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The Global Language of Business

Web enabled, structured path identification

GS1 product identification and AIDC carrier support for EU Digital Product Passport via ISO/IEC 15459 identifiers, GS1 Digital Link URI syntax and global 2D barcode migration

Empowering green product choices for consumers

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1 Introduction

GS1 welcomes the Ecodesign for Sustainable Products Regulation (ESPR), published in June 2024, as a key pillar of the EU Circular Economy agenda and of the Green Deal. The ESPR introduces the Digital Product Passport (referred to as DPP from this point forward in this document) for products and components being placed on the EU market[1]. This paper aims to:

1. Explain the role of GS1 standards in supporting the implementation of the DPP.
2. Highlight the benefits of using ISO/IEC 15459 conformant GS1 identifiers for product identification in line with ESPR requirements.
3. Outline the 2D barcode migration GS1 user companies are making to ensure one barcode can support legacy supply chain applications, enhanced consumer communication, and regulatory compliance by 2027.

As an ISO/IEC 15459-compliant Issuing Agency for many product types impacted by the ESPR, GS1 has established a Circularity/DPP Mission Specific Work Group to ensure GS1 standards are ready for the implementation phase of the Regulation by industry that use or are exploring the use of GS1 standards. In line with the new Ecodesign framework, which builds upon the Ecodesign Directive, focus is on providing better information to consumers and enabling greener choices.

One of our aims is to ensure backward compatibility with supply chain AIDC[2] implementations while introducing innovative approaches to share data with regulators and consumers via web-enabled smart devices. As it relates to regulatory data requirements, the goal is to utilise extensible data sharing techniques to provision information while avoiding national or region-specific approaches to foundational identification and AIDC carrier specifications and so avoid inventory segmentation, out-of-stock conditions and significant increases in the cost of products for industry and consumers.

By using structured ISO/IEC 15459 identifiers (e.g., GTIN) in the AIDC technology domain with the web-enabled innovation of ISO/IEC FDIS 18975, one AIDC carrier on each physical product can support business-to-business (B2B), business-to-government (B2G) and business-to-consumer (B2C) requirements at an international level.

Users of GS1 standards, through years of careful planning, are advancing interoperability of legacy supply chain systems to enable consumer smartphone connectivity to information, including regulatory data, on the web. Regarding the usage of 2D data carriers, at this stage, industry is four years into a GS1 seven-year global migration program to support 2D data carriers and a standardised web-enabled identification syntax. This program will ensure consumers find a product landing page with links to many types of information, including, if appropriate, to DPP but also possibly instructions for use, required maintenance, proper disposal, etc.

In summary, the web-enabled, structured path identification detailed in Section 2 facilitates a circular economy where various regulatory efforts around the world interoperate based on implemented international standards. These standards couple innovation with the years of work and investment by industry required to implement it.

[1] See ESPR Article 1 paragraph 2 for out-of-scope products: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1781&qid=1719580391746#d1e1513-1-1 and see ESPR Article 18 paragraph 5 for the full list of the prioritised product categories (iron and steel; aluminum; textiles, in particular garments and footwear; furniture, including mattresses; tyres; detergents; paints; lubricants; chemicals; some energy related products; information and communication technology products and other electronics): https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1781&qid=1719580391746#d1e3926-1-1

[2] AIDC: Automatic Identification and Data Capture. The GS1 GenSpecs defines the rules for the use of the GS1 system within AIDC applications and technologies. In the GS1 System Architecture Document | GS1 see section 2.1 & 4.2.

2 Product identification landscape

Among the various identification approaches, our method aligns with ISO/IEC 15459 and ISO/IEC FDIS 18975, the use of Global Trade Item Number (GTIN), and industry's 2D/GS1 Digital Link adoption plans for 2027. This method is web enabled, and it includes structured path identification, as supported by the GS1 users.

The standards factors described in the points below are based upon industry large implementation of unique product identification and data sharing at EU and global level and also constitute the basis of the GS1 DPP standardisation table:

1. Use of the Global Trade Item Number (GTIN) or GTIN with a version code (e.g., consumer product variant) to support ESPR granularity requirements for 'model'.
2. Use of GTIN with a lot/batch number to support ESPR granularity for 'batch'.
3. Use of GTIN with a serial number to support ESPR granularity for 'item'.
4. All ISO/IEC 15459 identifiers that begin with a digit (0, 1, 2, 3, 4, 5, 6, 7, 8, or 9) signify the identifier is issued by GS1 and identifiers that begin with an alpha character are used by alternative ISO/IEC 15459 Issuing Agencies to GS1. This means GTIN shall begin with a digit and appear first in the full identification string when GTIN and other data elements (e.g., variant, lot/batch number, serial number) are stored as a concatenated string.
5. As a GTIN at any granularity level, once allocated to one product, shall not be reallocated to another product, all the identifiers above, once allocated to a product subject to the ESPR, will never be reused to identify another product to safeguard uniqueness. Additional rules may be required (e.g., requirements for 'non-new' products and configurable products).
6. There shall be a single 'value' for any identification data element on any single physical product, its packaging, or documentation accompanying the product independent of the AIDC carrier. For example, if there is a 1D and 2D barcode on the same product and both encode the same data element, the values in both barcodes shall be the same.
7. GS1 Digital Link URI syntax will be used in the AIDC carrier to permit consumer smartphone web connectivity (using the full URI) but the identification data elements, which will persist independent of the domain address, will be used to identify the product in the EU DPP registry data fields as well as in industry transactions and databases for supply chain use. In the 'structured path' approach within ISO/IEC FDIS 18975, the ordering of the data elements concerned with product identification is well-defined and always predictable.
8. GS1 users can assign the same lot/batch or serial number 'value' to every GTIN value because there is a mandatory association of the lot/batch number or serial number with the GTIN. This means the lot/batch or serial number have no meaning independently of the GTIN. While GS1 users may assign lot/batch or serial numbers across multiple GTINs from one pool, this increases the lot/batch or serial number length and so allocating values for these attributes of GTIN per each GTIN value is recommended where reduction in barcode size or tag memory is a consideration.
9. The coarsest level of granularity (see Figure 2.1-2 on page 8 for a description of coarsest and finest granularity) as specified by regulation will always be mandatory but finer levels of identification granularity will remain optional or mandatory as specified by other GS1 AIDC application standards for other regulations or industry requirements.
10. ISO/IEC 15418 GS1 Application Identifiers shall be used exclusively with GS1 identifiers by GS1 user AIDC systems (design, printing, verification, scanning).

    NOTE: The ANSI MH10.8 Data Identifier (DI) standard deprecated the use of DIs (3P, 4P, 8P, 17P, 17S, 2V, and 3V) with GS1 identifiers in 2020 to conform with ISO/IEC 15418, 15459, 15424, and 15434. DI 4N remains and is defined as,

"*Coding Structure and Formats in Accordance with GS1 Application Identifiers (AI plus data) (GS1).*" This may be useful to user companies that need to encode DIs then GS1 identifiers with AIs, but GS1 standards do not support DI 4N because GS1 standards-conformant AIDC systems do not require processing of DIs.

Table 2.1-1 summarises how web-enabled, structured path identification, as defined in ISO/IEC FDIS 18975 (final standard approval expected in 2024), when coupled with QR Code and possibly other AIDC carriers described in Section 3 (e.g., RAIN RFID, Data Matrix, NFC), is compliant with ESPR, conformant with ISO/IEC and GS1 standards, and supported by industry plans to support 2D barcodes with GS1 Digital Link URI syntax by 2027.

NOTE: It should be mentioned that ISO/IEC FDIS 18975 allows for two approaches, structured path and query string. While GS1 Digital Link URI conforms to the structured path approach, other ISO/IEC Issuing Agencies may specify the query string approach utilising ANSI MH10.8 Data Identifiers.

In a nutshell, by using structured ISO/IEC 15459 identifiers (e.g., GTIN) in the AIDC technology domain with the web-enabled innovation of ISO/IEC FDIS 18975 and one ISO/AIDC 2D data carrier on each physical product, DPP requirements will be met at both international and EU level.

2.1 Unique Product Identifier (UPID) method for GS1 users

Discussions about unique product identifiers occur inside and outside GS1 in forums like GS1's Global Standards Management Process (GSMP), ISO/IEC, CEN/CENELEC, Cirpass and other venues.

This Section will provide the state of play in a broad directional sense for the method GS1 standards users support (#1 in table 2.1-1), do not support, and others they do not use and will not assess. Table 2.1-1 looks at various proposals being discussed (columns) and weighs them against the criteria for assessment by GS1 user companies (rows) based upon the ESPR and the EU Standards Request. Descriptions of the criteria and methods follow Table 2.1-1 on page six.

NOTE: While GS1 standards do not utilise ANSI Data Identifiers, other Issuing Agencies so and they conform to ISO/IEC 15418, 15459, 15424, 15434. ISO/IEC FDIS 18975 also allows for a web-enabled, query string approach utilised by other Issuing Agencies.

