Beyond the Barcode: Digimarc Makes Retail Operations Safer and More Profitable

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Introduction

In “Powering the Future of Retail”, GS1 US described the case for migration from the Universal Product Code (UPC) to support increased demands for product information, traceability, and authentication in ways that do not impede checkout, which was the original focus of the UPC symbol. Their research indicated an industry-wide desire for more data on packages “cluttered with proprietary barcodes.”

The UPC symbol has played a central role in retail for nearly 50 years. The data capacity and form factor of the symbol limits its ability to support modern requirements for automatic identification (“Auto ID”). Digimarc has developed a successor data carrier (“Digimarc Barcode”) that addresses these limitations and delivers unprecedented ease of use, reliability and efficiency in retail applications relying on Auto ID. Market development for Digimarc Barcode began with a core value of the UPC symbol: supporting checkout. The data carrier simplifies and speeds up all forms of checkout, including cashier-assisted checkout (“point of sale”, or “POS”), self-checkout (“SCO”), and in-aisle checkout by consumers, associates and contract shoppers. It does so through a unique technological breakthrough that encodes data in ways that are generally imperceptible to people, permitting the carrier to be repeated many times over the surface of the package—no more searching for the barcode!

Digimarc Barcode’s superior performance results from its massive mathematical and graphical redundancy. This innovation will result in the eventual elimination of the UPC symbol and other visible symbols used for automatic identification. Changes in retail due to the Covid-19 coronavirus pandemic have made its value more evident and compelling. The goals of this whitepaper are to:

- Discuss lessons from the pandemic concerning the role of automatic identification in retail,
- Summarize findings of the GS1 report on potential successors to the UPC symbol,
- Provide a technical description of Digimarc Barcode,
- Describe the range of applications Digimarc Barcode supports,

2 We use the term UPC symbol to encompass EAN/UPC barcodes. See https://www.gs1.org/standards/barcodes/ean-upc
3 “Powering the Future of Retail,” page 3.
https://www.digimarc.com/resources/forrester-study
• Summarize the state of market development for Digimarc Barcode,
• Compare Digimarc Barcode’s capabilities with other established data carriers,
• Help the retail industry to make judgments about how it might transition beyond the UPC symbol as the backbone of automatic identification.

Lessons from the Coronavirus Pandemic about Importance of Automatic Identification

Retail operations have been dramatically affected by the pandemic. Supermarkets have adopted many new safety procedures: checking employee temperatures, enforcing checkout queue spacing, and dictating pre-determined paths to walk through the store, among other things. Some of these changes are likely to endure, as will associated costs. Social distancing naturally reduces the density of shoppers. Longer lines at checkout consume more space than before. Fewer shoppers per square foot leads to lower sales per square foot, making efficiency increasingly crucial to profitable operations. Digimarc Barcode makes checkout faster and easier for everyone, especially consumers. Simplifying scanning facilitates more consumer in-aisle and SCO checkout, reducing person-to-person interaction and unnecessary handling of packages consistent with epidemiological guidelines.

People are worried that they may get sick from a surface that has the virus on it. According to McKinsey, “The fight to defeat COVID-19 could also start to affect packaging choices, favoring packaging designs and substrates that demonstrably address hygiene and consumer-safety concerns—for example, those that minimize the possibility of the virus’s survival on the packaging surface.” Digimarc can help here, too, by eliminating the need for associates and consumers to manipulate packages to locate and scan traditional barcodes that are typically on the back or bottom of packages. With Digimarc applied to the front of packages, associates can manage shelves with less touching of packages and robots can accurately identify products.

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5 https://www.wsj.com/articles/safety-advice-if-you-must-visit-the-grocery-store-11585336520
8 https://www.usatoday.com/story/money/2020/04/03/coronavirus-limits-walmart-counting-number-shoppers/2944542001/
9 https://www.huffingtonpost.com/2020/04/03/walmart-counting-number-shoppers/coronavirus/6798907
without human intervention. A visible barcode on the back or bottom of packages does not help these activities.

More people are shopping from home. Mixed-use retail space, sometimes referred to as hybrid warehousing, has expanded with the growth in online grocery ordering. Efficiency is front and center here, again, with the importance of customer satisfaction and profitability of efficient pick and pack to maximize sales while minimizing interference with shoppers in the stores.

Pandemics are not the only health risk that grocers need to manage. There are also growing global threats to health, safety, and well-being in food safety and the use of plastics. Retailers and brand owners can mitigate these threats as well through more reliable and efficient Auto ID of product and packaging lifecycles.

The UPC revolutionized the global supply chain 45 years ago. The need to move beyond the UPC symbol is growing more urgent. There is a need for more data capacity, but more capacity alone does not address the pressing needs of retailers to manage profoundly important health and safety risks. The form factor of traditional barcodes is a growing problem in modern retail’s quest for ease of use, efficiency, and reliability. The need for change is most urgent in grocery retail. Digimarc Barcode is the optimal successor to the UPC symbol as the bedrock of the global supply chain.

Findings of “Powering the Future of Retail” Report

The GS1 US commissioned the report, “Powering the Future of Retail,” which presented findings from mid-2018 interviews with Tier 1 retailers ($1B+), consumer brand owners, solution providers, academic institutions, and industry associations concerning the adequacy of the traditional barcode to serve evolving requirements for Auto ID. The findings indicated that the industry believed that traditional UPC barcodes do not adequately address modern Auto ID needs. The report opened with “the case for change”:

Consumer and retailer demands for product information (from ingredients to freshness to reviews), traceability, authentication, and the seamless facilitation of checkout and returns go well beyond the original price look-up function of the current U.P.C.

