The Global Language of Business

GS1 US Advanced Data Carrier for Point-of-Sale (POS) Getting Started Guide

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About GS1

GS1® is a neutral, not-for-profit, global organization that develops and maintains the most widely used supply chain standards system in the world. GS1 Standards improve the efficiency, safety, and visibility of supply chains across multiple sectors. With local Member Organizations in over 110 countries, GS1 engages with communities of trading partners, industry organizations, governments, and technology providers to understand and respond to their business needs through the adoption and implementation of global standards. GS1 is driven by over a million user companies, which execute more than six billion transactions daily in 150 countries using GS1 Standards.

About GS1 US

GS1 US®, a member of GS1 global, is a not-for-profit information standards organization that facilitates industry collaboration to help improve supply chain visibility and efficiency through the use of GS1 Standards, the most widely used supply chain standards system in the world. Nearly 300,000 businesses in 25 industries rely on GS1 US for trading-partner collaboration that optimizes their supply chains, drives cost performance and revenue growth while also enabling regulatory compliance. They achieve these benefits through solutions based on GS1 global unique numbering and identification systems, barcodes, Electronic Product Code (EPC®)-based RFID, data synchronization, and electronic information exchange. GS1 US also manages the United Nations Standard Products and Services Code® (UNSPSC®).

1 Introduction

***Important**: As with all GS1 Standards and solutions, this guideline is voluntary, not mandatory. It should be noted that use of the words "must" and "require" throughout this document relate exclusively to technical recommendations for the proper application of the standards to support the integrity of an implementation. The information contained herein is for informational purposes only as a convenience and does not constitute legal advice or a substitute for legal counsel. GS1 US Inc. assumes no liability for the use or interpretation of the information contained herein.*

1.1 Background

The U.P.C. barcode (UPC-A) has been a trusted and ubiquitous data carrier for facilitating the price look-up function at retail point-of-sale (POS) since 1972. This innovation automated a critical business process for cashiers everywhere. However, the tried-and-true UPC-A barcode was not built for the more complex data needs of today's retail environment that is being transformed by significant technology developments and shifting consumer expectations.

The UPC-A is limited to carrying only the Global Trade Item Number® (GTIN®) associated with a product. It is 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).

To present industry perspectives on the landscape, considerations, and options for a migration path toward the "next generation" of barcodes that meet more robust data needs, GS1 US®, in partnership with VDC Research, authored the research and insights paper, "*Powering the Future of Retail: Building on the Foundation of the U.P.C. Barcode.*"

1.2 Purpose

The impetus for change is driven by the industry need to encode more data on-pack than simply the GTIN in order to meet the growing information demands of consumers, enable additional supply chain efficiencies, and build brand trust by providing more accurate, complete, and up-to-date product information.

Based on more than 45 years of industry collaboration and the above-mentioned research, brand owners, retailers and solution providers have pointed to the need for guidance from GS1 US to help:

- Build solutions based on standardized 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 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 optimize 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 advanced data carriers while minimizing disruptions to existing business processes. This *Getting Started Guide* is focused primarily on the considerations and implications of utilizing an advanced data carrier at point-of-sale. For the purposes of this document, "advanced data carriers" include any data carriers that can encode data in addition to the GTIN, allowing for use cases beyond price lookup.

The key 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
- 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 an advanced data carrier using the GS1 Application Identifiers
  This document is expected to expand over time based on growing user implementations and as the standards are updated.

1.3 Scope

In Scope	Out of Scope
▪ Guidance for U.S. retailers, brand owners, and solution providers ▪ Any consumer units scanned at retail POS. ▪ Guidance on how to use GS1 DataMatrix, Data Matrix, QR Code, and Radio Frequency Identification (RFID) ▪ Encoding data attributes using GS1 element string syntax and GS1 Digital Link URI (Uniform Resource Identifier) syntax ▪ Dual marking: EAN®/UPC barcode + 2D data carriers	▪ 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], 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.

2 General guidance

This section provides information that may be used by any sector or any side of the trading partner relationship that is looking to implement data carriers containing additional attribute information. Before beginning to implement advanced data carriers 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 US University*.

2.1 What is a U.P.C. and what is a GTIN?

When discussing U.P.C. barcodes, it is important to properly define the terms. As we move to advanced data carriers, 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.

When people mention U.P.C. barcodes, they typically are referring to the UPC-A barcode, which is a member of the EAN/UPC family of barcodes. This family of barcodes was developed for POS scanning and includes the UPC-A, EAN-13, UPC-E, and EAN-8. The UPC-A is the most commonly used barcode at POS in the U.S.

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, commonly used for POS applications outside the U.S. For more information on GTINs, see the GS1 US *Intro to the Global Trade Item Number (GTIN*).

