The Global Language of Business

2D Barcodes at Retail Point-of-Sale

Getting started guide

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1 Executive summary

The purpose of this document is to provide guidance for industry for getting started on their 2D journey and enable a smooth, voluntary transition to using more capable 2D barcodes while minimising disruptions to existing business processes. This *Getting Started Guide* is focused primarily on the considerations and implications of utilising 2D barcodes encoded with interoperable GS1 data at retail point-of-sale (POS).

1.1 The retail industry changing landscape

To better enable the digital consumer and unlock business use cases, the retail industry is embarking on one of the biggest changes since the original introduction of the barcode: the adoption of 2D barcodes. 2D barcodes, like QR codes or Data Matrix for example, can include more data than the current EAN/UPC linear barcode (like expiry date, lot number or serial number and internet links to ingredients and allergen information, product pictures and videos, consumer reviews, etc.). This journey will enhance the experiences of consumers, brands, retailers and everyone in between. GS1 is supporting industry around the world to harness the power of these barcodes to enable new business solutions for today...and into the future.

1.2 Ambition for 2027

GS1 with Industry has set the ambitious goal of transitioning from legacy linear 1D barcodes to new, more capable 2D barcodes on-pack with an initial goal of retail POS scanners globally capable of reading and processing **both** old and new barcodes by the end of 2027. GS1 and industry are working together to support this migration and generate globally consistent guidance for business use cases. While there is no expectation that there will be a single 2D barcode selected for all industries, GS1 will strive to enable options that allow each industry choice in how they evolve towards more capable barcodes while ensuring globally consistent implementations now and in the future. Note that 1D EAN/UPC barcodes will not go away, they will coexist with 2D barcodes for as long as there are uses for them.

1.3 Let the journey begin!

The remainder of this document includes a significant amount of information designed to help companies plan for 2D implementations. Sections 2 through 6 are focused on **definitions and explanations**, including:

- Current EAN/UPC linear barcodes and 2D barcodes
- Prioritised industry use cases for 2D barcodes
- An introduction to GS1 Application Identifiers (AIs)

Sections 7 through 9 are focused on **implementation guidance** for brand owners, retailers and solution providers. While the information provided is not intended to enable a complete 2D implementation across a company, it can be used as a resource for implementers to reference along their journey.

For further information, make sure to reach out to your local GS1 Member Organisation.

2 Background

The 12-digit Universal Product Code barcode (UPC-A) and 13-digit European Article Number barcode (EAN-13) have been trusted and ubiquitous data carriers for facilitating the price look-up function at retail point-of-sale (POS) since the early 1970s. This innovation automated a critical business process for Retail POS everywhere.

These EAN/UPC barcodes have space limitations and are limited to carrying only the Global Trade Item Number® (GTIN®) associated with a product. Because of this data capacity limitation, they are not suited to meet today's evolving consumer and business needs for additional product data. To address industry expectations for speed and convenience, information transparency and a variety of operational efficiencies, more and more emerging use cases require a data-rich carrier capable of holding more on-pack data than just the product identifier (GTIN).

2.1 Purpose

The momentum for change to more capable barcodes is driven by industry need to encode more data on-pack. This meets the growing information demands of consumers, enables additional supply chain efficiencies and builds brand trust by providing more accurate, complete and up-to-date product information…all while enabling the POS process.

Based on more than 50 years of industry collaboration and industry insights, brand owners, retailers and solution providers have pointed to the need for guidance from GS1 to help them to:

- Build solutions based on standardised and interoperable data—so that trading partners can exchange and understand one another's information and import it into their own systems.
- Decrease the number of data carriers on retail point-of-sale (POS) packages—to reduce confusion and enable better use of valuable space on the package for graphics and merchandising.
- Support widespread adoption of data-rich carriers—to optimise the benefits across entire industries for more efficient, reliable and interoperable information exchange.

The purpose of this document is to provide guidance for industry for getting started on this journey and enable a smooth, voluntary transition to using more capable 2D barcodes while minimising disruptions to existing business processes. This *Getting Started Guide* is focused primarily on the considerations and implications of utilising 2D barcodes encoded with interoperable GS1 data at POS.

The focus areas of this guide include:

- Recommendations for using GS1 Standards to identify and capture product information, allowing for interoperability in a fragmented and evolving data carrier landscape.
- Using GS1 Standards to connect products to relevant experiences in the digital world and still be leveraged at the POS.
- An outline detailing how to apply GS1 Standards to encode the GTIN and product attributes such as serial number, batch/lot number, best-by date, or production date into 2D barcodes using the GS1 Application Identifiers.

Notes:

- While Point-of-sale (POS) is mainly referred to as being enabled by fixed or hand-held scanners at the front of the store, retail POS can happen in multiple locations and ways, including utilising scanners in POS lanes, at self-checkout or using mobile phones or handheld units on the sales floor and the backroom.
- While RFID data carriers that leverage GS1 Standards are seeing increasing use in supply chain to improve inventory management – especially in the apparel sector – they will not be addressed in this document. For more information on RFID, see EPC/RFID standards.

This document is expected to expand over time based on growing user implementations and as the standards are updated.

2.2 Scope

In Scope	Out of Scope
▪ Guidance for retailers, brand owners and solution providers ▪ Any consumer units scanned at retail POS ▪ Guidance on how to use GS1 DataMatrix, Data Matrix and QR Code at POS ▪ Encoding data attributes using GS1 element string syntax and GS1 Digital Link URI (Uniform Resource Identifier) syntax ▪ Dual marking: EAN/UPC barcode + 2D barcodes	▪ Radio Frequency Identification (RFID) usage for retail POS (see EPC/RFID standards for more information) ▪ Guidance to meet the requirements of specific regulations ▪ Industry or product type specific guidance ▪ Non-consumer units and packaging hierarchies scanned in distribution and non-retail environments ▪ Non-GTIN solutions (Restricted Circulation Numbers [RCN], proprietary encoding, etc.)

Important: Products may exist in multiple channels (e.g., retail and foodservice, clinical healthcare settings). This document only addresses scanning at point-of-sale in retail channels.

3 General guidance

This section provides information that may be used by the retail sector both at POS and any retail trading partner relationship that is looking to implement data carriers containing additional attribute information. Before beginning to implement 2D barcodes or capture additional data, it is highly recommended that stakeholders gain an initial understanding of the GS1 System of Standards related to product identification and data capture, beginning with the GS1 General Specifications. For further education on GS1 Standards, see GS1 Two-dimensional (2D) barcodes, GS1 DataMatrix Guideline and GS1 Digital Link URI standard .

3.1 What is an EAN/UPC and what is a GTIN?

When discussing EAN/UPC barcodes, it is important to properly define the terms. As we move to 2D barcodes, different barcodes and formats of GTINs will be used. Trading partners need to ensure they are using the same language so they can understand one another, especially when sharing data or meeting trading partner requirements.

The EAN/UPC family of barcodes was developed for POS scanning and includes the UPC-A, EAN-13, UPC-E and EAN-8.

It is also important to draw a distinction between the barcode, in this case the UPC-A, and the data encoded, which in a UPC-A is always a GTIN-12. The GTIN-12 is one of four GTIN data structures. Internationally, the most commonly used GTIN is the GTIN-13, which is encoded in EAN-13 barcodes. EAN-13 barcodes are another member of the EAN/UPC family. For more guidance on GTINs, see the GTIN Management Standard and the 10 steps to barcode your product guide.

3.2 Primary identification vs. attribute data

The GTIN uniquely identifies a trade item by serving as its means of primary identification. Sometimes, there is a need to provide attribute information beyond the primary identification. Attribute data provides more granular and detailed information about a product. It can include data elements such as batch/lot number, serial number and expiration date. Two-dimensional (2D) barcodes have a large capacity for data and can encode both the GTIN and attribute data. Depending on the needs of each use case, the additional attribute data may need to be scanned, processed, stored and used in the POS system. To leverage the additional data, systems may need to be upgraded and the implications for both hardware and software will be explored in this document.

3.3 Static vs. dynamic data

The GTIN and most of the data typically associated with it are static; they contain consistent data points that remain the same across all individual units of a specific trade item. Additional static data such as the ingredient list and net weight can be printed on the package or stored in master data and shared via systems like the GS1 Global Data Synchronisation Network™ (GDSN®).

The addition of attribute data onto packaging will increase the use of dynamic data (e.g., batch/lot number, expiration date, serial number), which can vary across instances of the trade item. Dynamic data printed on-pack can link to additional information about the trade item. For example, a lot number on a tube of toothpaste can be linked to the production date, manufacturing location and even a specific production line. Or the serial number on a seafood item could be linked to information about the waterway and fishing method. This data can be used for B2B purposes,

facilitating traceability or targeted product recalls. Or with GS1 Digital Link, a dynamic web link (URL) can be encoded in the data carrier that links to a webpage specific to the lot or serial number.

Dynamic data needs to be printed, stored, shared and processed differently than static data. For existing use cases such as food items, the static GTIN and nutritional information may arrive at the manufacturing plant pre-printed by packaging suppliers.

Dynamic data such as expiration dates and batch/lot codes are usually printed on demand at the plant or production line. As more dynamic attribute data is encoded into data carriers on packaging, brand owners and manufacturers will need to do more of this type of dynamic printing themselves.

The Table below summarises the points above and provides examples.

	Static	Dynamic
Data	Data that is constant across all instances (individual units) of the trade item: ▪ GTIN, ingredients list, nutrition facts	Data that can vary among instances of a trade item: ▪ Batch/lot number ▪ Serial number ▪ Expiration date ▪ Weight
Printing	Consistent across the GTIN and often pre-printed: ▪ Nutrition facts panel ▪ EAN-13, UPC-A ▪ 2D barcode encoding only the GTIN	Printing applied at the time of manufacturing and can vary from package to package: ▪ Best before date ▪ Batch/lot number ▪ 2D barcode encoding GTIN + attribute data
Web Links	Link that is the same across a GTIN: ▪ Product information URL	Link that changes depending on dynamic data: ▪ Traceability web page URL for product based on batch/lot number

An example of static and dynamic printed data on product packaging is shown below.