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12 “Powering the Future of Retail,” see figure 1 for companies interviewed.
13 Id., page 4.
14 Id., page 3.
The study focused on data capacity limitations of the UPC, ignoring significant effects on ease of use, reliability, and efficiency due to its nature as a non-human discernable discrete logic symbol typically printed once on a package in a specified location, typically printed on the lower right side of the back or bottom of the package. The report discussed the relative effectiveness of proposed successors to the UPC symbol. Key findings from the 2018 survey included:

- 82 percent of retailers and 92 percent of brand owners support transitioning from the traditional 1D barcode to extended linear formats like GS1 DataBar, 2D barcodes (QR Code, Data Matrix, and Dot Code), digital watermarks (Digimarc), or RFID in the next 1-5 years;
- Although 69 percent of retailers are using scanners that cannot read 2D barcodes; 84 percent are evaluating or planning to move to more advanced Point-of-sale (POS) technology that can scan 1D and 2D barcodes, and digital watermarks;
- 60 percent of Tier 1 retailers plan to upgrade their POS infrastructure in the next 18-24 months (by mid-2020);
- The UPC symbol does not carry enough data to meet modern demand; and
- Most of this is due to consumer desire to get more data and information from products.

Nineteen percent of respondents identified Digimarc as the likely successor, demonstrating substantial awareness and appreciation for Digimarc’s new data carrier after only a few years of retail market development. A recently-published addendum reported findings from additional interviews in August and September 2019 with Tier 2 and 3 retailers and brand owners that indicated heightened concern about UPC support for traceability, including regulatory compliance, provenance and food safety.

Digimarc Barcode

A great deal of progress has been made since the date of the survey, including basic technology improvements, elaboration of the enabling ecosystem, growing adoption by retailers and consumer brand owners, significant growth in the supplier community, enablement of more applications, and a high level of

15 Id., figure 9.
16 Id., page 12.
industry awareness. There has also been growing evidence that increasing the capacity of the carrier alone is not enough, especially with the effects of the pandemic described above.

Digimarc is a pioneer in the automatic identification of everyday objects, including product packaging and labels, and has a 25-year history in high-security applications for government customers. Digimarc can infuse digital identities into virtually any media, including print, images and audio. Digimarc has created a software and services platform that supports a broad swath of applications benefiting retailers and consumer brand owners, national and state government agencies, and the media and entertainment industries.  

**Platform Description**

The Digimarc platform (the “Platform”) is comprised of software and services for putting data into media (“Identification”), extracting the data (“Discovery”), and ensuring quality (“Quality Management”) to improve performance and expand the reach of Auto ID. The focus of this essay is on packaging. It is essential to keep in mind, however, that Digimarc can enhance all kinds of media. Thus, unlike all other successors considered in the GS1 US report, Digimarc Barcode can support the Auto ID requirements of enterprise-wide digital transformation for retailers and brand owners.

![Fig. 1. Digimarc Platform](image)


18 [https://www.digimarc.com/about/digimarc-platform](https://www.digimarc.com/about/digimarc-platform)
Digimarc Barcode provides unique data redundancy, with the code typically repeated hundreds of times without visibly altering the design aesthetics of the package artwork. The data can be detected by enabled point of sale scanners, industrial scanning devices, and mobile phones, making it easier and faster to scan and identify products. Digimarc Barcode can be used to replace, complement, or supplement UPC symbols, extended 1D Barcodes, 2D Barcodes, RFID, and image recognition.

The data is typically infused into package designs via imperceptible changes in color artwork printed using traditional offset processes by leading premedia and packaging suppliers, including Schawk!, SGScoc, Sun, Wipak, Westrock, and Equator. Like conventional barcodes, Digimarc Barcode can be applied in ink with no significant additional printing cost. All popular forms of analog and digital printing are supported. Digimarc can also be applied to substrates via thermoforming, mold design, laser engraving, or 3D printing.

Identification tools create a two-dimensional (2D) data carrier with higher data capacity than the UPC symbol. Static and variable data (“serialization”) are supported using GS1 standards wherever applicable. Like matrix symbols, such as QR Code and Data Matrix, Digimarc Barcode encodes data into a 2D matrix of cells called a tile; however, there are many essential differences in technical construction and features that are discussed in detail later in this whitepaper.

The Discovery layer of the Platform enables many applications for Enhanced media. Digimarc Discover software19 is incorporated by leading POS scanner manufacturers including Datalogic, NCR, Zebra, Honeywell, and other machine vision manufacturers to decode Digimarc Barcode. Seven of the top ten scanner vendors in the world are incorporating Digimarc Discover software into their products. Digimarc Barcode-enabled scanners are deployed at leading retailers in the US and Europe. Discover software has also been integrated into applications for smartphones, tablets, and other mobile devices. Digimarc Barcode decoding has been built into Microsoft’s Windows 10 Operating System to facilitate application development. Toshiba Global Commerce has added support for Digimarc Barcode to their POS operating system, TCx Sky, enabling retailers to better measure and apply transaction logic to important functions of the software.

The software and services that make up the Platform do much more than traditional barcodes do. Importantly and uniquely, Digimarc Barcode performs in harmony with the UPC, creating a seamless transition path from this trusted foundation of global commerce.

19 In conventional barcode terminology, this is decoder software.
**Technical Characteristics of Digimarc Barcode**

Existing 1D and 2D codes are designed using a fixed mapping of information (bits) to a fixed pattern of high-contrast graphical elements (black and white lines for 1D and black & white modules for 2D). Decoding is only possible at or near 100% recovery of the finder pattern modules, requiring that they be where expected and formed as expected (rigid requirements on spacing, edges, etc.). Digimarc Barcode is constructed differently, using spread-spectrum, a technology commonly used in telecommunications, including GPS, cell phones, WiFi, and RFID. The signaling difference is analogous to AM radio compared to WiFi, but the practical difference is much more significant. AM radio and WiFi are human-imperceptible signals, while existing barcodes are highly visible and Digimarc is not. Therefore, a closer analogy might be comparing billboards to WiFi.