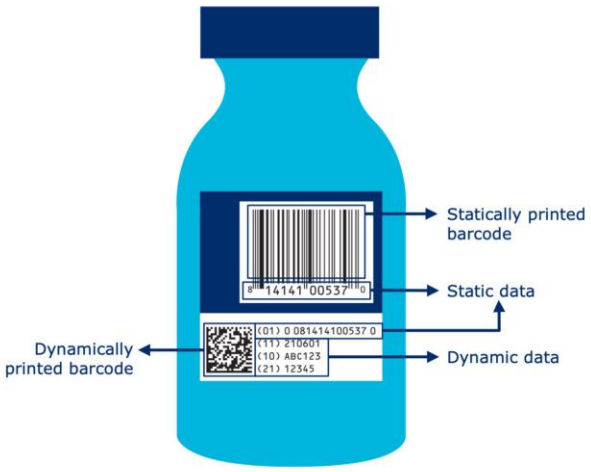
2.2 Primary identification vs. attribute data

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 number, serial number, or expiration date. Advanced data carriers such as two-dimensional (2D) barcodes and RFID tags 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, ingested, and processed at POS. This upgrade has system implications for both hardware and software, which will be explored in this document.

2.3 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 Global Data Synchronization 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 an automobile part 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 location and ship where it was caught. 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 then printed on demand at the plant or production line, using inkjet printers or laser marking systems. 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.

Static vs. dynamic (with non-exhaustive 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
Printing	Consistent across the GTIN and often pre-printed: ▪ Nutrition facts panel ▪ 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 ▪ SmartLabel® URL	Link that changes depending on dynamic data: ▪ Traceability web page URL for product based on batch/lot number

2.4 Scanners

2.4.1 Types of scanners

Barcode scanners come in two general categories: linear (laser) scanners and optical (camera-based) scanners. Linear scanners can only scan linear or one-dimensional barcodes; these are the familiar barcodes with vertical bars and spaces. Until recently, most barcode scanners were linear scanners.

Optical scanners take a picture of a 1D or 2D barcode and analyze it to apply the proper decoding algorithm. This type of scanner is needed to scan 2D barcodes. Most mobile devices can serve as optical scanners, utilizing the device's camera or a mobile app. The *Powering the Future of Retail* research showed rapid adoption of optical scanners by the retail industry.

Barcodes and RFID tags are different types of data carriers that require different scanning systems. RFID tags are read by specialized RFID readers, which read radio waves transmitting data from RFID tags and unlike barcode scanners, do not require a line of sight to retrieve data from the data carrier.

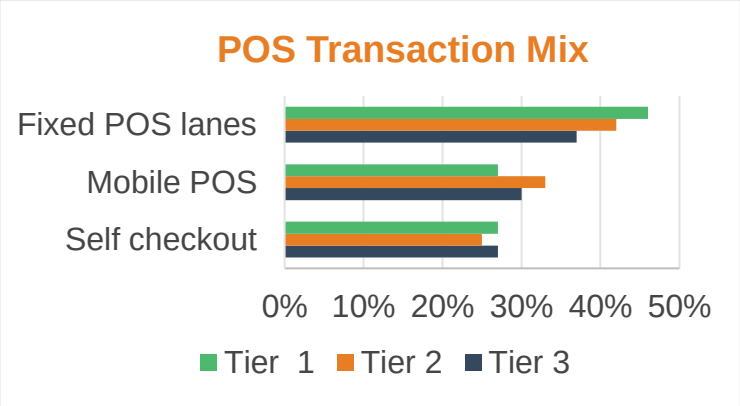
2.4.2 Scanner programming

Scanners can be programmed to identify and process only a single type of barcode or upwards of 30 depending on what the systems need to interact with. The scanners use decoding algorithms to determine what type of barcode is being scanned and then process the data accordingly. This data is then ingested into systems based on programmed settings that move the standardized data to the required fields in the application. There may be different settings based on the application such as POS systems, inventory management, or receiving. To save the time of running the scan results through all the programmed algorithms, scanner users usually have the option of choosing and prioritizing the barcodes that are used within their application.

Traditionally, POS scanners in the U.S. would mostly scan UPC-A barcodes. Therefore, most scanners utilized for point-of-sale have prioritized the UPC-A and have turned off or disabled other barcodes right from the factory. With multiple data carrier options emerging, many industry stakeholders—including retailers—will have to reconsider their scanner programming and which barcodes they will prioritize. Work with solution providers and internal teams to ensure scanners can decode the barcodes they will be encountering and prioritize them based on specific business needs. As implementations and the data carrier environments evolve, the scanner settings may need to be updated accordingly.

2.5 Expansion of scanning environments

One major finding of the *Powering the Future of Retail* research was the expansion of non-traditional POS channels. POS transactions have long been centered 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.



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

2.6 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 standardized data will be key 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 Overview page* or *GS1 US University*.

2.7 Data sharing and analytics

Attribute data encoded on-pack along with the GTIN provides additional data that the retailers, brand owners, and consumers can leverage. To fully leverage this data, data analytics, artificial intelligence, machine learning, and robotic process automation solutions are evolving and need to be able to drive process change in the near-term horizon. 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 that are outlined in the use cases in *Section 3* of this *Getting Started Guide*.