3.4 Ambition 2027

The industry-defined goal is to enable the use of 2D barcodes, in addition to existing 1D barcodes, at retail point-of-sale across the globe by the end of 2027. While different regions of the world will move at different paces towards this ambition, retailers and brand owners will need to begin their transition in the coming years.

Note: the EAN/UPC barcode is not going away and will continue to scan at POS after 2027. Brand owners should continue to stay connected with their local GS1 Member Organisation to stay informed of regional progress and adoption.

Transition Period	Ambition for 2027
	
Dual-marking transition phase EAN/UPC ***and*** a 2D barcode	EAN/UPC ***or*** a 2D barcode

To support the Ambition for 2027, retailers will need to upgrade their scanner infrastructure to replace linear/laser scanners with optical scanners. This upgrade is already occurring—the research highlighted in Section 3.5.1 shows that optical scanners are quickly becoming more prevalent in the marketplace.

Getting started requires the following of retailers and brand owners:

- Retailers and Brand owners:
  - Discuss use cases, data requirements and sharing with trading partners.
  - Consider piloting with a trading partner.
- Retailers only:
  - Upgrade scanner infrastructure to optical for the reading of 2D barcodes encoded with GS1 application identifiers such as an AI (01).
  - Upgrade POS systems to process, at minimum, a 14-digit GTIN and, optimally, data attributes as well.
- Brand owners only:
  - Evaluate existing packaging, data carrier printing and data encoding.

3.5 Scanners

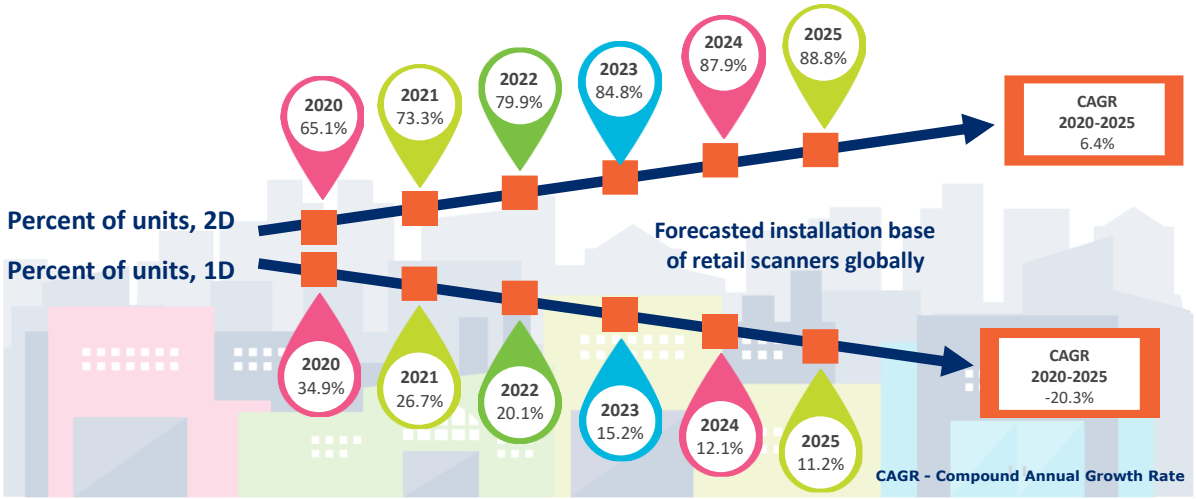
3.5.1 Types of scanners

Barcode scanners come in two general categories: 1D or linear (laser) scanners and optical (camera-based) scanners. Barcode scanners are found on the production line, in the distribution centre, on the retail floor and at the point of sale. Most mobile devices can serve as a barcode scanner by utilising the device's camera or a mobile app.

1D scanners can only scan linear or one-dimensional barcodes; these are the familiar barcodes with vertical bars and spaces. The 1D laser scanner identifies the type of 1D barcode and decodes the encoded data.

Optical scanners take a picture, identify the 1D or 2D barcode and analyse it to apply the proper decoding algorithm. This type of scanner is needed to scan 2D barcodes. Additionally, for 2D barcodes that include web URL links, optical scanners can extract the relevant data from a URL that

is formatted with GS1 Digital Link URI syntax – such as the GTIN to perform a price lookup – without the need to be connected to the web. The industry research is showing rapid adoption of optical scanners by the retail industry. See the graphic below summarising the projected adoption of optical scanners, based on data provided by VDC Research, a technology market intelligence and consulting firm.



Source: 2021 VDC research for GS1 on Global image-based scanner adoption

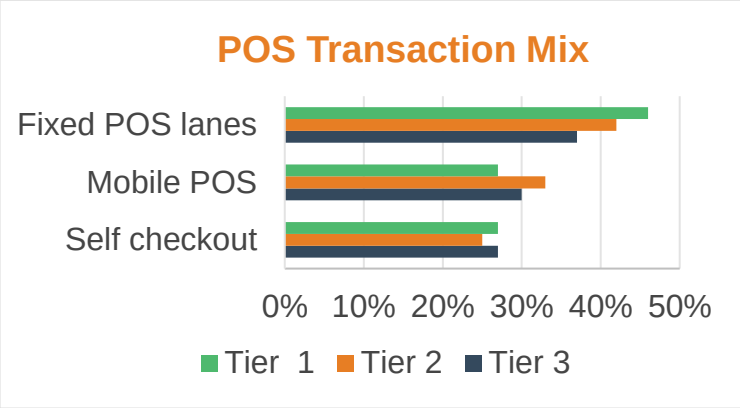
3.5.2 Scanner programming

Scanners can be programmed to identify and process only a single type of barcode or upwards of 30 barcodes simultaneously, depending on what systems the scanner needs to interact with. Barcode scanners use decoding algorithms to determine what type of barcode is being scanned and then process the data accordingly. This data is then processed based on programmed settings that move the standardised data to the fields required by the downstream application or system. Scanners may have different settings based on their application (such as POS systems, inventory management or receiving scanners). To save the time of running images through all the possible barcode algorithms, scanner users usually have the option of choosing and prioritising the barcodes that are used within their application (and disabling those not relevant to their application).

Traditionally, POS scanners have factory settings that prioritise linear (e.g., EAN-13 or UPC-A) barcodes and have turned off or disabled other barcodes decoding algorithms. With multiple data carrier options emerging, many industry stakeholders—including retailers—will have to change their scanner programming to enable the set of barcodes they will need to scan into the future. Retailers should work with their solution providers and their internal teams to ensure scanners can discriminate and decode the barcodes they will be encountering, guided by their specific business needs. As implementations and the data carrier environments evolve, the scanner software and settings may need to be updated accordingly.

3.6 Expansion of scanning environments

One major finding from research conducted by GS1 US (*Powering the Future of Retail*) was the expansion of non-traditional POS channels. The 2019 retailer and brand owner findings were segregated by Tiers[1].



Source: Powering the Future of Retail: Building on the Foundation of the U.P.C. Barcode, 2019.

POS transactions have long been centred around cashiers scanning products on fixed-lane POS checkouts. As consumer demand and retail strategies have evolved, many retailers are expanding their POS options to include mobile checkout, self-checkout and buy-online/pick-up in store (BOPIS). This means that barcodes are more often scanned by handheld scanners and mobile devices, not just traditional scanners. Increasingly, the barcodes are not even scanned by a store employee, but by the customer, either at a self-checkout terminal or with their mobile device. Use cases, data carrier selection and placement on packaging all must take this expansion of POS environments into account. While this presents challenges, it also creates opportunities as consumers learn to interact more and more with the data carriers on products.

3.7 Trading partner collaboration

Implementing advanced use cases using 2D barcodes at POS will require extensive trading partner collaboration. Successful implementations will rely on trading partners sharing more types of data more often. For example, if a retailer POS system is expected to reject recalled items based on batch number, it will need an up-to-date list of recalled GTIN and batch/lot combinations from suppliers. To prevent the sale of counterfeit goods based on serial number, the retailer will need a list of authentic GTIN and serial number combinations from its suppliers as well. Early adopters and pilot program participants will need to work with their trading partners to ensure they can both scan the data carrier and properly route the data. Building solutions and implementations on standardised data will be essential for interoperability. GS1 Share standards such as GDSN, Electronic Data Interchange (EDI) and Electronic Product Code Information Services (EPCIS) can help trading partners share this data in an interoperable way. For more information, see the Share section of our GS1 Standards.

3.8 Data sharing and analytics

Data encoded on-pack along with the GTIN provides additional information that retailers, brand owners and consumers can leverage. To fully leverage this data, data analytics, artificial intelligence and process automation solutions are evolving to meet emerging use cases. Retailers and brand owners are expecting solution providers to provide systems and tools that will enable data to be converted into actionable insights to drive better consumer engagement and supply chain efficiencies. Select use cases are outlined in the next section of this *Getting Started Guide*.

[1] Retailer and brand owner tiers are defined by revenue (USD$) as Tier 1: $1B+; Tier 2: $100M-$1B; Tier 3: $10M-$100M.

4 Use cases

In GS1's research, industry members conveyed important benefits of migrating to a data-rich carrier, which revolved around additional data that can be encoded on-pack. These benefits varied by industry and even by business category and product. The business needs and required solutions are not one-size-fits-all. Each brand owner will have different use cases and priorities. One data carrier can also be used for multiple use cases. For example, a GS1 DataMatrix encoding a GTIN and serial number could be used for a combination of price lookup at POS, inventory accuracy and product authenticity.