These technical differences allow Digimarc Barcode to intertwine a signaling element required to find and orient the tile with another signal that carries the information itself. The result is a data carrier that is holographic (only a small piece is required to reconstruct the full signal) and decodable from portions of tiles on curved or wrinkled surfaces.

![Figure 2: Simplified (spatial domain only) mapping signaling elements from an existing UPC-A to a Digimarc Barcode tile.](image)

There is intense competition for package real estate from increasing regulatory and consumer demands for on-pack information. Digimarc Barcode can be applied to packaging in ways that are generally imperceptible to users in normal use; or in more obvious ways to provide a call to action, as in the case of thermal printed labels. This flexibility provides unique and important advantages. In the general case,
package designs will no longer require space reserved for a highly visible black and white striped symbol, an artifact of the state of art computer technology 50 years ago. Digimarc Barcode is an integral element of package design, not a discrete “logic symbol” overtly placed in a space reserved for it that breaks with design.

Each Digimarc Barcode tile redundantly encodes the full data payload. A tile is approximately the size of a thumbnail. The general imperceptibility allows massive redundancy, both mathematically within a tile and graphically by repeating tiles. For example, a 4.75 inch x 5.5 inch x 2.5 inch package has room for approximately 100 repetitions of Digimarc Barcode. The holographic nature of Digimarc Barcode enables it to be inserted in one or more colors, or in a sparse pattern where there is no image information, using a variety of print, embossing, and engraving marking methods. The sparse binary pattern variant of Digimarc Barcode provides additional savings in consumable costs while enabling a wide variety of marking technologies.

Fig. 3. On a Digmarc Barcode-enhanced package, GS1 information is massively repeated and spread in tiles shown as the orange grid pattern over the entire artwork.
The repetition of Digimarc Barcode tiles throughout the package artwork allows the decoder to reassemble the GTIN with only a random sampling of the package; for example, a cereal box decodes with as little as 0.2% of the total area sampled. A package enhanced with Digimarc Barcode is robust to geometric distortion (curves, wrinkles, etc.), occlusions (damage to the package including smudges and tears), and eliminates the need to orient a 2D barcode towards the scanner.

The capacity of Digimarc Barcode has doubled since its introduction five years ago and will continue to increase over time to broaden application support. While capacity has doubled, the size of the Digimarc Barcode tile has gotten smaller, increasing the number of Digimarc Barcodes contained within a given area by four times, adding to the benefits of massive redundancy. Conscientious adherence to the rule of parsimony can foster greater utility and efficiency without material increases in capacity, as Digimarc has
demonstrated in its support for the GS1 Digital Link standard\(^{20}\) for mobile web lookup of product information, described in more detail below.\(^{21}\)

**Retail and Consumer Brand Owner Adoption**

The use of Digimarc Barcode in retail began with Wegmans in 2015.\(^{22}\) The first Digimarc-enhanced package was shown at the National Retail Federation Big Show in January 2015. In 2019, Walmart entered into a multi-year contract for the use of Digimarc\(^ {23}\) in its private brand packaging and fresh product labels. Later in the year, Walmart expanded the use of the Platform to provide an enhanced shopping experience in its Christmas Toy Catalog. Netto Marken-Discount, a major European retailer with more than 4,200 stores and 21 million customers, also came on board, enhancing more than two thousand private brand products in the first year of production. Digimarc’s work with Netto was recognized by EHI Retail Institute’s “Top Supplier Retail 2020” award at EuroShop, the world's largest trade fair for retail investment needs.\(^ {24}\)

![Fig. 5. Top Supplier Retail 2020 award](image)

Netto Marken-Discount was also recognized, awarded “Best Instore Solution” for its Connected Packaging made possible by Digimarc Barcode. A growing number of global consumer brand owners\(^ {25}\) are adopting as

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21 GS1 Digital Link specifies a standard format for a web URL, GS1 GTIN and several GS1 Application Identifiers in a standardized syntax. This initiative helps to support many types of business-to-business and business-to-consumer information needs.


well, supported by an expanding global network of leading packaging design and printing suppliers, and retail scale printer and barcode scanning manufacturers.\textsuperscript{26}

There are over 600 suppliers in the rapidly expanding Digimarc ecosystem:

**Expanding Global Supplier Network**

- 600+ Supplier Network
  - Numerous pre-media and packaging solutions leaders
  - Top 7 AIDC suppliers
- Six of Top 11 Global Consumer Brands
- Three of Top 10 Retailers
- Thousands of Printers

![Supplier Map](image)

*Fig. 6. Digimarc’s expanding Global Supplier Network*

**Potential Successors to the UPC**

**Key Characteristics**

The firm conducting the research for the GS1 US report framed the problem:

“The need for more data is already evident on packages cluttered with proprietary barcodes to drive consumer engagement and enable more advanced use cases for retail, brand management, and supply chain. A single barcode symbology that contains all of this information, in addition to product identification, could provide benefits for every stakeholder along the supply chain.”\textsuperscript{27}

\textsuperscript{26} [https://www.digimarc.com/partner-map/](https://www.digimarc.com/partner-map/)

\textsuperscript{27} “Powering the Future of Retail,” page 3.
The next generation of the barcode is presumed to be more “data-rich” to “meet more robust data needs”. This framing of the problem, focused on only one inadequacy of the UPC – data capacity – ignores the crucial limitations of the data carrier’s form factor, which is one of the reasons for the proliferation of codes on packages. This narrow framing is evident in Figure 14 of the report, a decision tree for data carrier selection. The first decision in the tree is “need to capture additional data beyond GTIN” – yes/no. The remaining decisions in the tree relate to how much data is needed to satisfy each use case. Thus, the notion of a single location-specific barcode successor to the UPC is an artifact of the design of the research, not a finding from the survey, nor a necessity.