2.8 Sunrise 2027

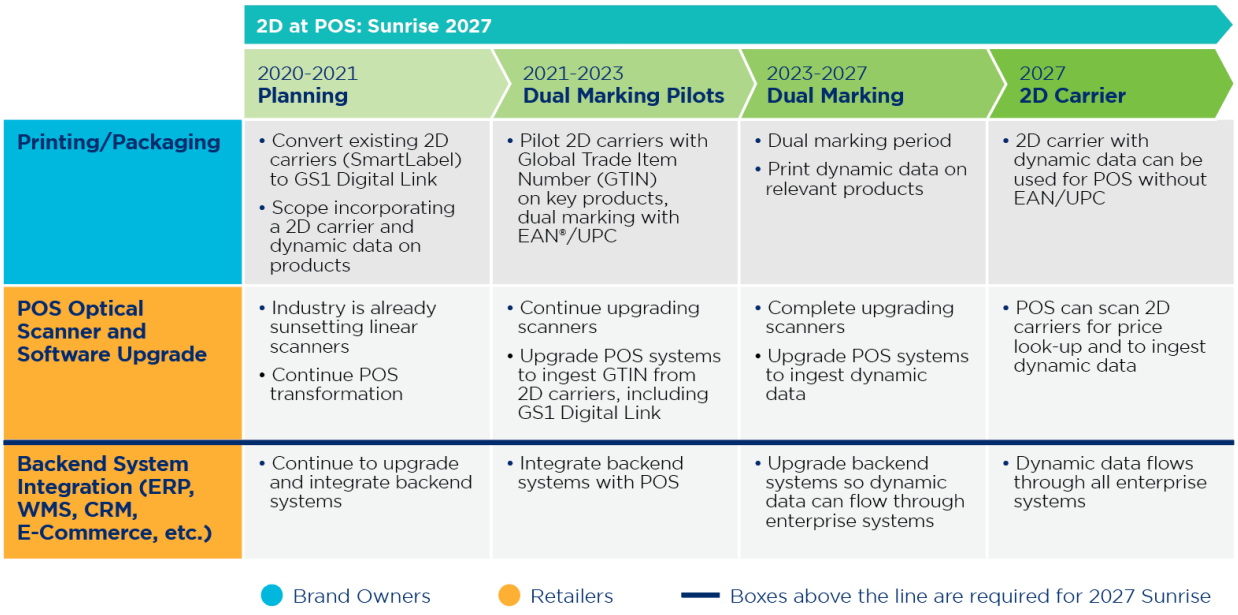
In May 2020, GS1 US began the Sunrise 2027 initiative to support adoption of 2D barcodes at POS. The *Powering the Future of Retail* research revealed that retailers and brand owners expressed a need to encode more data on-pack and that the retail industry would be ready to transition in three to five years (2023-2025). After the Sunrise 2027 date, advanced data carriers encoded in element string or GS1 Digital Link URI syntax will be usable at any retail POS without the need for an EAN/UPC barcode (dual marking not required). **The EAN/UPC barcode is not going away and will continue to scan at**

POS after 2027. After 2027, brand owners will be able to choose between using an EAN/UPC or a 2D barcode.

To support the Sunrise 2027 initiative, retailers will need to upgrade their scanner infrastructure to replace linear/laser scanners with optical scanners. This upgrade is already occurring—the research showed optical scanners are quickly becoming more prevalent in the marketplace.

The sunrise date asks 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 to read 2D barcodes encoded with an AI (01) + 14-digit GTIN.
  - Upgrade POS systems to ingest, 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 Use cases

In the *Powering the Future of Retail* research, industry members conveyed key 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, inventory accuracy, and product authenticity.

3.1 Current use case: price lookup

The UPC-A barcode was 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 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.

3.2 Overview of advanced use cases

3.2.1 Inventory accuracy

Inventory accuracy was cited as the most frequent driver for adopting advanced data carriers. Although a UPC-A can be used for inventory accuracy, it is limited to encoding the GTIN and requires line-of-sight scanning. As a result, the apparel industry and others have migrated to EPC/RFID, which allows for real-time inventory to be taken without line of sight. RFID and 2D barcodes also allow more granular identification beyond the GTIN with capacity to encode serial numbers. Using both an RFID tag and a 2D barcode together can allow item-level identification throughout the supply chain, offering non-line-of-sight scanning and a barcode on-pack when needed. Inventory accuracy is also related to micro-manageability by expiration date for monitoring product freshness and waste reduction.

3.2.2 Improved 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 recognized 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, limiting enabled uses to SmartLabel applications only. Brand owners are also printing advanced data carriers 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 data carrier 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.

GS1 Digital Link URI syntax was developed to overcome these limitations by providing a standard URI, web format, or website URL address such as *www.GS1US.org*. Utilizing 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 2.8* and *Section 5.3* to understand the path to using GS1 Digital Link at POS. More information on GS1 Digital Link can be found in *Section 4* and in the *GS1 US GS1 Digital Link Implementation Guide*.

3.2.3 Product authenticity

Both consumers and brand owners are concerned about product authenticity. Counterfeit goods cost the U.S. $29 to $41 billion annually[1]. Serialization 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 serialized 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.

3.2.4 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.

3.2.5 Freshness/waste prevention

Currently, one-fifth of all food waste is caused by date confusion[2]—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. This benefit was cited by one-third of retailers.

3.2.6 Returns management

There has been a 34 percent increase in retail returns over the last six years[3]. Seamless returns contribute significantly to positive consumer experiences. They also reduce operating costs, but retailers require more information than is available within the UPC-A to effectively facilitate returns. Serialization 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.

3.2.7 Variable measure trade items

Fresh food priced by variable measure, such as weight or count (e.g., pre-packaged salads and entrées, produce, meat, and seafood), can have the product identifier (GTIN), weight, count, and price encoded on an advanced data carrier. 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.

