possible.

Building the right data practices and ecosystems will prepare organizations for adoption of 2D barcodes, and brands that are prepared to supply and manage clean, accurate, interoperable data about every product and material they handle will be best prepared to make innovative use of them.

Most importantly, as today's consumers look for more engaging, personalized, and transparent interactions with brands, 2D barcodes stand ready to enable a people-centered shift. "When you and I see a 1D barcode today, there's nothing we can do with it. It's centered around just the supply chain, not the people," says Guinard. "Mobile phones can read 2D codes containing web addresses, so when you transform a 1D to a 2D barcode containing a GS1 Digital Link, brands can deliver all kinds of dynamic content and services to users via a single on-pack code."

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Dominique Guinard, Vice President of Innovation, Digimarc

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insights@technologyreview.com