Within this context, a chart summarizing findings from the mid-2018 interviews highlighted the likely candidates to succeed the UPC at that time:

QR Code topped the list. The authors noted the advantage that QR Code can be natively read by leading smartphone operating systems and that Data Matrix is popular in some industries because it can be etched or printed on smaller items. DotCode is a 2D pattern of dots in limited use on some cigarette and pharmaceutical packages.

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28 Id., page 15.
29 Standardized as AIM DotCode Rev 3.0. Public domain. Used to track individual cigarette and pharmaceutical packages.
Beyond the Barcode: Digimarc Makes Retail Operations Safer and More Profitable

pharmaceutical packages. The survey firm attributed the primary motivation for choosing alternatives to the UPC to be enabling “data-rich capabilities,” managing fresh and prepared foods, serialization, SmartLabel, and traceability.30

The study ignored many problems associated with location-specific symbols in addressing modern needs. It also ignored the layering of when and how identity is created and added to primary and secondary packaging throughout the typical package lifecycle. For instance, traceability is called out in the report as an important goal of the transition beyond the UPC. A single symbol is problematic, as noted in the GS1 Global Traceability Standard:

Batch/lot-level or serialized identification are dynamic data and therefore cannot be included in the artwork of the packaging. This means that adding dynamic data in a barcode will have an impact on printing and packaging needs.31

The report overlooked the need for automatic identification at the component level in design and manufacturing through the supply-chain to retail, consumption, and recycling. There are many other inadequacies of the UPC that are not addressed simply by replacing it with another longer or two-dimensional version of a visible barcode. There was no mention of the common practice in Europe of up to six barcodes per package to speed up checkout. Adding capacity to each symbol would do nothing to address the critical need for fast, easy, accurate checkout, whether cashier-assisted, self-checkout at front of store or in-aisle, or third-party shopping (e.g., Instacart). On the other hand, Digimarc obviates the multiple UPC symbol practice popularized in Europe with its massive graphical redundancy. Robots for shelf management cannot pick up a package and turn it to read the barcode.32

The location-specific nature of the UPC causes consumers, associates, and contract shoppers to waste precious time and engage in excessive handling to read barcodes. There are many other examples of limitations of the traditional barcode that are not addressed by extended 1D, QR Code, or other 2D codes that are considered as successors to the UPC. All these data carriers suffer from the same problems: users must find the symbol to scan it, and it must be in good condition.

30 “Powering the Future of Retail,” page 9.
The report does not describe with particularity the data requirements that are not satisfied by the UPC. Appendix 2 of the GS1 report identified several “emerging benefits of alternative barcode symbology: inventory accuracy, improved consumer engagement, product authenticity, traceability, freshness/waste prevention, and returns management.” Digimarc Barcode supports GS1 Application Identifiers (AIs) for packaging and labels that provide these benefits. The relevant data can be concatenated in a single Digimarc code. Alternatively, with Digimarc Barcode, different areas of a package can be seamlessly encoded with different or complementary identifiers.

Digimarc Barcode’s unique value is that it is designed to be repeated many times over the surface of a package in peaceful coexistence with other design elements and any legacy barcodes. No other printed data carrier has this quality. The size of tiles and the number of potential repetitions in a package design is related to capacity. Digimarc adheres to a rule of parsimony in payload definition. Limiting data in the payload only to what is necessary allows for more repetition; thus, easier access, more efficiency, robustness, and reliability in the scanning process. Parsimony is an important principle in visible carriers as well: more data complicates quality management and increases symbol size.

There will be an enduring need for more than one symbol on a package, whether due to reliability constraints, security, privacy, access control, legacy scanner infrastructure, government product information regulation, etc. Witness the typical shipping label: it requires that symbols (data carriers) coexist and can be overlaid in the same visual space as other symbols without impacting performance. Digimarc Discover software contemplates the coexistence of multiple indicia of identity for the foreseeable future, including the data carriers referenced in the GS1 report. It is designed to provide users with seamless multi-modal identification by analyzing scenes, intrinsic and discrete data in the scene, as well as contextual clues, to deliver an optimal identification of the object. One of the most promising features of Digimarc Barcode is the opportunity to reduce and eventually eliminate the multiplicity of discrete 1D and 2D symbols on packages that have become commonplace.

**Limitations in Common for 1D and 2D Barcodes**

The view that QR Code, Data Matrix, DotCode, or GS1 DataBar might become the successor to the UPC appears to be motivated solely by a desire for more data capacity. This would continue the practice of having the data carrier be represented in packaging design as a high contrast, square or rectangle filled with lines, squares or dots that does not contain information in a way people can understand. The new symbols would
be obtrusive, inconvenient and inefficient, presumably most often sheltered in the lower right corner of the back of a package or on the bottom. These symbols would compete for space with other uses. The report states they would appear only once, creating inefficiency associated with discovery and orientation of the package to scan it. The quality risk of a single symbol is vulnerable to wrinkles, crinkles, tears, smudges, inadequate contrast, and uneven surfaces that render it unreadable or inaccurate.