[1] Feb 2017, *Inc.* magazine. Retrieved on March 11, 2019 from https://www.inc.com/associated-press/counterfeiters-cost-600-billion-a-year.html

[2] 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

[3] 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

Prioritization of Point-of-Sale Use Cases

	Inventory Accuracy	Improved Consumer Engagement	Product Authenticity	Traceability	Freshness/ Waste Prevention	Returns Management
Pharma	★	★	★	★	★	
OTC	★	★			★	★
Apparel	★	★	★	★		★
Health & Beauty	★	★			★	★
Baked Goods	★	★			★	
Fresh Foods/Produce	★	★	★	★	★	
Hardlines	★	★				★
Beverages	★	★			★	
Grocery	★	★			★	
	★ Priority		Nice to have		Unimportant	

Note: Regulated healthcare was considered out of scope for this research.

Source: Beyond the U.P.C. Research, 2018

4 GS1 Application Identifiers

4.1 Introduction to GS1 Application Identifiers

While we may be entering a world with multiple data carriers in use (UPC-A + data-rich carriers such as GS1 DataMatrix, Data Matrix, QR Code, or RFID), interoperability can still be accomplished across industries and trading partners by ensuring these carriers encode standardized data elements in a common syntax. Standardized 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 specialized 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 of the AIs reside in the *GS1 General Specifications*.

While this document focuses on encoding AIs in traditional element string syntax, GS1 data can also be encoded using Electronic Product Code (EPC) syntax or the GS1 Digital Link URI syntax. EPC syntax can also be used to encode GS1 data in RFID tags. More information can be found in the *EPC Tag Data Standard*.

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, etc.), and other GS1 keys such as GLN, SSCC, etc.

https://example.com/01/00614141999996

Note: *Any* valid combination of GS1 element strings, as defined in Section 4.14 of the *GS1 General Specifications*, can be encoded using Element String Syntax or a GS1 Digital Link URI.

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

https://example.com/01/*00614141999996*/10/ABC

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

(01)00614141999996(10)ABC

The same information can be expressed in EPC syntax as an LGTIN (combination of GTIN and lot number):

urn:epc:class:lgtin:0614141.099999.ABC

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

4.2 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 UPC-A or EAN-13 barcodes that can only encode GTIN-12 or GTIN-13 respectively, so the AI (01) is not required. 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, advanced data carriers are needed that can carry many different AIs. Then the AI (01) will be needed to indicate that a GTIN is encoded. In order to ingest the GTIN from these data carriers, POS systems will need to be able to recognize AI (01) in both traditional 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 ingest and store 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-12 in 14-digit format, using AI (01)

QR Code using GS1 Digital Link URI syntax encoding a GTIN-12 in 14-digit format, using AI (01)

4.3 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 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 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 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 (01)

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

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

appears first in the element string, it means a GTIN follows in the next segment. The AI for production date is (13). When (13) appears in the element string, it means a production date follows in the next segment.

4.4 Important AIs for advanced data carriers 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. The appendix in the *Powering the Future of Retail* research paper contains a decision tree to help determine which AIs may be used to support specific use cases.

AI	Data Content	Format	FNC1 Required	Data Title
01	Global Trade Item Number (GTIN)	N2+N14		GTIN
10	Batch or Lot Number	N2+X..20	(FNC1)	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)	SERIAL
30	Count of Items (Variable Measure Trade Item)	N2+N..8	(FNC1)	VAR. COUNT
320 (*)	Net Weight, Pounds (Variable Measure Trade Item)	N4+N6		NET WEIGHT (lb.)
392 (*)	Applicable Amount Payable, Single Monetary Area (Variable Measure Trade Item)	N4+N..15	(FNC1)	PRICE

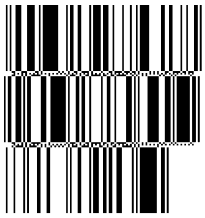
*The fourth digit of this GS1 Application Identifier indicates the implied decimal point position.

Example: 3103 net weight in kg with three decimal points

5 Data carriers

5.1 Benefits of 2D barcodes over linear barcodes

The UPC-A has long served industry's need for automated price lookup at POS, but its ability to meet other use cases is limited, as it 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 a UPC-A and GS1 DataBar Omnidirectional Stacked barcode, encoding just a GTIN. A GS1 DataMatrix, GS1 DataBar Expanded Stacked, and a QR Code encoding GS1 Digital Link URI syntax are also included, encoding GTIN, expiration date, and batch/lot number. All examples use target sizing. The black boxes indicate required quiet zones that must remain empty for the barcode to be decoded correctly, where applicable.

5.2 Advanced data carrier options

The data carrier landscape is fragmented, not just in the U.S., but globally. Data carriers are selected based on each specific use case, and this practice will continue. GS1 US will continue to monitor the development and adoption of additional data carriers but has identified the following four that can meet industry's current use cases: GS1 DataMatrix, Data Matrix, QR Code, and RFID. Although RFID is not a barcode, it offers benefits such as non-line-of-sight scanning that are needed for some implementations. A decision tree is available in the appendix of the *Powering the Future of Retail* research paper to help brand owners find their best data carrier options. As the data carrier landscape continues to evolve, GS1 and GS1 US will continue to provide guidance.