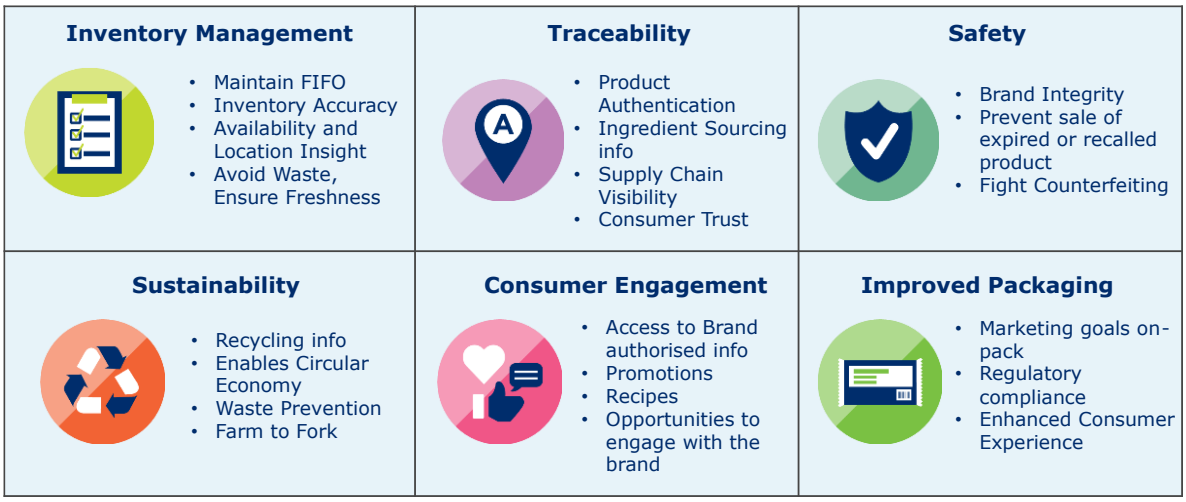
4.1 Current use case: price lookup

The EAN/UPC barcodes were originally implemented nearly 50 years ago to facilitate price lookup at the point-of-sale/purchase (POS) register. In this simple process, the scanner extracts the GTIN from the EAN-13 or UPC-A barcode and the POS system matches the GTIN with the price of the item to facilitate checkout.

Price lookup remains the most critical use case as the industry migrates to an advanced data carrier. Today, the price lookup occurs at the fixed register, self-checkout and mobile checkout so that customers can purchase items with speed and convenience. As noted in Section 3.5.1, optical scanners can extract the GTIN for price lookup from a 2D barcode that is formatted with GS1 Digital Link URI syntax without the need to be connected to the web.

4.2 Overview of advanced use cases

The figure below highlights a wide variety of use cases that can be unlocked by leveraging additional data in a 2D barcode. While not all use cases will be addressed in this document, the following sections highlight some of the top near-term use cases. Note that these benefits/use cases are mentioned here in no particular order of importance. Additionally, retail stakeholders will select for themselves the use case that applies to their situation.



4.2.1 Inventory management

Improved inventory management is an important driver for adopting advanced data carriers. Although an EAN-13 and UPC-A can be used for inventory accuracy, it is limited to encoding the GTIN. 2D barcodes encoded with the GTIN + more granular data can offer first in, first out manageability using batch/lot or expiration date. Retailers that scan 2D barcodes with expiration dates into inventory and out at checkout can monitor product freshness without having store associates physically check inventory. The additional granular data can ensure product freshness, reduce waste and create opportunities for automatic price adjustments.

4.2.2 Consumer engagement

Use of data-rich barcode solutions gives brand owners an opportunity to provide consumers with richer product data such as nutritional and sustainability information, promotional information, marketing videos, traceability data and more.

Industry has recognised these benefits; many proprietary implementations of 2D barcodes can be seen on-pack today. SmartLabel, for example, delivers nutritional and ingredient information by use of a URL embedded in an advanced data carrier. However, this limits the uses to SmartLabel applications only, but these QR codes could become more multi-functional and unlock more if they add the GTIN and become compliant with the GS1 Digital Link standard. Brand owners are also printing 2D barcodes on-pack that consumers can scan using their mobile phones to access a digital experience, receive a promotion, or interact with a loyalty program. These proprietary implementations provide limited experiences, especially when the barcode does not carry a GTIN. Without encoding the GTIN, the carrier cannot be used at POS and throughout the supply chain for price lookup and product identification.

The GS1 Digital Link URI syntax was developed to overcome these limitations by providing a standard URI, web format, or website URL address. Utilising GS1 identifiers encoded in a data carrier would allow simple rules to be applied to help apps, websites and eventually POS scanners enable multiple experiences, including checkout at point-of-sale. All of this requires a ready environment and appropriate timing. See Section 3.4 and Section 6.3 to understand the path to using GS1 Digital Link at POS. More information on GS1 Digital Link can be found in Section 5 and in the GS1 Digital Link Implementation Guide.

4.2.3 Traceability

Sharing richer product data such as product identification and place of purchase across the retail value chain can help create opportunities for improved consumer protection. For example, a single barcode that contains information about a product's GTIN and batch/lot could help provide greater supply chain visibility, building the infrastructure for faster and more targeted recalls. Items such as fresh fish can be tracked from catch to store, giving consumers, manufacturers and retailers greater visibility to their food's origin and supply chain journey.

4.2.4 Product authenticity

(Also supports Safety, Traceability and Consumer Engagement use cases)

Both consumers and brand owners are concerned about product authenticity. Trade in fake goods is now 3.3% of world trade and rising according to a report by the OECD and the EU's Intellectual Property Office. Trends in Trade in Counterfeit and Pirated Goods[2] puts the value of imported fake goods worldwide based on 2016 customs seizure data at USD 509 billion. Serialisation of products (where every item is identified with a GTIN and unique serial number) can be used to verify that a product is genuine. Further attribute data about the specific serialised instance of a product (such as batch/lot, production date and country of origin) can be encoded on-pack or linked to the serial number in a database or through a GS1 Digital Link URI.

4.2.5 Freshness/waste prevention

(Also supports Inventory Management, Sustainability and Safety use cases)

Currently, one-fifth of all food waste is caused by date confusion[3]—for example, sell by (the last day the retailer can sell an item) vs. expiration date (the last day it can be consumed). Improvements to sell by/expiration date management can enhance product rotation for improved freshness and potentially eliminate sales of expired products.

[2] OECD/EUIPO (2019), Trends in Trade in Counterfeit and Pirated Goods, Illicit Trade, OECD Publishing, Paris, https://doi.org/10.1787/g2g9f533-en.

[3] National Resources Defense Council, "Wasted: How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill" author Dana Gunders, NRDC, page 12, https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf

4.2.6 Returns management

(Also supports the Inventory Management use case)

There has been a 34 percent increase in retail returns over the last six years[4]. Seamless returns contribute significantly to positive consumer experiences. They also reduce operating costs, but retailers require more information than is available within the EAN-13 or UPC-A to effectively facilitate returns. Serialisation would allow the retailer to tie the item back to a specific transaction to obtain the price and sales tax paid, method of payment, warranty and other useful information.

4.2.7 Variable measure trade items

(Also supports the Inventory Management use case)

Fresh food priced by variable measure, such as weight or count (e.g., pre-packaged salads and entrées, bakery, produce, meat and seafood, etc.) can have the product identifier (GTIN), weight, count and price encoded data in a 2D barcode. This also supports increased food traceability. Many variable measure trade items are currently encoded with an RCN (restricted circulation number) instead of a GTIN. These RCNs are intended for use within the "four walls" of one physical retailer and are not globally unique. As supply chains interconnect, it is becoming more necessary for these items to be identified with GTINs so they can be uniquely identified and traced outside the physical retail store, throughout the supply chain. For more specific information on guidance on migration of RCN to GTIN and use of 2D barcodes for variable measure fresh foods, see the latest Fresh Foods Implementation Guideline.[5]

[4] Sidecar Discover, "The 4 Trickiest E-commerce Returns Challenges," post by Rishon Roberts, Senior Marketing Specialist, Optroro, https://discover.getsidecar.com/4-trickiest-ecommerce-returns-challenges
[5] GS1 AIDC Fresh Foods Sold at Point-of-Sale implementation Guideline. Release 1.2, October 2020. https://www.gs1.org/docs/freshfood/Fresh_Food_Implementation_Guide.pdf

5 GS1 Application Identifiers

Note: For clarity, all 2D barcode examples shown in this section and in Section 6 will include the encoded data underneath for illustrative purposes—for example, the QR codes show the full web address encoded in the QR. However, in practice, human readable text below barcodes typically do not include the entire web address. For more information on human readable text underneath barcodes, see Section 6.5.

5.1 Introduction to GS1 Application Identifiers

While we may be entering a world with multiple data carriers in use (EAN/UPC + data-rich 2D barcodes carriers such as GS1 DataMatrix, Data Matrix or QR Code), **global interoperability can still be accomplished across industries and trading partners by ensuring these carriers encode standardised data elements in a common syntax**. Standardised data elements and syntax can replace internal and proprietary solutions, enabling global interoperability. This allows trading partners to share, encode and scan data across the supply chain and understand its meaning.

GS1 Application Identifiers (AIs) are a finite set of specialised identifiers encoded within data carriers to indicate the type of data that follows (e.g., GTIN, serial number, expiration date, etc.). Each AI is a two-, three-, or four-digit numeric code. There are over 150 AIs, including one AI for each GS1 identification key (e.g., GTIN, Global Location Number (GLN), Serial Shipping Container Code (SSCC), etc.), as well as numerous AIs for attribute data (e.g., expiration date, batch/lot, serial number, etc.). The definitions for all the AIs reside in the *GS1 General Specifications*. Also see GS1 AI browsers.

The GS1 Digital Link Standard defines how to structure web URLs to include GTINs as well as attribute data (e.g., batch/lot number, expiration date, serial number) and other GS1 keys such as GLN, SSCC, etc.

Note: Any valid combination of GS1 Application Identifiers, as defined in Section 4.14 of the *GS1 General Specifications*, can be encoded using GS1 element string syntax or a GS1 Digital Link URI syntax.

For example, given a GS1 Digital Link URI syntax such as:

https://example.com/01/09526000134367/10/ABC123

We can easily extract and express the same information using GS1 element string syntax:

(01)09526000134367(10)ABC123

For more information on GS1 Digital Link, see the GS1 Digital Link Implementation Guide.