The visible 1D and 2D symbols identified in the survey do not remedy any of these deficiencies, nor do they remedy chronic performance problems. These alternatives cannot be read by retail robots unless they are moved to the front of package designs. The continuation of traditional symbol placement does nothing to improve shelf audit productivity and accuracy, consumer information gathering, and in-aisle checkout by store associates, contract shoppers, and consumers. None of these limitations are noted in the “limitations” section of the Data Carrier Options Table in the report.33

Digimarc’s unique data carrier is more reliable, accessible, and robust than the UPC, yet it does not need to displace it until the traditional symbol is no longer useful. In the meantime, scanning is improved on packages that have both. Digimarc provides increased data capacity, along with greater ease of use, greater reliability and robustness, and application to more materials and form factors than traditional barcodes or other proposed successors to the UPC. It delivers these advantages in a manner complementary with other symbols and does not compete for real estate with the symbols or other important visual qualities of packaging. These unique attributes extend support to a wider range of applications throughout the entire lifecycle of packaging and other objects with barcodes, without disrupting the artwork design.

QR Code was most often identified by survey respondents, which is not surprising since it has been in use for over 25 years. These codes are commonplace in China and Japan, less so in Europe and the US. QR Code’s advantage over UPC is data capacity, delivered across two geometric dimensions, supported by Reed Solomon error correction. However, it does not remedy the form factor disadvantages referred to above.

2D barcodes often have simultaneously too little and too much capacity: too little to provide meaningful information without network connectivity and too much capacity to uniquely identify the object in a reasonable amount of space, which is all that is necessary in networked environments. Most of the theoretical capacity of QR Codes has seldom been used in consumer products due to practical limitations of

33 “Powering the Future of Retail,” page 18.
print quality and physical size on packaging. The most common payload is a URL. The SmartLabel industry initiative promoted QR Code based on observations and assumptions regarding its maturity and the familiarity of consumers with the codes similar to those described in the GS1 US report. Some brand owners have added QR Codes to packaging for this purpose. Consumer engagement has been illusory and unremarkable.

Another proposed use of QR Code is as a carrier of GS1 identifiers to support both product identification for supply chain applications and a link to online material for consumer and business partner interactions according to the GS1 Digital Link syntax. The exemplary syntax has large data requirements; larger, for instance, than would fit in SmartLabel-compliant QR Codes on packaging today. While the latest version of the Digital Link specification provides a means for data compaction, important practical limitations posed by these data requirements have not been addressed. The GS1 General Specifications have not been updated to establish standards for scan reliability that impact QR Code size for this application. Currently, GS1 recommends a target QR Code module size of at least 0.02 inch. This recommendation is not for use at POS. More stringent reliability requirements of POS would increase the size of the code, colliding with package design and text elements. The SmartLabel program recommended a ‘maximum number of encoded characters’ at 26 characters in a 0.5 inch by 0.5 inch QR Code.

An exemplary Digital Link payload with only a GTIN, for example “https://id.gs1.org/01/12345678901231”, is 36 characters. The core premise of the GS1 US report is the need to carry additional data beyond just the GTIN. This would further increase the length of the data string. For example, the same GTIN with a Serial Number value would be “https://id.gs1.org/01/12345678901231/21/1234567890” or 50 characters. In order to get this much data into a single QR Code, the symbol would need to be significantly larger than the recommended SmartLabel size or have an unacceptably small X-dimension (module size). If the code is intended to serve mission-critical applications, error correction would need to be more rigorous than level M proposed for SmartLabel for marketing purposes. With the new compaction methods under development, the minimum size for a QR Code printed using the quality standard for enterprise applications (error

36 SmartLabel Implementation Guide 1.5 v2 revisions, released December 2017
37 The GS1 General Specifications require error correction level H for QR Codes used for a traceability system for tobacco products. This requirement underscores the need for more reliable encoding for supply chain applications. See 5.10.3.12 of the GS1 General Specifications, Release 20.0, January 2020, page 350. https://www.gs1.org/sites/default/files/docs/barcodes/GS1_General_Specifications.pdf
correction level H), would be 0.9 by 0.9 inches\textsuperscript{38}, imposing a daunting consumption of package real estate in addition to the UPC as shown in Fig. 8. Even at this increased error correction, Digimarc Barcode’s redundancy results in a far more robust and reliable carrier.

Fig. 8. Adding a QR Code in addition to a UPC barcode consumes more package area and conflicts with package design elements (here, overlapping ingredients).

\textsuperscript{38} Compaction of the above GS1 Digital Link syntax according to the GS1 Digital Link specification yields at least 35 bytes. For the use case of POS/supply chain relying on a single QR Code, an error correction level of H is recommended, which means the error correction allows for recovery of up to 30% data codeword errors. According to the GS1 General Specifications, the parameters of the QR Code required to carry this amount of information at level H are Version 5 (37 modules per side plus 8 for quiet zone), and module size of at least 0.02 inch, making the area of the QR Code 0.9 inch by 0.9 inch as shown in Fig. 8. In comparison, a Digimarc Barcode tile is 0.85 inch by 0.85 inch. A Digimarc Barcode tile has error resiliency of at least 30% for a single tile and that error resiliency grows by repeating tiles, as the decoder can accumulate data from other available tiles.
The rule of parsimony that guides the development of Digimarc Barcode applies to the implementation of Digital Link regardless of the data carrier. The GS1 Digital Link workgroup is building specifications to enable the use of federated resolvers to reduce the data requirements, enabling the data carrier to rely on back-end resolution to retrieve additional GS1 Identifiers and information as needed, following the lead of resolving infrastructure pioneered by Digimarc. The technology underpinning Digimarc Barcode, digital watermarks, is included in the Digital Link standard. Digimarc Barcode was the first symbology used to enable Digital Link functionality on a shipping product and did so without requiring changes to the POS infrastructure at the retailer (Datalogic scanners, Toshiba POS system, etc.).