5.2.1 Transition considerations

Adoption of these advanced data carriers is underway, largely to accommodate consumer engagement or supply chain use cases. Current use at POS is limited. The only 2D barcode allowed for POS

applications in version 21.0 of the *GS1 General Specification* is the GS1 DataMatrix for variable-measure fresh food and only with trading partner agreement. As industry capabilities evolve (retailers upgrading scanners and POS systems while brand owners upgrade printing and encoding of advanced data carriers and data attributes) and as retailers and brand owners begin advocating for it, the *GS1 General Specifications* will be updated to include additional data carriers for POS.

This does not mean that advanced data carriers cannot be used at all right now. **Between now and Sunrise 2027, dual marking is critical.**

- In the U.S., UPC-A will remain the primary POS barcode until 2027.
- If adding an advanced data carrier, the following applications are approved in the *GS1 General Specifications*, *Version 21.0 (January 2021)*:
  - Data Matrix or QR Code can be used to encode a GS1 Digital Link URI 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 element string syntax.
  - RFID can be used for use cases that benefit from non-line-of-sight scanning, such as inventory management.

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 3.2*. **Beginning in 2027, industry will be ready to accept an advanced data carrier at POS and brand owners will have the option of removing the UPC-A barcode.**

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 the U.S. Food and Drug Administration's (FDA's) Drug Supply Chain Security Act (DSCSA).

For more information on the path to using 2D barcodes at POS, see *Section 2.8* and *Section 5.3*.

2D barcodes by syntax			
	GS1 DataMatrix	**Data Matrix**	**QR Code**
Syntax to use:	Element string syntax	GS1 Digital Link URI syntax	GS1 Digital Link URI syntax

5.2.2 GS1 DataMatrix and Data Matrix

Data Matrix is a 2D barcode. It has several advantages such as its compact design and the existence of various production methods that accommodate placing the symbology onto various substrates.

There are two versions of the Data Matrix in the *GS1 General Specifications Version 21.0.* 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.

(01) 0 0614141 99999 6
(10) ABC123

5.2.2.1 GS1 DataMatrix

GS1 DataMatrix features all the benefits of the Data Matrix symbology but only encodes GS1 element string syntax. This has led to its adoption for applications including healthcare and direct part marking:

(01) 0 9506000 13435 2
(10) ABC123

- In the U.S., GS1 DataMatrix is the standard for regulated healthcare trade items. To meet requirements of the U.S. Food and Drug Administration (FDA) Drug Supply Chain Security Act (DSCSA), 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 preferred 2D barcode for use with GS1 element string syntax. 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.

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

5.2.2.2 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. The Data Matrix could be recognized by mobile device apps, allowing consumers to easily connect to brand-authorized 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 Section 5 of the 2021 release of the *GS1 General Specifications*.

https://example.com/01/00614141123452/10/ABC123

5.2.3 QR Code

A QR Code is a 2D barcode that is often used for consumer engagement. QR Codes are recognized by the consumer and by most smartphone camera apps. Consumers have learned to scan the codes using their mobile devices to access brand-authorized 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 utilized to create a multi-use barcode that allows consumer engagement and price look-up without adding another data carrier or taking up additional space on packaging graphics. QR Codes can be used to encode GS1 Digital Link URI but shall not be used with element string syntax because systems will not be able to recognize the AIs. QR Codes cannot be used at retail POS at the time of publication. For details see *Section 2.8*. 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, Version 21.0*.

https://example.com/01/00614141123452/10/ABC123

5.2.4 RFID

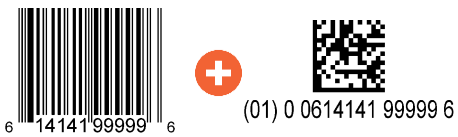
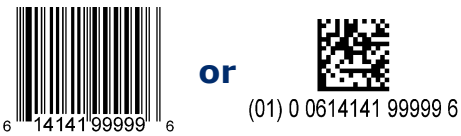
Unlike barcodes, RFID tags are data carriers that enable non-line-of-sight scanning. RFID readers do not need a direct line of sight to the data carrier because the information is transmitted wirelessly. This works well with use cases such as inventory accuracy; a worker with an RFID reader can walk through the warehouse, with the reader retrieving information from every tag within range, without having to individually scan a barcode on each item. While most RFID applications do not focus directly on scanning at POS, it has been adopted for retail use cases that interact directly with POS and backend systems. However, solution providers, brand owners, and retailers continue to explore RFID solutions at POS, especially due to the volume of RFID tags present on items in industry like apparel. For example, UHF RFID can be used to read the full contents of an entire basket at once. Doing so requires all the products available for purchase to have an RFID tag attached, as well as additional hardware and supporting systems to ensure only the items in the basket are read.

Especially in the apparel industry, Electronic Product Code (EPC)-enabled UHF RFID has been used for inventory accuracy, to allow inventory counts at the serialized level. Using the EPC to encode GS1 data in RFID tags allows the same standardized data to be encoded in the RFID tag and the POS barcode so that the POS and inventory accuracy systems can communicate and share data. For example, an apparel store can manage inventory on the retail floor with RFID tags, but scan a 2D barcode at POS. If the same GTIN and serial number are encoded in the RFID tag and the 2D barcode, the POS and inventory management system can be linked, and the specific instance of the item removed from inventory when it is sold at POS. For more on implementing RFID using GS1 Standards, see *GS1 EPC/RFID.*

5.3 Dual marking and multiple data carriers

While the *Powering the Future of Retail* research showed that optical scanners are becoming more common in retail, an installed base of linear scanners is still in use. POS systems will need to be updated to prioritize advanced data carriers and extract the GTIN from either element string syntax or the GS1 Digital Link URI. Until these updates have been made across all retailers, a dual-marking period with advanced data carriers and the existing EAN/UPC barcode will be needed. This will ensure that advanced use cases can be implemented by retailers who have upgraded their hardware and software while the existing price look-up use function will still work for retailers who have not.