5.2 Application Identifier - AI (01) GTIN

One of the most common GS1 Application Identifiers—and the most important for POS—is AI (01), or GTIN. The AI (01) designation indicates that the data that follows will be a 14-digit GTIN. Currently most POS transactions are done with EAN-13 or UPC-A barcodes that can only encode GTIN-13 or GTIN-12, respectively, so the AI (01) is not required. For example, if a POS system sees a UPC-A barcode, it knows a GTIN-12 will be encoded.

As we move to enable more sophisticated use cases, data carriers are needed that can carry more than just the GTIN. In order to process and use the GTIN from these data carriers, POS systems will need to be able to recognise AI (01) in both traditional GS1 element string and GS1 Digital Link URI syntaxes. Additionally, the GTIN will be in 14-digit format, so systems will need to be updated to

ensure they can process, store and use the full 14 digits of the GTIN. Storing all GTINs in a 14-digit format allows all GTINs, regardless of format, to be stored in the same database, while ensuring no data is lost.

UPC-A barcode encoded with a GTIN-12

EAN-13 barcode encoded with a GTIN-13

GS1 DataMatrix using GS1 Digital Link URI syntax encoding a GTIN-13 in 14-digit format, using AI (01)

QR Code using GS1 Digital Link URI syntax encoding a GTIN-13 in 14-digit format, using AI (01)

5.3 General encoding principles

When encoding GS1 Application Identifiers in a GS1 barcode, it is important to follow a recommended presentation order. This ensures that the data is encoded as efficiently as possible, reducing the size of the barcode.

The GS1 Identification key (for the use cases in this document this will be the GTIN) is presented first, followed by any fixed-length AI element(s) (e.g., production date, expiration date) and then followed by any variable-length element(s) (e.g., batch/lot number, serial number, etc.).

Variable-length elements require group separators (FNC1 or <GS>) between them to indicate that the data element has ended, prompting the system to look for the next AI and data element. Encoding variable-length data as the last element reduces the number of group separators needed and thus shortens the length of the barcode.

If there are several fixed-length and variable-length AIs, the order of the fixed or variable-length AIs is up to the discretion of the brand owner, provided all fixed-length AIs are presented before all variable-length AIs.

As many different trading partners will be encoding different combinations of AIs in many different sequences, systems should be set up to process AIs in any order. Otherwise, unnecessary errors will occur in scanning systems when unexpected AIs occur, or they occur in a different sequence.

Example: GS1 Identification key + fixed-length AI(s) + variable-length AI(s)

When encoding a barcode, each data element is preceded by its AI to create an element string. The AI defines the data type and field size that follows it. For example, the AI for GTIN is (01). Thus, when AI (01) appears first in the element string, it means a GTIN follows in the next segment. The AI for packaging date is (13). When (13) appears in the element string, it means a packaging date follows in the next segment.

GS1 DataMatrix with AI (01) for GTIN and AI (13) for packaging date in the GS1 element string syntax

QR Code with AI (01) for GTIN and AI (13) for packaging date in the GS1 Digital Link URI syntax

5.4 Important AIs for 2D barcodes at POS

Section 3 of the *GS1 General Specifications* provides full details on all the AIs in the GS1 System. Below is a list of AIs that could commonly be used to support industry's retail POS use cases. Sector-specific guidelines (such as the Fresh Foods Implementation Guideline) may include additional AIs not listed below.

AI	Data Content	Format	AI Separator Required	Data Title
01	Global Trade Item Number (GTIN)	N2+N14		GTIN
10	Batch or Lot Number	N2+X..20	FNC1 or <GS>	BATCH/LOT
11	Production Date (YYMMDD)	N2+N6		PROD DATE
13	Packaging Date (YYMMDD)	N2+N6		PACK DATE
15	Best Before Date (YYMMDD)	N2+N6		BEST BEFORE or SELL BY
17	Expiration Date (YYMMDD)	N2+N6		USE BY or EXPIRY
21	Serial Number	N2+X..20	FNC1 or <GS>	SERIAL
30	Count of Items (Variable Measure Trade Item)	N2+N..8	FNC1 or <GS>	VAR. COUNT
310n (*)	Net weight, kilograms (Variable Measure Trade Item)	N4+N6		NET WEIGHT (kg)
320n (*)	Net Weight, Pounds (Variable Measure Trade Item)	N4+N6		NET WEIGHT (lb.)
392n (*)	Applicable Amount Payable, Single Monetary Area (Variable Measure Trade Item)	N4+N..15	FNC1 or <GS>	PRICE
393n (*)	Applicable Amount Payable with ISO Currency Code (Variable Measure Trade Item)	N4_N3_N..15	FNC1 or <GS>	PRICE
395n (*)	Amount payable per unit of measure single monetary area (variable measure trade item)	N4+N6	FNC1 or <GS>	PRICE/UoM
412	Purchased from Global Location Number	N3+N13		PURCHASE FROM
414	Identification of a Physical Location – Global Location Number	N3+N13		LOC No
422	Country of Origin of a Trade Item	N3+N3	FNC1 or <GS>	ORIGIN
8008	Date and Time of Production	N4+N8+N..4	FNC1 or <GS>	PROD TIME
*The fourth digit of this GS1 Application Identifier indicates the implied decimal point position. Example: 3103 net weight in kg with three decimal points				

6 Data carriers

6.1 Benefits of 2D barcodes over linear barcodes

The EAN-13 and UPC-A barcodes have long served industry's need for automated price lookup at POS, but their ability to meet other use cases is limited, as they can only contain the GTIN. Data carriers capable of encoding attribute data are needed to meet industry's evolving use cases. Industry has also expressed a desire to reduce the footprint of data carriers on-pack, especially as brands introduce multiple data carriers on their packaging. The first attempt to meet these requirements was addressed by the GS1 DataBar family of barcodes. Several members of the GS1 DataBar family only encode the GTIN and offer a reduced footprint compared to EAN/UPC barcodes. Two types of GS1 DataBar can encode GTIN and additional AIs.

However, these symbols were often not small enough to encode more data in a smaller space and did not allow brands to leverage barcodes for consumer engagement. To meet these requirements, industry is now investigating and implementing 2D barcodes. In addition to a smaller footprint, 2D barcodes also offer the advantage of error correction—encoding redundant data in the barcode that can help the symbol be read in case it is damaged. This provides some additional protection to ensure the data encoded in 2D barcodes can be scanned accurately.

Above are examples of an EAN-13 and GS1 DataBar Omnidirectional Stacked barcode, encoding just a GTIN. A GS1 DataMatrix, GS1 DataBar Expanded Stacked encoding GS1 element string syntax and a QR Code encoding GS1 Digital Link URI syntax encoding GTIN, expiration date and batch/lot number. All examples use target sizing.

6.2 Barcode options

The data carrier landscape is fragmented. Data carriers are selected based on each specific use case, and this practice will continue. GS1 will continue to monitor the development and adoption of additional data carriers but has identified the following three 2D barcodes that can meet industry's current use cases: GS1 DataMatrix, Data Matrix, QR Code.

Organisations looking to implement 2D barcodes need to select a data carrier and syntax based on their business needs and stakeholder capabilities. GS1 recommends actively engaging with trading partners to ensure the path forward is collaborative and the solutions are capable and compliant.

Capable

- Is the data carrier capable of encoding a GS1 data syntax/format?
- Can the data carrier be created and/or applied at the speed and quality required for the use case?
- Are those intended to interact with the barcode able to process it?

Compliant

- Does the barcode meet regulatory requirements?
- Is the barcode approved for standardised use for your application?

Collaborative

- Have the data, data carrier, packaging, scanning hardware/software and receiving systems capability to store/use data all been considered?
- Have all internal and external stakeholders been brought together to agree on and enable the transition to the future solution? Stakeholders can include local GS1 Member Organisations, industry/trading partners and solution providers. These stakeholders may include those involved with label design, printing, scanning, data storage, processing, etc.

6.2.1 Transition considerations

Adoption of these higher capacity 2D barcodes is underway, largely to accommodate consumer engagement, retail or supply chain use cases. Current use at POS is limited. Many of the current implementations utilise GS1 DataMatrix for variable-measure (weight or count) fresh food, which is allowed for POS applications in version 22.0 of the *GS1 General Specifications* under trading partner agreement. As retailers and brand owners begin advocating for higher capacity 2D barcodes to meet their business, the industry capabilities and GS1 General Specifications will also evolve to enable them:

- Retailers upgrading scanners and POS systems.
- Brand owners upgrade printing, in house scanners and production systems.
- Retailers and brand owners encoding of 2D barcodes and data attributes.
- *GS1 General Specifications* will be updated to include additional data carriers for POS.

This does not mean that 2D barcodes cannot be used right now. **Industry and GS1 recommends a transition that includes dual marking to enable early adopters and maintain interoperability as industry 2D barcode capabilities grow.**

- EAN-13 and UPC-A will remain the primary POS barcodes until we reach the 2027 ambition for 2D barcode adoption.
- If adding a 2D barcode to meet a use case, the following applications are approved in the *GS1 General Specifications*, *Version 22.0 (January 2022)*:
  - Data Matrix or QR Code can be used to encode a GS1 Digital Link URI syntax for consumer engagement.
  - GS1 DataMatrix can be used for variable-measure fresh food use cases by trading partner agreement or non-POS use cases requiring GS1 element string syntax.

Between now and 2027, brand owners and retailers can collaborate through pilots and trading partner agreements to scan 2D barcodes at POS for price lookup and the additional use cases outlined in Section 4.2. **Our ambition is to have industry ready in 2027 to accept 2D barcodes at POS and brand owners will then have the option of removing the EAN/UPC barcodes.**

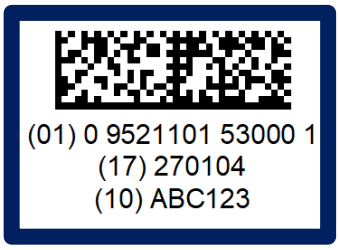
Note: Please be advised that there may be regulation(s) in certain market areas that are more stringent and must be adhered to. This includes regulated pharmaceuticals covered by regulations from specific geographic regions, for example USA FDA Drug Supply Chain Security Act (DSCSA), European Union's Falsified Medicines Directive (EU FMD), China National Drug Administration (CNDA) traceability system and many more as detailed within the GS1 Healthcare Public Policy Group.