![Digimarc Barcode with GS1 Digital Link](image)

Size and form factors are not the only problems with QR Codes. There are known legal and security risks; whereas, Digimarc provides a secure managed platform for brand owners, ensuring a quality experience for users, supported by a strong patent position and 20 years of trouble-free operation. The improved security from Digimarc Platform is especially important when addressing shrink due to barcode swapping, counterfeit and gray market deterrence, and traceability.

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40 Bed & Bath, for example, was sued by a company that claimed patent infringement because the retailer put a QR Code on their ads. [http://www.qrcodepress.com/qr-code-lawsuit-aimed-bath-body-works-patent-infringement/8532928/](http://www.qrcodepress.com/qr-code-lawsuit-aimed-bath-body-works-patent-infringement/8532928/)
A transition to greater use of localized, visible 2D barcodes would not accommodate new modes of shopping and store operations. The isolated placement of the proposed alternative 1D and 2D symbols means that consumers, store associates, and Instacart shoppers would still have to pick up the product, turn it around, find the barcode on the back or bottom, and point and scan to get information, do price checks and other shelf management tasks, and in-aisle checkout. Robots checking on-shelf availability, planogram compliance, and pricing, cannot flip products to look for barcodes. Store associates would continue to waste precious time doing what the robots cannot do. Cashiers and self-checkout customers would still be required to spin and flip packaging, maneuvers that we all observe cashiers doing routinely. Cashiers would still suffer fatigue and injury from chronic package manipulations. Searching for barcodes would still create health and safety risks for cashiers and consumers at checkout. These challenges would still foster the opportunistic crime of frustrated cashiers and shoppers.

Digimarc also works better than 2D barcodes in the early stages of product lifecycles. For instance, in parts matching, Digimarc has demonstrated superior performance over Data Matrix in a collaboration with Procter & Gamble. The superiority of Digimarc’s data-carrying capacity extends to the entire supply chain and facilitates unification with demand cycles, as described in more detail later.

**RFID**

Radio Frequency Identification (RFID) uses electromagnetic fields to automatically identify tags attached to objects. Each tag has a radio transponder, receiver, and transmitter. Identification is not limited to line of sight like 1D and 2D printed codes and Digimarc Barcode. The first modern version of RFID was patented in 1973, the same year as the UPC’s first commercial use.

Over the years, RFID has been used in access management; tracking goods, persons, and animals; toll collection; contactless payment; travel documents; luggage tracking; and apparel. Retail use at the item level has primarily been limited to hang tags for apparel merchandise to improve inventory management and protect against theft. RFID tags require radio signal readers. Readers are not universally available, for instance, in POS or smartphones. The radio transmission nature of RFID tags that cannot be easily removed

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43 [https://www.digimarc.com/customers/procter-gamble](https://www.digimarc.com/customers/procter-gamble)
from products or do not contain a kill mechanism has created privacy concerns. Hang tags are typically removed and discarded shortly after purchase.

There are environmental costs, too. RFID tags contain metals that can be difficult to separate for recycling purposes. For instance, aluminum antennas on glass containers can reduce the amount and quality of recycled glass if they cannot be separated during the process. In the paper waste stream, laminated copper foil antennas do not readily break down.\footnote{There are many open questions regarding the impact on the recycling of RFID tags at the item level. A 2012 study by Rand Corporation, funded by the European Commission highlighted these unresolved matters affecting broader use of the technology:}

- Understanding where value is created and where it is captured in the value chain, which can, in turn, provide a better understanding of where investments are likely to be made and how they might be influenced by policy
- Understanding and controlling the effects of RFID tags on waste, because the material content of RFID tags can affect the recovery of other materials
- Developing technical requirements for RFID to become effective for end of life
- Addressing privacy and security concerns
- Mandating the tag-based or online accessibility of environmental information

The relations between RFID and waste are still in their infancy. There is a long way to go to build necessary awareness; assess the technical, legal and commercial feasibility of new approaches; and stimulate interest throughout the value chain.\footnote{RFID has not been a practical concern for plastic recycling because it has not been used much at the item level, leaving the concerns expressed above largely unresolved.}

RFID has not been a practical concern for plastic recycling because it has not been used much at the item level, leaving the concerns expressed above largely unresolved.

The lack of a line-of-sight requirement is the primary benefit of RFID. This benefit is balanced against limitations and risks associated with the cost of tags and readers, the complexity of attaching tags to objects,
availability of readers, difficulties in recycling, event filtering issues (e.g., it is often difficult to tell which item was read), and security and privacy concerns, application by application. Due to these limitations and risks, at the item level of consumer products, RFID is generally viewed as complementary to 1D and 2D codes rather than a replacement.

Addressing 21st Century Demand and Supply Chain Needs

The report identified shared industry objectives in moving beyond the UPC:

- Streamline operations for both retailers and brand owners;
- Leverage a single identifier to enable accurate traceability, authenticity, and effective returns management;
- Reduce the complexity of multiple labels or codes on a single product – and overhead that it creates; and
- Seamlessly share and use product data, often captured by scanning the data carrier, within operations and with trading partners.

The Digimarc Barcode satisfies these objectives. The report further identified “universal priorities” of achieving a better understanding of consumer buying habits and improving accuracy at point of sale. It goes on to say: “The ultimate use case for change comes from the need to provide data while minimizing disruption at the POS.” The initial focus of Digimarc was on fast, easy checkout and facilitating consumer engagement. Use has expanded to numerous applications that improve ease of access, and quality of data, throughout the product lifecycle.
Digimarc has been seamlessly integrated into leading retail scanners and POS systems, meeting the goal of improving accuracy at POS, while also improving speed, efficiency, and safety.\textsuperscript{47} Digimarc’s POS benefits are operational at Walmart, Wegmans, Netto, and other leading retailers. Implementation of multiple visible bar code symbols could prove confusing to cashiers and shoppers. Details of a transition to these codes at POS have not been worked out.