GS1 US currently recommends a dual-marking period (using both a UPC-A and an advanced data carrier) and after the *2027 Sunrise*, recommends marking products solely with an advanced data carrier. The graphic below summarizes the likely glide path to an advanced data carrier. Upgrading to an advanced data carrier is optional; the UPC-A can continue to be used by itself or in conjunction with advanced data carriers beyond 2027.

UPC-A (Today)	**Dual Marking – UPC-A and 2D Barcode** (Now - 2027)	**UPC-A or 2D Barcode** (2027)
		

5.4 Symbol placement

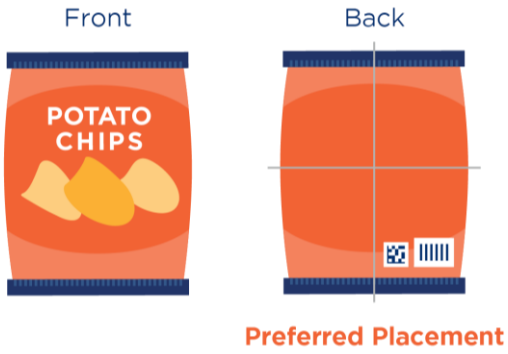
When moving to a package with multiple data carriers, symbol placement is important. The UPC-A should remain in its existing placement, according to the symbol placement rules laid out in Section 6.3 of the GS1 General Specifications. There are three placement possibilities for placing the 2D barcode 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 scanner setup to prioritize the correct barcode.

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

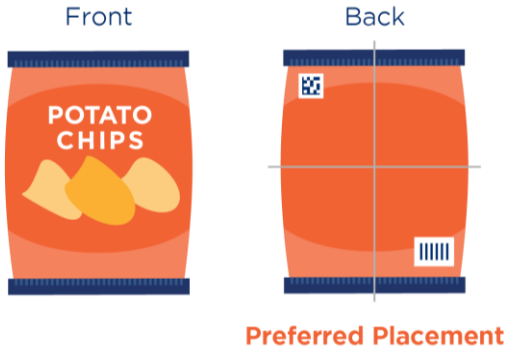
Adjacent placement also allows for a transition from a UPC-A to dual marking to a sole 2D barcode while maintaining consistent symbol placement. When placing adjacent symbols, each symbol's quiet zones and other symbol placement rules must be respected. The orientation (stack or row of symbols) or sequence (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 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:

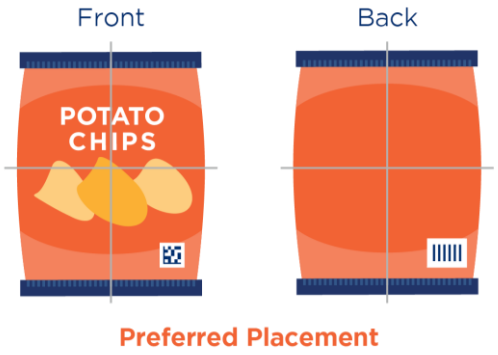
Wherever two symbols are used for different applications (one for POS and another for consumer engagement or internal supply chain purposes), non-adjacent placement should be used. The recommendation is to not have these two symbols (U.P.C. + 2D carrier) adjacent to one another and additionally, consider placing them on different product packaging panels so flatbed 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.



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 GS1 DataMatrix on the other side of the tag, or at the very least, 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.



5.5 Human readable interpretation (HRI)

When designing a 2D barcode and packaging graphics, it is important to consider what data also 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 *GS1 General Specifications* for the full rules on HRI and non-HRI text.

For symbols encoding a large amount of data (2D barcodes), 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.

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*).

GTIN 00614141999996
EXPIRY 31 Dec 2025
LOT(10) ABCEF12345
SERIAL (21) 4815162342ABC

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

(01) 0 0614141 99999 6

HRI with some of the data omitted

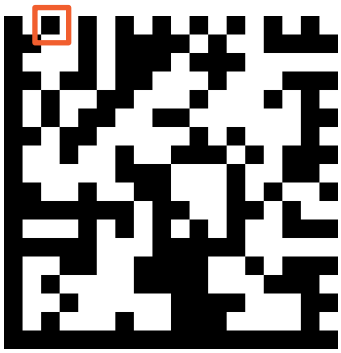
5.6 Barcode print quality

When implementing advanced data carriers 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 coloring, 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 21.0* will include an addendum to Table 1, covering QR Code and Data Matrix for use with GS1 Digital Link.

5.6.1 Size of the barcode

Barcode scanners are optimized 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 on the "checkerboard." It is to be square (as wide as it is tall). The size of one module is expressed in inches (shown in parentheses) and millimeters 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 symbol 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 symbols below all encode the same GTIN, batch/lot number, and production date. They encode the minimum (.0148"), target (.0246"), and maximum (.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.