For more information on the path to using 2D barcodes at POS, see Section 3.4 and Section 6.3.

6.2.2 GS1 DataMatrix and Data Matrix

Data Matrix is a 2D barcode consisting of black and white "cells" or dots arranged in either a square or rectangular pattern, also known as a matrix. Data Matrix offers error correction (30%) that provides safeguards and additional capabilities for handling poorly printed or damaged symbols. A Data Matrix symbol has a high data capacity and can store up to 2,335 alphanumeric characters. It has several advantages such as its compact design and the existence of various production methods that accommodate placing the symbology onto various substrates. Several rectangular variants are also available to fit on narrow or curved surfaces, expanding on the wide array of surfaces and printing processes available for printing GS1 DataMatrix.

There are two versions of the Data Matrix in the *GS1 General Specifications Version 22.0.* GS1 DataMatrix is a subset of Data Matrix that is specifically designed for encoding GS1 element string syntax, while in the GS1 system, Data Matrix is used to encode GS1 Digital Link URI syntax only. Since the two versions of Data Matrix look very similar, using both on one package could lead to confusion; trading partners and consumers would not know which to scan. Best practice is to use only one of these symbologies on-pack.



6.2.2.1 GS1 DataMatrix

GS1 DataMatrix features all the benefits of the Data Matrix symbology but only encodes GS1 element string syntax. GS1 DataMatrix has seen adoption for applications in healthcare, transportation, logistics, fresh foods (fish, meat, prepared foods, etc.) and direct part marking.

GS1 DataMatrix is the standard for regulated healthcare trade items in many countries (such as the USA FDA Drug Supply Chain Security Act (DSCSA), European Union's Falsified Medicines Directive (EU FMD), China National Drug Administration (CNDA) traceability system and many more). As such, regulated healthcare manufacturers have developed extensive experience printing a dynamic GS1 DataMatrix encoding GTIN, batch/lot, expiration date and serial number.

GS1 DataMatrix is the carrier of choice for items that require permanent, non-ink barcodes (known as direct part mark or DPM) such as certain medical devices, unpackaged DIY items and those items that are not suited for packaging.

In several applications around the world, GS1 DataMatrix has been used on fresh food items at POS. These solutions encode the GTIN and additional variable-measure AIs to provide the necessary information at POS.

These existing implementations have built up a knowledge base among solution providers, brand owners, retailers and distributors, making the GS1 DataMatrix the B2B preferred 2D barcode.

For further details on the GS1 DataMatrix see GS1 DataMatrix Guideline and Section 5.6 of the GS1 General Specifications.

6.2.2.2 Data Matrix

As of the 2021 version of the *GS1 General Specifications*, the Data Matrix symbology can be used for applications encoding GS1 Digital Link URI syntax. The Data Matrix could be recognised by mobile device apps, allowing consumers to easily connect to brand-authorised content based on the encoded web link. Data Matrix shall not encode GS1 element string syntax; GS1 Digital Link URI syntax must be used instead. Data Matrix barcodes cannot currently be used for retail POS. More details on Data Matrix can be found in found in the relevant ISO Standard: ISO/IEC 16022 and Section 5 of the GS1 General Specifications.

6.2.3 QR Code

A QR Code is a 2D barcode consisting of black and white "cells" or dots arranged in either a square or rectangular pattern, also known as a matrix. QR Code offers a range of error correction levels (L – 7%, M –15%, Q –25% and H – 30%) that provides safeguards and additional capabilities for handling poorly printed or damaged symbols. A QR Code has a high data capacity and can store up to 4,296 alphanumeric characters. QR Codes are recognised by the consumer and by most smartphone camera apps and are often used for consumer engagement. Consumers have learned to scan the codes using their mobile devices to access brand-authorised content. Many existing implementations of QR Codes on-pack are now enabling proprietary experiences. When these barcodes are repurposed to use GS1 Digital Link URI syntax, they can be utilised to create a multi-use barcode that allows consumer engagement and POS price look-up without adding another data carrier or taking up additional space on packaging graphics. QR Codes cannot be used at retail POS at the time of publication. More details on QR Codes can be found in the relevant ISO Standard: ISO/IEC 18004 or in Section 5 of the GS1 General Specifications.

Note that GS1 QR code is a particular type of QR code that encodes Application Identifiers using GS1 element string syntax. This 2D code exists in some warehousing and logistics applications around the world, but it can be confusing in scenarios of consumer engagement, as it does not resolve to a website URL when scanned with a camera phone. Aside from specific implementations already in place that use GS1 QR code, new applications are recommended to consider QR codes with GS1 Digital Link syntax. More information on GS1 QR code can be found in Section 5.7 of the GS1 General Specifications.

6.3 Standardised Dual marking and multiple data carriers

When using a 2D barcode, a linear barcode, like the EAN/UPC, is still needed on-pack for a transition period. This is because not all systems are currently capable of scanning and processing 2D barcodes. This is partly because 2D barcodes cannot be scanned by linear scanners that have been used for 1D barcodes. 2D barcodes require optical scanning technology. Optical scanners are becoming more common in retail, but a substantial percentage of linear scanners are still in use. For the systems that already have optical scanners, additional updates may be needed to process and use the data that 2D barcodes hold.

POS systems must be updated to scan 2D barcodes and process, at minimum, the GTIN. Until these updates have been made across all retailers, a dual-marking transition period with a 2D barcode and the existing EAN/UPC barcode is required. This will ensure that advanced use cases can be implemented by retailers who have upgraded their hardware and software while the existing price lookup function will still work for retailers who have not.

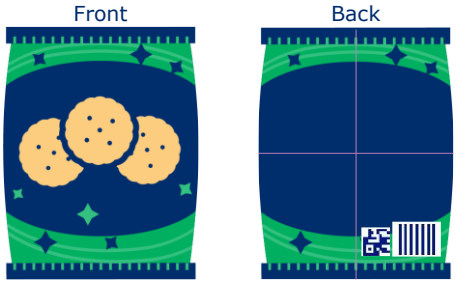
Industry has set the ambitious goal of retail POS scanners globally being capable of scanning and processing 2D barcodes by the end of 2027. For those determining which barcode to use on products, they would be able to continue to use a 1D barcode or select from standardised 2D barcode options.

Transition Period	Ambition for 2027
	
Dual-marking transition phase EAN/UPC ***and*** a 2D barcode	EAN/UPC ***or*** a 2D barcode

6.4 Symbol placement

When moving to a package with multiple data carriers, symbol placement is important. The EAN-13 or UPC-A should remain in its existing placement, according to the symbol placement rules laid out in Section 6.3 of the GS1 General Specifications. There are three placement possibilities for placing the 2D barcode during the dual-marking period: adjacent, non-adjacent and non-adjacent on front of pack.

Adjacent placement: Wherever two symbols can be used for the same application (for POS or for general distribution) they should be placed adjacent to one another. If a symbol is intended for POS and other applications, POS should take priority to ensure an item scans at POS. Adjacent placement allows supply chain partners to continue using their existing scanning processes while ensuring that at least one of the barcodes can be scanned. It will require proper setup to ensure scanners can discriminate and decode the barcodes they will be encountering based on specific business needs.



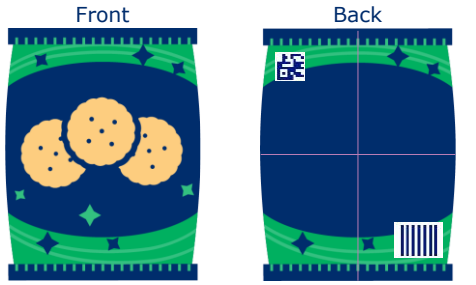
Preferred Placement

For instance, a retailer whose systems are set up to cancel the sale of expired products can prioritise scanning 2D barcodes to ensure those symbols are decoded first instead of the EAN/UPC barcode, which would not contain the expiration date. If the scanner is linear or only identifies an EAN-13 or UPC-A but not a 2D barcode, the EAN/UPC barcode could be decoded, and the sale processed using only the GTIN processed.

Adjacent placement also allows for a transition from an EAN-13 or UPC-A to dual marking to a sole 2D barcode while maintaining consistent symbol placement. When placing adjacent symbols, each symbol's quiet zones and other symbol placement rules must be respected. The orientation (stack or a row of symbols) or sequence (which symbol is placed on the left, right, top, or bottom) is determined by the brand owner.

If adjacent placement is not possible, symbols should be placed on the same panel. Symbols must be within the same field of vision and close enough to be within a scanner's timeout period (less than 150mm (6 inches) apart). If they are placed farther apart, scanners may think the symbols are from two different items, causing checkout issues like charging a customer twice for the same item.

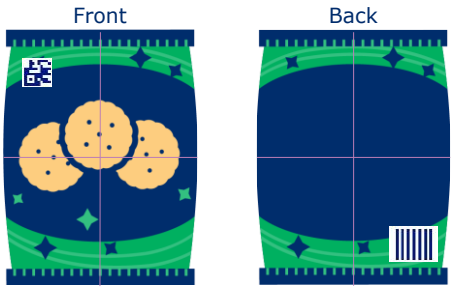
Non-adjacent placement: Wherever two symbols are used for different applications (one for POS and another for consumer engagement or internal supply chain purposes), non-adjacent placement should be used. The recommendation is to not have these two symbols (EAN/UPC + 2D barcode) adjacent to one another and additionally, consider placing them on different product packaging panels so scanners will not read them both. This will allow trading partners to scan the barcode that fits their scanning capabilities, or the barcode required for their application, either manually or automatically.



Preferred Placement

The guidance for hang tags is generally the same as for product packaging. Place the EAN/UPC in the same location as always and the 2D barcode on the other side of the tag, or in a different zone on the tag.