\textsuperscript{47} https://www.digimarc.com/docs/default-source/default-document-library/benefitsofconnectedpackagingforretailers.pdf?sfvrsn=a1c7fc37_6
Digimarc has demonstrated its superiority over other potential successors to the UPC, in reliability, efficiency, and ease of use; the many types of media that it can be applied to, and the range of applications supported, including:

Manufacturing
- A recent study indicated the superiority of Digimarc Barcode in solving the problem of mismatched and incorrect manufacturing parts labeling.\(^{48}\)
- Reducing manufacturing waste resulting from improper labeling.\(^{49}\)

Supply Chain
- Limiting waste due to overbroad recalls by enabling Track & Trace.\(^{50}\)
- Streamlining warehouse and distribution.\(^{51}\)
- Reducing counterfeiting and gray market diversion by tracking inventory in transit.\(^{52}\)

Retail
- Market development of Digimarc Barcode began with a focus on fast, easy checkout and rapidly expanded to:\(^{53}\)
- Reducing fresh department waste,\(^{54}\)
- Reducing stock outage and identifying voids,\(^{55}\)
- Reducing front of store shrink,\(^{56}\)
- Protecting the health and welfare of customers and associates, and\(^{57}\)
- Providing consumer engagement in promotional displays.\(^{58}\)
- Providing enhanced consumer engagement with links to health information, user instructions, recipes, re-ordering and recycling information with a reliable digital identity.\(^{59}\)

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\(^{48}\) https://www.digimarc.com/customers/procter-gamble

\(^{49}\) https://www.digimarc.com/images/default-source/beyondtheupc/figure09.jpg

\(^{50}\) https://www.digimarc.com/images/default-source/beyondtheupc/figure10.jpg

\(^{51}\) https://www.digimarc.com/images/default-source/beyondtheupc/figure11.jpg

\(^{52}\) https://www.digimarc.com/images/default-source/beyondtheupc/figure12.jpg

\(^{53}\) https://www.digimarc.com/solutions/easy-checkout

\(^{54}\) https://www.digimarc.com/images/default-source/beyondtheupc/figure13.jpg


\(^{56}\) https://www.digimarc.com/images/default-source/beyondtheupc/figure15.jpg

\(^{57}\) https://www.digimarc.com/images/default-source/beyondtheupc/figure16.jpg

\(^{58}\) https://www.digimarc.com/images/default-source/beyondtheupc/figure17.jpg

\(^{59}\) https://www.digimarc.com/images/default-source/beyondtheupc/figure18.jpg
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Recycling

Digimarc also improves performance in the later stages of the product lifecycle, in some cases in an unprecedented fashion, revealing additional deficiencies with the UPC and 1D extended and 2D visible codes. The most obvious is the search for a way to mitigate the impending “single-use plastics Armageddon” endangering the planet. Digimarc has been identified as a potential means to improve recycling, making possible sortation by characteristics not previously identifiable in waste streams. Digimarc is collaborating with stakeholders in the HolyGrail 2.0 project, including Procter & Gamble, to speed up the transition to a Circular Economy for plastics by increasing the quantity and quality of recyclable material identification in waste management systems. The BBC News filmed Digimarc’s work in Europe with HolyGrail. There have been other important HolyGrail developments in recent months. The CPG industry has lauded Digimarc for its effectiveness in improving the sorting of plastics in waste sorting facilities, a critically important application for which 2D visible codes provide virtually no value.

Fostering an Efficient Transition

Industry-leading retailers, consumer brand owners, and their suppliers are adopting Digimarc to improve retail store operations, supply chain visibility, and consumer engagement. Digimarc is proving its value and reliability in retail operations, food safety and waste reduction, supply chain visibility, and plastics recycling, supporting the Circular Economy and health and well-being of everyone. Digimarc Barcode is helping to modernize supply chains need for timely and accurate product data to drive real-time business, provide transparency to consumers, and improve product lifecycle management from design to recycling.

Transitioning to other potential successors to UPC would leave in place space-consuming location-specific black and white machine-readable codes. The new code would still be challenging to find and scan, and subject to common print quality problems. Moving from UPC to extended 1D or 2D barcodes would require the coexistence of at least two barcodes for many years, if not decades, while users and the detection

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60 [https://www.bing.com/search?q=frontline+plastics+wars&docid=13981947752741&mid=1610E93C11095AFF0D6F1610E93C11095AFF0D6F&view=detail&FORM=VIRE](https://www.bing.com/search?q=frontline+plastics+wars&docid=13981947752741&mid=1610E93C11095AFF0D6F1610E93C11095AFF0D6F&view=detail&FORM=VIRE)
62 [https://vimeo.com/378880522](https://vimeo.com/378880522)
63 Digimarc can improve plastic sorting, giving plastic a “digital recycling passport” supporting many aspects of product lifecycle management. P&G recently announced several products (Fairy and Lenor) will be applying Digimarc to their products to enhance sustainability. HolyGrail 2.0 has over 160 companies, agencies and associations pledged to participate and help define the path to commercializing a plastic sorting solution. [https://www.plasticsnews.com/news/pgs-holy-grail-quest-fulfilled](https://www.plasticsnews.com/news/pgs-holy-grail-quest-fulfilled)
infrastructure adapt to a new paradigm. All this merely for increased capacity? The successor codes would not improve reliability, efficiency, or ease of use. Many applications would continue to be unsupportable or suboptimal. Commonly available imaging scanners, coupled with Digimarc Barcode, are already providing sought after increased capacity, along with better ease of use, reliability, and efficiency.