5.6.2 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 degrades 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. The GS1 US Solution Provider Finder can help identify companies that can provide *verifiers* or *verification services*.

6 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-authorized 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 GS1 Digital Link. More resources on GS1 Digital Link, including the Standard and U.S. Implementation Guide, can be found in *Section 10.3*.

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 on the 2022-2024 horizon[4]. Meanwhile, implement product packaging strategies to incorporate dynamic and GTIN data, while supporting the multiple barcodes recommended in a flexible data structure.

The convergence of key technologies necessary to support industry migration to advanced data carriers is already starting. It will grow considerably in the 2022-2024 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 advanced data carriers. This section will outline the steps brand owners need to take to develop their individual plans. See *Section 2.8* for the roadmap GS1 US has laid out for industry as a whole.

6.1 Evaluate existing data carriers on-pack

Many brand owners have already integrated advanced data carriers 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 advanced data carriers 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 utilized 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 share 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 advanced data carriers on packaging and the ability to read and ingest 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 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 (see *Section 2.8*), dual-marking with a UPC-A barcode will ensure that the product will still scan for price lookup by all retailers. During this interim period, it will be important to collaborate with individual trading partners to

[4] GS1 US Research and Insights Paper, "Powering the Future of Retail: Building Upon the Foundation of the U.P.C. Barcode", Release 1.1, February 2020.

understand who has updated their systems to scan advanced data carriers and ingest 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.

6.2 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. Tying in with the previous section, specific trading partners should run pilot programs focused on specific use cases and products.

6.3 Determine use case

Each company will have different priority use cases based on industry, trading partner requirements, and business needs. *Section 3* overviews the most common use cases identified by industry and includes the priorities for each industry segment.

6.4 Data element selection

While the GTIN will still be necessary for price lookup at POS, 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 an advanced data carrier, encoding AI (01) with the 14-digit GTIN, as well as any optional AIs driven by use case, will be required. See *Section 4* for the standardized GS1 data elements that will most likely be used at POS. The decision tree in the Powering the Future of Retail research paper also provides some suggested data attributes for major use cases.

There may be circumstances where different retail trading partners each demand different data elements to be encoded in an advanced data carrier. It is important to follow the general best practices offered by the GS1 System specifications. All of the required data elements for different retailers may be encoded in a single advanced data carrier. *Section 7* provides retailers with best practices for ingesting advanced data carriers with many data elements and retrieving only the data they need.

6.5 Data carrier selection

As explored in *Section 5.2*, there are several advanced data carriers that can be used, depending on the use case. Figure 14 in the Powering the Future of Retail: Building Upon the Foundation of the U.P.C. Barcode research paper contains a data carrier decision tree that helps brand owners identify the data carriers that may meet specific use case needs. To ensure a product can be scanned by all retailers for all use cases, multiple on-pack data carriers may be needed, including a dual-marking period in which both the UPC-A and an advanced data carrier are used (see *Section 5.3*). While RFID can be leveraged to meet many use cases, it is not commonly seen as a POS technology. Items tagged with RFID will also need to be barcoded with a 2D carrier and U.P.C. for point-of-sale.

Once data carriers have been selected, see *Section 5.4* to determine where the additional data carriers should be placed on pack. *Section 5.5* overviews considerations for how the data contained in barcodes should be included in human-readable text.

6.6 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 advanced data carriers and the attribute data encoded within. For RFID, readers and encoders would be needed.

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/projects as well as hardware and software procurement plans (RFP - request for proposal).

6.7 Encoding 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 5.6.2*, is strongly recommended to ensure that barcodes meet the quality requirements and can be scanned by trading partners.

7 Guidance for retailers

GS1 US recommended that retailers should be able by 2005 to scan the EAN-13 as well as the UPC-A and to process the GTIN-12s and GTIN-13s that are delivered by these barcodes. GS1 US also strongly advised that GTIN storage database tables be made 14-digit capable. This capability has now paved the way for scanning GTINs from the advanced data carriers discussed in this document.

Now with the Sunrise 2027 initiative (see *Section 2.8*), GS1 US recommends developing 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 ingest AI (01) + GTIN +, if applicable, attribute data. These requirements need to be incorporated in retailers' technology roadmaps/projects and hardware and software procurement plans (RFP - Request for Proposal).

Brand owners are required to accommodate many different customer needs. In an advanced data carrier environment, this means a variety of data elements will be encountered by distribution centers 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.

7.1 Evaluate POS infrastructure

POS systems need to be able to recognize 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 element string or GS1 Digital Link URI syntax.
- 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 advanced data carriers. Optical scanners need to be capable, configured, and activated to process currently used symbologies such as the UPC-A barcode and GS1 DataBar and advanced data carriers 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 advanced data carrier in the GS1 element string and Digital Link 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 utilization 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.

7.2 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 fulfillment 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/labeling 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 and any solution providers

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

7.3 Collaborate with trading partners

It is critical to collaborate with trading partners to:

- Prioritize the use case(s) to address those that are not being solved by the UPC-A
- 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

7.4 Educate associates

Educating associates is a vital element of an advanced data carrier implementation project. The AIs selected and shared by suppliers will dictate which associates need specific orientation around the scanning of advanced data carriers 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.