Non-adjacent placement on front of pack:
This is a subset of non-adjacent placement with a specific recommendation for the 2D barcode to be placed on the front of pack. It ensures a more consistent placement of the 2D barcode, allowing trading partners to locate and scan the barcode more quickly, especially at POS. Placing the 2D barcode on the front of the package also makes it visible while stocked on store shelves, allowing faster or automated scanning for inventory management or planogram accuracy. It can also allow consumers to scan the barcode without having to pick up and manipulate the product. However, front of pack placement does take up valuable real estate on the front of the package.



6.5 Human readable interpretation (HRI)

When designing a 2D barcode and packaging graphics, it is important to consider what data needs to be included in a human-readable format and how that data should be represented. Human-readable text allows manual key entry of data and makes the information accessible to consumers. By providing the data in a standard location near the barcode, information such as expiration dates can be found more easily by consumers and supply chain partners.

Human readable interpretation (HRI) refers to text printed exactly as it is encoded in the barcode. The only exception is the parentheses around the AIs, added in the HRI to help distinguish them. Non-HRI text is all other text on pack. See Section 4.15 of the GS1 General Specifications for the full rules on HRI and non-HRI text.

For barcodes encoding a large amount of data, it may not be practical to display all the data in HRI form. According to HRI Rule 9 in the *GS1 General Specifications*, even if there is space to show it in this form, it may not be required to include that much data. In these instances, some of the data may be omitted from the HRI if not required to meet critical use case needs. However, primary identification data (the GTIN, for the use cases covered by this document) must always be displayed. When deciding what data to include it is also important to consider if that data is represented elsewhere on-pack, especially where multiple barcodes are used. If data is omitted from the HRI and it does not appear anywhere else on-pack in non-HRI text, then the barcode is the only source of that data. If the barcode is damaged, or a user does not have a scanner, the data cannot be retrieved, and all the barcode and product data benefits are lost.

Using a blend of HRI/non-HRI text with data titles

HRI with some of the data omitted

Consider the data encoded in all barcodes on-pack and ensure all necessary information can be retrieved by trading partners and consumers when needed. To meet these needs most packaged goods, contain a mixture of barcodes, HRI text and non-HRI text. As a non-HRI text option, the data title may be associated with the data instead of using the AI numbers, see Section 3.2 of the GS1 General Specifications.

6.6 Barcode print quality

When implementing 2D barcodes at POS, brand owners will begin using new types of barcodes, encoding more data and printing more barcodes dynamically during the manufacturing process. It will be important to ensure these barcodes are printed at a high enough quality to be scanned throughout the supply chain. Scanners have limited capability to accurately decode a poorly printed barcode. Some examples of poor printing include (but are not limited to) poor contrast between light and dark, inconsistent colouring, or varying size of the squares (modules) that make up the barcode. Poor-quality barcodes may not be read by trading partners or may be decoded inaccurately.

Properly sizing a barcode is fundamental to ensuring good print quality. The Symbol Specification Tables found in Section 5.10.3 of the *GS1 General Specifications* can be used to design a barcode of proper size and quality. The parameters for size of a retail POS barcode are specified in The Symbol Specification Tables 1 and 3 of the GS1 General Specifications *Version 22.0* and includes an addendum to Table 1, covering QR Code and Data Matrix for use with GS1 Digital Link URI.

Manufactures can add in a production scanning system to monitor the print quality in real time or audit the print quality with an offline barcode verification system.

6.6.1 Barcode verification

To ensure that barcodes meet the quality needs outlined above, it is highly recommended to adopt a barcode verification program. Barcode verifiers are special pieces of equipment that scan a barcode and based on an assortment of parameters, give a quality grade for the printed barcode from 0.0 to 4.0. The minimum quality grade for all barcodes discussed in this document is 1.5; barcodes above the minimum quality grade should scan without problems in the open supply chain. However, print quality can degrade over time (and during transit), so higher grades should be targeted at the time of printing.

Verification can help companies understand the quality of their barcodes, whether trading partners can scan them, and what needs to be done to improve them. Without verification it is difficult to ascertain whether trading partners will be able to scan the barcodes and retrieve the correct data. Barcode verification can be done in-house or by an external company that will verify sample barcodes. The frequency of verification can vary depending on the manufacturing process and quality needs. Every barcode can be verified by an inline verifier or a select sample can be verified, such as from the beginning, middle and end of each run. To find a Solution Provider or learn more, contact your local GS1 Member Organisation.

6.6.2 Size of the barcode

Barcode scanners are optimised for a specific range of barcode sizes based on the scan environment. This document is focused on the barcode sizes allowed for point-of-sale scanning, although other scanning environments may be encountered.

The size of a 2D barcode is specified at the module level. As highlighted in orange (in the image to the right) a module is the individual square within the matrix. The size of one module is expressed in millimetres and inches (shown in parentheses) and is known as the X-dimension.

The symbol specification tables give minimum, target and maximum X-dimensions for each barcode. The amount of space on-pack, scanning environment, the quality of printing and the resolution of the printing process all factor into the optimal X-dimension for a package. A symbol that is too small may not be easily read by scanners, or it may be difficult to print at a high quality and sufficient resolution. If the 2D barcode is too large, it may be too difficult to scan up close or to print with high enough quality or resolution. Brand owners should not default to the minimum, target, or maximum dimensions but consider all these factors to choose the proper size for each barcode and product. To demonstrate the available X-dimension range, the GS1 DataMatrix (GS1 element string syntax) symbols below all encode the same GTIN, batch/lot number and production date. They encode the minimum 0.375mm (.0148”), target 0.625mm (.0246”) and maximum 0.990mm (.0390”) X-dimension listed in Symbol Specification Table 1 for trade items scanned in general retail POS and not general distribution. A rectangular symbol at target X-dimension has also been included. Rectangular symbols can fit better on small spaces or on narrow, curved surfaces.

7 Guidance for brand owners

Brand owners may have unique requirements such as disclosing country of origin, maintaining traceability to enable product recall, or establishing an expiration date for short-lived products. These needs can be met by encoding additional data on-pack.

Brand owners and retailers can also leverage the same data carrier on-pack to encode a GTIN for use at POS within a URL that provides a direct link to brand-authorised product information and content including product images, expiration dates, nutritional data, warranty registration, troubleshooting instructions, discount offers and more for consumer engagement in the store and post-purchase. This can be accomplished by using the GS1 Digital Link URI syntax. For more resources on GS1 Digital Link, including the Standard and Implementation Guide, see GS1 Digital Link.

Suggested checklist for brand owners to begin their 2D journey:

- Evaluate existing barcodes on-pack
- Pick a pilot product, line or category
- Determine use case
- Select the right data
- Select 2D barcodes based on use case
- Ensure software, hardware and databases are up-to-date
- Encode dynamic data in barcodes (where applicable)

The ability to deliver additional data via machine-readable code requires updates from manufacturing all the way to retail POS. Dynamic (vs. current, GTIN-only) information requires changes to printing and packaging. Widespread, higher-speed dynamic printing capabilities (800-1200 units per minute, or UPM) are emerging. Today high-speed digital printing technology can be utilised to print high quality 2D barcode on labels or packaging as part of the packaging strategy. Often the current printing technologies deployed in manufacturing are capable of printing 2D barcodes with dynamic data, but the product printing process may need to be modified to ensure print quality. Brand owners should implement product packaging strategies to incorporate dynamic and GTIN data, while supporting the multiple barcodes recommended in a flexible data structure.

The convergence of important technologies necessary to support industry migration to 2D barcodes is already starting. It will grow considerably in the 2022-2025 timeframe with adoption of higher-speed printing and as more retailers upgrade to optical scanners. Now is the time for businesses to evaluate their need for additional data on-pack and develop a plan to encode that data in 2D barcodes. This section will outline the steps brand owners need to take to develop their individual plans.

7.1 Evaluate existing barcodes on-pack

Many brand owners have already integrated 2D barcodes into their packaging graphics for various use cases. Typically, these cannot be scanned at POS and only enable a single use case, such as consumer engagement or supply chain management.

Transitioning these existing 2D barcodes on-pack to GS1 Standards can be a great first step to enable more use cases and interoperability—for example, existing QR Codes or Data Matrix barcodes on packaging can be updated to the GS1 Digital Link URI syntax, encoding the GTIN in a URL format. The 2D barcode could then be scanned for both price lookup and consumer engagement, leading the consumer to a GTIN-specific webpage. GS1 DataMatrix could be utilised at POS but does not currently offer the consumer engagement capability of QR Code or Data Matrix leveraging GS1 Digital Link.

These examples could be accomplished just by making a graphics change, even without updating packaging printing processes as use cases involving dynamic data require. Additional attribute data can be encoded on-pack at a later date as use cases are evaluated and systems are upgraded to print, process, store and use information beyond the GTIN. Collaborate with trading partners to determine if and when they can handle new data carriers and additional data.

The process of adding 2D barcodes on packaging and the ability to read, process and use the data at POS must be a collaborative process. Understand this cannot be a one-sided project. Before beginning, it is important to contact trading partners (suppliers, solution providers, distribution

centres, retailers, etc.) to enlist their help and advice and to determine what additional data would be mutually advantageous to share.

Prior to universal adoption of optical scanning and updated POS systems by retailers, dual marking with an EAN/UPC barcode will ensure that the product will still scan for price lookup by all retailers. As noted in the barcode option (see Section 6.2), it will be important to collaborate with individual trading partners to understand their capabilities and know who has updated their systems to scan 2D barcodes and process the contained data. Data sharing between trading partners also needs to be considered. To meet advanced use cases, additional data may need to be shared, such as lists of authentic GTIN and serial number combinations or recalled GTIN and batch/lot number combinations.

7.2 Pick a pilot product, line, or category

The prospect of converting all product packaging to include the extra data elements and the advanced data carrier that is needed to contain them may seem overwhelming. Consider selecting a single product, product line, or category to pilot the process. Once the specific use case for the pilot is identified, collaborate with your trading partners, solution providers and your GS1 Member Organisation to plan out the pilot.