The presumed pace of change in POS reported in the survey was overly optimistic. The mid-2018 interviews found that 60 percent of Tier 1 retailers planned to upgrade their POS infrastructure in the next 18-24 months (by mid-2020). This broad statement was taken to mean that QR Code would somehow be accommodated at check-out, which has not happened. In the meantime, leading retailers and brand owners have made substantial progress in adopting Digimarc Barcode. There is a significant transition underway from laser to imaging scanners, which is an enabler of use of all the potential successors other than RFID. As noted earlier, the leading scanner vendors are already incorporating Digimarc Discover software.

The dominant Operating Systems for back-end POS systems of Tier 1&2 retailers are TCx-SKY and Windows, both of which are accommodating Digimarc Barcode. Given the deep interconnects to ERP, CRM, SCM and other large IT properties that generate the analytics retailers depend on, changes to these mission-critical systems are carefully managed and incremental. Most investment in these systems has been to support more forms of self-checkout – at front of store and in-aisle, by consumers, associates, and shopper surrogates fulfilling online orders.

Digimarc and the UPC coexist synergistically at point of sale, with the same data in each carrier facilitating more reliable, efficient and robust barcode reading or with more data in the Digimarc barcode to enable multiple applications by supplementing the UPC. In most applications during the transition period, Digimarc can operate unobtrusively in the background, augmenting UPCs and other barcodes that have been ripped, torn, crinkled, smudged, or improperly printed or placed without taking up more package real estate. This accommodation of 1D and 2D barcodes with Digimarc Barcode in a single field of view of modern scanners, industrial cameras, and smartphones is an integral part of the design of the Digimarc Platform. Over time the UPC and other symbols can be retired as redundant and the space they occupy repurposed. No deadlines or hard cutovers are required.

Conclusion

In conclusion, Digimarc offers multiple benefits in many areas of retail technology:

**Stores and Safety**
- Digimarc speeds up all forms of checkout and reduces congestion in stores.
- Supports scan-and-go models for less person-to-person contact.
- Reduces hand keying items and promotes less handling of products.
- Reduces cashier muscle strain by mitigating the need to twist and turn packaging to get a reliable scan.
- Enables faster pick-and-pack for store employees to fulfill mobile orders and curbside pick-ups.

**Supply Chain**
- Makes automatic identification of packaging components easier during the manufacturing inspection process.
- Reduces product waste due to mislabeling and other inaccuracies, which can imperil consumer safety.
- Reduces food waste with reduced-to-clear (dynamic pricing) to sell perishables before they expire.
- Improves store audits and inventory management including handhelds and future inspection robots.

**Merchandising**
- Enables and engages shoppers through connected print and enhanced menus, direct mail, in-store signage, and catalogs – making it easy to scan and buy.
New Channels

- Digitally-enables products and digital assets for unified commerce, mobile orders, buy online pick up at store (BOPUS).
- Links print and digital channels to drive mobile commerce and support an omnichannel experience.

Digimarc’s unique ability to provide digital identities for media objects, aligned with advances in imaging, computer processing and networks, provides a robust and enduring successor to the UPC, and other 1D and 2D codes as well. Over time, Digimarc will coalesce its imperceptible infusion of structured data with AI-driven image and audio recognition to provide reliable and efficient Auto ID of all media, without the unsightly and wasteful remnants of 1950s computer technology that barcodes represent. The structured data of Digimarc will enhance performance and expand opportunities for Auto ID beyond traditional barcode use cases, supporting significant changes in the digitally-driven, global coordination of demand and supply chains.

Digimarc Barcode satisfies the objectives stated in the GS1 US report, and it has many capabilities not addressed there that are important to a vision of what lies beyond the UPC. Digimarc Barcode streamlines operations for retailers and brand owners by leveraging a single identifier to enable accurate traceability, authenticity, and effective returns management. It provides massive mathematical and graphic redundancy covering much of the surface of packaging and labels. It can carry different data in different components of packages without consuming precious space. It can be applied at different stages of the product lifecycle to augment the initial identity, reducing the complexity of multiple labels or codes on a single product. Digimarc’s adherence to GS1 standards supports seamless sharing and the use of product data captured by scanning within retailer and brand owner operations and with trading partners.

The report’s statement of “universal priorities” of achieving a better understanding of consumer buying habits and improving accuracy at point of sale has been a core value of the Digimarc Platform since inception. The report goes on to say: “The ultimate use case for change comes from the need to provide data while minimizing disruption at the POS.” Digimarc does not disrupt POS, it significantly improves the speed, ease, and accuracy of all forms of checkout, supports new safety and convenience-driven shopping models, improves the efficiency of store operations, helps automate recalls and recycling, and generally improves the quality of data throughout the enterprise.
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The alternative data carriers considered in “Powering the Future”, except for RFID, merely increase data capacity, leaving in place for the next generation the many limitations associated with form factor discussed above. RFID has a vital role in Auto ID, but costs, technical attributes, and operational characteristics make it unsuitable as the bedrock of the supply and demand cycles of retail.

Digimarc envisions a world of seamless multi-modal discovery of media providing significant advancements in ease of use, reliability, efficiency, and application enablement. All these data carriers will play some role for the foreseeable future; however, there is only one data carrier capable of the universal application achieved by the UPC that transcends both its capacity and form factor limitations – Digimarc Barcode.

Multiple threads are advancing Digimarc as the global successor to traditional barcodes in the retail industry:

- Digimarc Barcode increases capacity while eliminating form factor limitations of the UPC;
- leading retailers and brand owners are in production;
- an expanding global supply chain is being equipped and trained;
- leading packaging suppliers are on board;
- the top suppliers in AIDC are integrating Digimarc Discover software into their products; and
- there is a growing application developer community.

The future of barcodes is here now. It is Digimarc.

Learn more about Digimarc for Retail.