If systems are adjusted to prioritize barcodes other than the UPC-A, store associates may need to be made aware to scan advanced data carriers.

7.5 Self-checkout, omni-channel, and consumer engagement—educate customers

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 advanced data carriers can be scanned at the self-checkout and on mobile apps for self-checkout.

Customers have been prepared for self-checkout by years of watching store employees scan UPC-A barcodes at fixed POS registers. Do not discount this valuable resource for educating customers about advanced data carriers and the value they provide them.

- Any advanced data carrier can be paired with a mobile app for a unified omni-channel experience and to drive consumer engagement outside the retail store
- Consumer engagements
- Recall management
- Returns processing
- Warranty registration

7.6 Private label

Private label or store brands offer a great opportunity to implement advanced data carriers 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 6*.

8 Guidance for solution providers

Solution partners have a critical role in the Sunrise 2027 transition to advanced data carriers at POS. Reach out to customers to understand their:

- Current systems (POS, printing, data storage, and sharing)
- Requirements for future capabilities
- Transition plans

Solution providers are instrumental in providing key solutions and services to help retailers and brand owners implement product identification and data programs.

8.1 AI (01) and 14-digit GTIN

It is essential, in the following systems updates, to ensure all systems can ingest AI (01) and 14-digit GTINs in both element string syntax and GS1 Digital Link URI syntax. This will be the bedrock to ensure that the information in advanced data carriers can be scanned at POS and shared amongst systems and 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.

8.2 Printers

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 a UPC-A barcode (with GTIN-12) and an advanced data carrier (with AI (01) + 14-digit GTIN and potentially attribute data).

Printer equipment for this application should be capable of producing the UPC-A barcode and at minimum, the 2D barcodes listed in *Section 5.2* (GS1 DataMatrix, Data Matrix, and QR Code) with the GS1 Application Identifiers listed in *Section 4.4*.

- Some AIs identify fixed-length data fields, while others support variable-length data fields. To obtain more information about the entire list of recognized AIs with their corresponding data fields and length rules, please refer to the GS1 General Specifications, Section 3.
- For Human Readable Interpretation label information, reference GS1 General Specifications, Section 4.

Note: For maximum and minimum barcode dimensions, reference GS1 General Specifications, Section 5.

8.3 Scanners

Scanners will encounter items with dual markings during the transition period: a UPC-A barcode (GTIN-12) 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 UPC-A barcode and pass that data to the POS system.

If the retailer has optical scanners installed, either the UPC-A barcode or the advanced data carrier can be read.

- If the retailer's POS system is not capable of handling the GS1 AI data, it should read the advanced data carrier and parse only the 14-digit GTIN.

- If the retailer's POS system can handle the GS1 AI data, it should read the advanced data carrier and parse the 14-digit GTIN and GS1 AI data.

For retailers with optical scanners that can ingest GS1 AI data, work with solution providers and internal IT teams to ensure scanners are properly processing the data and multiple barcodes. Retailer 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 an advanced data carrier. Priority AIs are outlined in *Section 4.4* 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.

8.4 POS systems

Different retailers' POS systems are at differing stages of readiness to ingest AIs. This 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 and ingest AI (01) and the 14-digit GTIN. POS systems should be capable of identifying and processing the GTIN in both traditional element string and GS1 Digital Link URI syntax. 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 and applies to 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 US 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.

8.5 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. All tiers have legacy backend systems—integration is complex, which appears to be the most significant bottleneck in the industry.

9 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 key. Attribute data can be encoded in GS1 element string and GS1 Digital Link URI syntax.
GS1 Application Identifiers (AI)	A finite set of specialized 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.
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 that gives consumers a way to digitally access more detailed product information than could ever fit on a package label about a wide range of food, beverage, supplement, household, pet care, personal care, and over-the-counter products. It is fast and easy to use, with a consistent digital format that shares accurate data directly from the manufacturer in real time. 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
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

10 Additional resources

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

10.1 GS1 US Future of Retail resources

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.

10.2 *GS1 General Specifications*

The foundational GS1 Standard that defines how identification keys, data attributes, and barcodes must be used in business applications.

10.3 GS1 Digital Link resources

GS1 Digital Link landing page, including GS1 Digital Link Standard and the

GS1 US Digital Link Implementation Guide.

10.4 Decision tree and comparison (including future data carriers)

The appendix in the *Powering the Future of Retail: Building Upon the Foundation of the U.P.C. Barcode* research paper provides guidance on:

- Data Carrier Decision Tree – Guidance on Data Attribute and Data Carrier Selection (Figure 14) for the following use cases:
  - Authentication or Inventory Accuracy
  - Product Traceability
  - Product Freshness or Waste Prevention
- Data Carrier Options Table (Figure 15) – This table summarizes GS1, non-GS1, and emerging data carriers and outlines carrier capacity, technology, limitations, and current deployment.

10.5 2D at POS for fresh foods

The *GS1 AIDC Fresh Foods Sold at Point of Sale Implementation Guide* 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.).

10.6 Private label

Additional resources on using GS1 Standards for private label identification can be found on the *GS1 US Store Brands landing page*.

10.7 EPC Tag Data Standard

GS1's EPC Tag Data Standard (TDS) defines the Electronic Product Code (EPC), including its correspondence to GS1 keys and other existing codes.

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IAPMO

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