7.3 Determine use case

Each company will have different priority use cases based on industry, trading partner requirements and business needs. See Section 4.0 to overview the most common use cases identified by industry.

7.4 Select the right data

While the GTIN will still be necessary for price lookup at POS and basic inventory management, inclusion of additional data attributes will be driven by the use case and any regulatory needs, retailer requirements, or industry guidance. As the industry transitions to 2D barcodes, encoding AI (01) with the 14-digit GTIN, as well as any optional AIs driven by use case, will be required. See Section 5 for the standardised GS1 data elements that will most likely be used at POS.

There may be circumstances where different retail trading partners each demand different data elements to be encoded in a high capacity 2D barcode. It is important to follow the general best practices offered by the GS1 System specifications, such as avoiding encoding master data or information that can be shared electronically. All the required data elements for the brand owner and the different retailers should be encoded in a single 2D barcode. Section 8 provides retailers with best practices for processing 2D barcodes with many data elements and retrieving only the data they need.

7.5 Select 2D barcodes based on use case

As explored in Section 6.2, there are several 2D barcodes that can be used, depending on the use case. To ensure a product can be scanned by all retailers for all use cases, multiple barcodes may be needed, including a dual-marking period in which both the EAN/UPC barcode and a 2D barcode are used (see Section 6.3). While RFID can be leveraged to meet many use cases, it is not commonly used as a POS technology. Items tagged with RFID will also need to be barcoded with a 2D barcode and EAN/UPC barcode for point-of-sale.

Once the 2D barcodes have been selected, see Section 6.4 to determine where the additional data carriers should be placed on pack. Section 6.5 overviews considerations for how the data contained in barcodes should be included in human-readable text.

7.6 Ensure software, hardware and databases are up to date

Enabling the use cases discussed in these documents requires updates not only to packaging, but also to software, hardware and databases. Software and databases must at a minimum be updated to handle and store AI (01) + 14-digit GTINs. They must also be updated to create, store and share any additional data elements that will be associated with products, such as batch/lot number and serial number. For use cases like product recall and traceability, the ability to search databases by

batch/lot number and find associated data such as production date or time and manufacturing location will be crucial.

Hardware such as barcode printers and scanners must also be updated to handle 2D barcodes and the attribute data encoded within.

Work with solution providers to ensure the proper hardware and software capabilities are in place. These requirements outlined above can be integrated into the technology upgrade roadmaps and projects as well as hardware and software procurement plans.

7.7 Encode dynamic data in barcodes

With human-readable batch/lot numbers and dates (e.g., best before and expiration dates), many manufacturers already have experience printing dynamic data in line. However, printing this information in a machine-readable barcode may require updates to printer lines and systems. A barcode verification program, as discussed in Section 6.6, is strongly recommended to ensure that barcodes meet the quality requirements and can be scanned by trading partners.

8 Guidance for retailers

With the ambition to transition to a retail ecosystem that accommodates scanning of 2D data carriers, without dual marking, by 2027, retailers that have not already made the transition should replace linear scanners with optical scanners and upgrade their POS systems to process AI (01) + GTIN +, if applicable, attribute data. GTIN storage database tables should be made 14-digit capable. This capability will better enable scanning GTINs from the 2D barcodes discussed in this document. These requirements need to be incorporated in retailers' technology roadmaps/projects and hardware and software procurement plans.

Brand owners are required to accommodate many different customer needs. In a 2D barcode environment, this means a variety of data elements will be encountered by distribution centres and store receiving systems that are not expected. It is important, when expanding the receiving system, to program it to ignore potentially unneeded product attribute data and not reject the barcode. This also means that the sequence of encoded data may not be in the expected order. It is further important not to program a required sequence for data elements.

Suggested checklist for retailers to begin their 2D journey:

- Evaluate POS infrastructure
- Ensure systems can handle an AI (01), a 14-digit GTIN and additional AIs
- Collaborate with trading partners
- Educate associates
- Educate consumers: self-checkout, omni-channel and consumer engagement
- Evaluate opportunities for private label products

8.1 Evaluate POS infrastructure

POS systems need to be able to recognise the AIs and store the data in their respective fields in the database.

- At minimum, retailers need to scan, process and store AI (01) + 14-digit GTIN in traditional GS1 element string syntax or GS1 Digital Link URI syntax (if not translated and parsed to GS1 AIs).
- As implementations evolve, retailers may also need to scan, process, store and share additional AIs containing attribute information.
- If additional AIs are present beyond those a system has been set up to process, parse the AIs without rejecting a barcode's scan.

Scanner hardware

POS scanner hardware needs to be upgraded from linear to optical scanners to read 2D barcodes. Optical scanners need to be capable, configured and activated to process currently used symbologies such as the EAN-13, UPC-A barcode and GS1 DataBar and 2D barcodes such as GS1 DataMatrix, Data Matrix and QR Code. POS scanners include POS lanes, self-checkout, self-scan and hand-held units in POS lanes and on the sales floor and backroom.

POS software

POS software includes programs used at cashier lanes, unattended lanes (self-checkout, self-scan) and home shopping applications. The software needs to be capable of processing the AI (01) + GTIN + optional attribute information encoded in the 2D barcode in the GS1 element string and GS1 Digital Link URI syntax (e.g., best-before date, batch/lot number, weight).

- POS systems should have the ability to accept multiple AIs and process only those relevant to individual retailers' POS processes.
- A POS Transaction Log needs to be capable of downstream processing and utilisation of the POS transaction data containing any additional GS1 Application Identifiers present, such as the batch/lot number, serial number, expiration date, net weight, etc.
- All relevant GTINs need to be listed in the POS system for price lookup to prevent checkout delays.

- The additional data needed for advanced use cases needs to be accessible by the POS system. An example is a list of recalled GTIN and batch/lot number combinations, or a list of authentic GTINs and serial numbers.
- POS applications need to accommodate the key entry of required AIs in human readable interpretation (HRI) format to meet retailer requirements. When barcodes fail to scan, any prompting of key entry or other processes must be considered for both checkout staff and self-scanning customers.

8.2 Ensure systems can handle an AI (01), a 14-digit GTIN and additional AIs

A POS system should be evaluated for the following capabilities:

- Ability to scan, process and store AI (01) and a 14-digit GTIN.
- Enabling advanced use cases with additional AI data – e.g., a "sale stop" when an expired or recalled product is encountered.
- Enabling automatic markdowns when products are scanned close to their expiration date.
- Allowing data collection/save function to facilitate efficient recall and return management from customer loyalty program information.
- Receiving function that can handle dynamic data and interact with POS system.
- Ability of e-commerce fulfilment and backend store systems to be fully integrated.
- Capability of host systems software/master data to support all forms of GTIN and one or more GTINs assigned to a stock-keeping unit reference.
- Ability of scale/labelling software to handle AI (01) + GTIN, at a minimum; and AIs that may be needed for a specific use case to be processed by the POS system.

Other system considerations:

- Ability of hardware equipment and software application for price verification, product receiving, inventory recording/checking, capable of reading and processing AI (01) and 14-digit GTIN and optional GS1 AIs in advanced data carriers.

Lastly, map out the end-to-end process for each product type to:

- Ensure clarity on data origination, movement through the complete supply chain and use in the store or head office systems .
- Confirm requirements with both supply chain partners and any solution providers .

Along with quantifying the business benefits, these steps can be helpful in any business case justification.

8.3 Collaborate with trading partners

It is critical to collaborate with trading partners to:

- Prioritise the use case(s) to address those that are not being solved by the EAN/UPC barcode.
- Identify what product attribute data is required to solve the use case(s).
- Determine what data and what platform will be used to query and share data.

8.4 Educate associates

Educating associates is a vital element of a 2D barcode implementation project. The AIs selected and shared by suppliers will dictate which associates need specific orientation around the scanning of the 2D barcodes and the storage/usage of data. For instance, store cashiers need to be made aware of recall messages that have been programmed into the POS system based on GTIN and batch/lot number data, or of potential counterfeit items based on GTIN and serial number.

Additionally, consider other processes that involve associates beyond POS, such as returns, price check, or other inventory actions.

If systems are adjusted to prioritise barcodes other than the EAN-13 or UPC-A, store associates may need to be made aware to scan 2D barcodes.

8.5 Educate customers: self-checkout, omni-channel and consumer engagement

This education may be in the form of advertisement on a website, mobile app, email campaigns, social media, TV, videos and/or sales flyers. Customers need to be aware that 2D barcodes can be scanned at self-checkout and on mobile apps for self-checkout.

Customers have been prepared for self-checkout by years of watching store employees scan EAN/UPC barcodes at fixed POS registers. Do not discount this valuable resource for educating customers about 2D barcodes and the value they provide them. Additionally, since any 2D barcode can be paired with a mobile app for a unified omni-channel experience, consider the opportunities to engage consumers outside the retail store, such as:

- Recall management.
- Returns processing.
- Warranty registration.

8.6 Evaluate opportunities for private label products

Private label or store brands offer a great opportunity to implement 2D barcodes since retailers have ownership of the entire supply chain (packaging, marketing, data, etc.). For additional guidance on next steps with private label, see the guidance for brand owners in Section 7.

9 Guidance for solution providers

Realising the benefits of data rich barcodes at scale is no small feat. Hardware, software, systems and entire ecosystems will need to further adapt at scale. Solution partners have a critical role in the 2027 ambition for a global transition to 2D barcodes at POS. Reach out to customers to understand their:

- Current systems – evaluate functionality used vs. capabilities (POS, printing, data storage and sharing).
- Requirements for future capabilities.
- Transition plans.

Solution provider support and expertise is critical to drive faster and better implementations. Early involvement and ongoing collaboration with both brand owner and retailer solution providers will provide additional value and help readiness activities and transition plans. Solution providers are instrumental in providing important solutions and services to help retailers and brand owners implement product identification and data programmes.

Suggested checklist for solution providers to support brands and retailers on industry's 2D journey:

- Enable AI (01) and 14-digit GTINs
- Support customers' printer requirements
- Support scanner updates
- Enable POS system readiness
- Integrate the 2D strategy with back-office systems

9.1 Enable AI (01) and 14-digit GTINs

It is essential, in the following systems updates, to ensure all systems can process AI (01) and 14-digit GTINs in both GS1 element string syntax and GS1 Digital Link URI syntax. This will be the basis to ensure that the information in 2D barcodes can be scanned at POS and shared amongst systems and encoded into data carriers. Importing additional AIs and data elements will be optional for retailers depending on their use cases and implementation, so systems should be flexible enough to provide the solutions that customers need. Keeping systems grounded in GS1 Standards will ensure interoperability between customers and trading partners.

9.2 Support customers' printer requirements

Dynamic encoding (GTIN + attribute data vs. GTIN-only encoding) of information requires changes to printing and packaging. Widespread, higher-speed dynamic printing capabilities (800-1200 UPM) are needed to support the high-speed lines of the CPG industry.

During the transition period, brand owners will need to implement product packaging strategies for dual marking to include an EAN/UPC barcode (with GTIN-13 and GTIN-12) and a 2D barcode (with AI (01) + 14-digit GTIN and potentially attribute data).

Printer equipment for this application should be capable of producing the EAN-13 or UPC-A barcodes and at minimum, the 2D barcodes listed in Section 6.2 (GS1 DataMatrix, Data Matrix and QR Code) with the GS1 Application Identifiers listed in Section 5.4. Some AIs identify fixed-length data fields, while others support variable-length data fields. The *GS1 General Specifications* includes additional information that can be useful, such as the entire list of recognised AIs with their corresponding data fields and length (Section 3), Human Readable Interpretation label information (Section 4) and maximum and minimum barcode dimensions (Section 5).

9.3 Support scanner updates

Scanners will encounter items with dual markings during the transition period: an EAN-13 (GTIN-13) or UPC-A (GTIN-12) barcode plus an advanced data carrier (AI (01) and 14-digit GTIN + additional AIs).

If the retailer has linear scanners installed, it will continue to read the EAN/UPC barcodes and pass that data to the POS system.

If the retailer has optical scanners installed, either the EAN/UPC barcode or the 2D barcode can be read.

- If the retailer's POS system is not capable of handling the GS1 AI data, it should read the 2D barcode and parse only the 14-digit GTIN.
- If the retailer's POS system can handle the GS1 AI data, it should read the 2D barcode and parse the 14-digit GTIN and GS1 additional AI data.
- Scanners should be able to translate and parse GS1 Digital Link URI syntax to 14-digit GTIN and GS1 additional AI data.
- Scanners should be able to auto discriminate the 2D barcodes encoded with GS1 additional AI data.
- If the product is dual marked, the scanner should deliver the 14-digit GTIN and GS1 additional AI data once.

For retailers with optical scanners that can process GS1 AI data, the retailer, solution providers and internal retailer IT teams should work together to ensure scanners are properly processing the data and multiple barcodes. Retail implementations should strive for these capabilities to maximize the benefits of all the attribute data encoded on-pack.

Scanners need to capture the GTIN and the GS1 Application Identifiers encoded in a 2D barcode. Priority AIs are outlined in Section 5.4 of this *Getting Started Guide*. For a complete list of all GS1 Application Identifiers, their length and data titles, reference *GS1 General Specifications*.

Notes:

- AIs are of different lengths.
- Data fields may be fixed or variable in length.
- Software solutions should be based on the latest table of GS1 Application Identifiers.
- Solution providers should make a provision for updating GS1 AIs with each software maintenance cycle.

9.4 Enable POS system readiness

Different retailers' POS systems are at differing stages of readiness to process AIs. This section describes the optimal end state to leverage the additional data.

It is recommended to have the scanner pass all AIs to the retailer's POS application software. Retailers' POS systems need to be able to read process and store AI (01) and the 14-digit GTIN. POS systems should be capable of identifying and processing the GTIN in both traditional GS1 element string and GS1 Digital Link URI syntax (if not translated and parsed to GS1 AIs). The retailer will specify which additional AIs they want processed from the POS application software.

For example, a retailer may only be interested in the GTIN and expiration date. One supplier may have the expiry date as the fourth AI in their barcode. Another may have the expiration date as the fifth AI. The retailers' POS processing will need to accurately pass the unused AIs and data between the GTIN and the expiration date. This approach requires that the POS software understands at least the data length associated with each AI. This is important even for AIs that are not currently being processed because the standard generally allows AIs beyond the GTIN to be in any order within the barcode.

GS1 recommends designing the POS application to understand the symbology identifier along with the AIs and barcode data, further allowing the POS system to be certain which barcode it is processing.

9.5 Integrate the 2D strategy with back-office systems

To fully leverage attribute data, the 14-digit GTIN + AIs need to be consumed and integrated into backend systems such as ERP, inventory, supply chain management and merchandising systems. Additionally, companies typically have legacy backend systems—which can add complexity to any system integration.

10 Glossary

Term	Definition
Two-dimensional (2D) barcode	Optically readable symbol that must be examined both vertically and horizontally to read the entire message. Two-dimensional symbols may be one of two types: matrix symbols and multi-row symbols. Two-dimensional symbols have error detection and may include error-correction features.
Advanced data carrier	Data carriers capable of encoding additional data beyond the GTIN. Includes 2D barcodes (e.g., GS1 DataMatrix, Data Matrix, QR Codes), RFID and future data carriers.
Attribute data	Data that provides additional information about a product identified with a GS1 identification key, such as batch/lot number and serial number, associated with a primary key like the Global Trade Item Number (GTIN) or another GS1 Identification key. Attribute data can be encoded in GS1 element string and GS1 Digital Link URI syntax.
GS1 Application Identifiers (AI)	A finite set of specialised identifiers encoded within barcodes to indicate the type of data represented in the various barcode segments (e.g., GTIN, serial number, expiration date, etc.). GS1 element string and Digital Link syntax are two ways to communicate attribute data.
Backend systems	Non-POS systems such as inventory, supply chain management and merchandising systems.
Dual marking	Inclusion of multiple data carriers on a package to meet advanced use cases while ensuring the basic price look-up use case can be met at all retailers.
Dynamic data (dynamic attribute data)	Data that is (not static) not fixed across a GTIN and may change. This may include production date of a product or, for example, the location and boat where a fish was caught. The GS1 GTIN Management Standard defines when changing the data associated with a GTIN requires a new GTIN.
EAN-13 barcode	A barcode of the EAN/UPC linear barcode family that encodes GTIN-13. EAN barcodes are used worldwide for price lookup at retail point-of-sale.
Encode	The process of placing data into a data carrier. For example, the UPC-A barcode encodes a GTIN, while advanced data carriers can encode the GTIN plus attribute data.
EPC®/RFID	EPC is an identification scheme for universally identifying physical objects (e.g., trade items, assets and locations) via RFID tags and other means.
GS1 Digital Link	A GS1 Standard, including a syntax that defines how to encode GS1 Application Identifiers into a barcode in a URL format.
GS1 Digital Link URI	A URL that conforms to the structure (syntax) defined in the GS1 Digital Link standard.
Global Trade Item Number® (GTIN®)	The GS1 identification key used to identify trade items. The key comprises a GS1 Company Prefix, an item reference and check digit.
Linear scanners (laser scanners)	Laser-based scanners developed to scan linear barcodes—the traditional POS scanner. Linear scanners cannot scan 2D barcodes.
On-pack	Printed or attached to the product or product package.
Optical scanners (image-based scanners)	Can read printed 1D and 2D barcodes, decode the data contained in the barcode and send the data to a system.
Point-of-sale (POS)	The point-of-sale (POS) or point of purchase (POP) is the time and place where a retail transaction is completed.
Restricted circulation number (RCN)	GS1 identification number used for special applications in restricted environments, such as inside the four walls of a retailer. Not intended for the open supply chain.
SmartLabel™	SmartLabel is a tool for manufacturers to provide consumers a way to digitally access more detailed product information. For more information about SmartLabel, please go to: http://www.smartlabel.org/.
Static data	Data that is fixed across a GTIN and will not change.

Term	Definition
Syntax	A format for expressing data. This document refers to both GS1 Digital Link URI syntax and GS1 element string syntax.
UPC-A barcode	A member of the EAN/UPC family of linear barcodes. It is the main barcode used at POS in the U.S.
Variable-measure trade item	A trade item that may be traded without a pre-defined measure, such as its weight or length.

11 Additional resources

Below are some additional resources that complement this *Getting Started Guide*.

11.1 GS1 General Specifications

The GS1 General Specifications are foundational GS1 standards that define how identification keys, data attributes and barcodes must be used in business applications.

11.2 GS1 Digital Link resources

GS1 Digital Link landing page, including GS1 Digital Link Standard and the GS1 Digital Link Implementation Guide.

11.3 2D at POS for fresh foods

The GS1 AIDC Fresh Foods Sold at Point of Sale Implementation Guideline provides direction for migrating from an RCN (restricted circulation number) to a GTIN and Application Identifiers (AIs) (e.g., pack weight, price, variable count of items, net weight, price, best-before date, batch number, etc.).

11.4 GS1 US Future of Retail resources

GS1 US has performed research with companies based in the United States. Results of their research are available online at the GS1 US Future of Retail landing page, including the *Powering the Future of Retail: Building Upon the Foundation of the U.P.C. Barcode* research paper. Additionally, GS1 US has a US-specific GS1 Digital Link Implementation Guide.

12 Corrections to the Getting Started Guide

Release 1.1 includes the following corrections:

- Section 5.2: typo corrected for the captions under the 2D codes – the GS1 DataMatrix and QR codes encode a GTIN-13 (not GTIN-12) represented in 14-digit format, using AI (01).
- Section 6.2.1: correction to clarify that GS1 DataMatrix for variable-measure (weight or count) fresh food is allowed for POS applications in version 22.0 of the *GS1 General Specifications* under trading partner agreement.

Release 1.2 includes the following correction:

- Section 5.3: typo correcting the description and captions for the 2D codes shown – AI (13) is the Application Identifier for packaging date, not production date.

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