Unique Product Identification (UPID) methods for DPP (columns) and assessment criteria (rows)	Method 1: Web-enabled, structured path syntax UPID (ISO/IEC 15418, 15459, FDIS 18975 using GS1 AIs (per GS1 Digital Link URI)	Method 2: Element string syntax UPID ISO/IEC 15418, 15459 using GS1 AIs	Method 3: Element string syntax (with a URL domain "stub" as a data element) ISO/IEC 15418, 15459 requiring GS1 AI (8200) which is no longer used by GS1 for new applications	Method 4: IEC 61406-1	Method 5: Decentralized identifiers (DIDs)
				Not assessed, See notes on Page 10	
Globally unique	Yes within the AIDC technology domain per ISO/IEC 15459	Yes within the AIDC technology domain per ISO/IEC 15459	Yes within the AIDC technology domain per ISO/IEC 15459		
Implementable by 31 Dec 2027	Native smart device support exists today for some AIDC carriers (QR, NFC); Pervasive support for 2D/GS1 Digital Link in industrial scanning systems is planned by GS1 users by 2027	No as this method requires additional software on all industrial and smart devices that looks up a URL "stub" then concatenates the URL domain stub and identifier data elements	No as this method requires additional software on all industrial and smart devices that concatenates the URL domain stub and identifier data elements		
Persistent	Yes	Yes	Yes		
Web resolvable syntax w/o APP	Yes	No	No		
Open standard	Yes	Yes	Yes		
Interoperable per ISO/IEC 15459 compliance	Yes	Yes	Yes		
Granular Product ID	Yes, AIs support model, lot, item level product identification	Yes, AIs support model, lot, item level product identification	While AIs and DIs support model, lot, item level product identification, AI (8200) supports only model level and is not used by GS1 for new applications like DPP		
Extensible (modifiable)	Yes, product identifiers can remain persistent even if additional data elements are later added to the AIDC carrier.	Yes, product identifiers can remain persistent even if additional data elements are later added to the AIDC carrier.	Yes, product identifiers can remain persistent even if additional data elements are later added to the AIDC carrier.		

Table 2.1-1

Globally unique: ESPR Article 10 (1) (a) states, "*it* [DPP] *shall be connected through*

*a data carrier to a persistent **unique** product identifier.*" Standards mandate, Recital (9) states, "*The unique identifier and the corresponding identification system of the product passport are to allow interoperability with existing legacy identification systems, as far as possible*."

As GS1 standards user companies are manufacturing or handling products for placement in every country of the European Union and over 100 countries outside of it, this means that two products shall not have the same identifier and one product shall not have two different identifiers. For example, two products at a model level require two GTINs and two production batches for the same product would have the same GTIN, but two lot/batch numbers. ISO/IEC 15459, parts 2 and 3, ensure that GS1 identifiers are unique in relationship to other ISO/IEC 15459 conformant Issuing Agencies and GS1 application standards (including identifier allocation rules) ensure GS1-standards conformant implementations conform to ISO/IEC 15459-3 (6) Common Rules.

Implementable by 2027: The date when the regulation is expected to be in force for the first product types using GS1 standards. By the end of 2027, the technology to encode (print barcodes, encode tags), verify barcode print quality, and decode (scan barcodes, read tags) must be in place. Given the implementation timeline is now rapidly approaching, anything not already pervasively implemented or well on its way to being implemented will be problematic for consumers and industry using GS1 standards, particularly small to medium size companies. Even using standards that are implemented or where migration is planned, the challenges for industry will be substantial (e.g., enriching existing product information, marking of small products with large barcodes, permanent product marking, products composed of multiple products each covered by DPP, variable data from granular identifiers encoded in AIDC data carriers as high production line speeds (100s or 1000s products per minute). By focusing on where the current standards are implemented and migration for new technology is years underway, the industry can focus on overcoming these challenges to realisation of a circular economy.

Persistent: ESPR Article 10 (1) (a) states, "*it* [digital product passport] *shall be connected through a data carrier to a **persistent** unique product identifier.*" Here there are several factors to consider.

- Consistency: Once the unique identification is assigned, it shall remain unchanged. Conformity to GTIN allocation rules ensures that a GTIN, once assigned to a product, is not used on another product.
- Preservation: The identifier shall be preserved throughout the expected lifetime, or for as long as access to the data in the DPP is required (lifecycle, lifetime, end-of-life). The use of GS1 Digital Link URI provides the Web resolvable feature (see next item) but the identification data elements (e.g., GTIN, GTIN variant, lot/batch number, serial number) will be used independently of the domain address to register the product within the EU DPP Registry. This means the structured identifiers, assigned per GTIN Management Rules, will persist in the registry independent of a domain address which may not persist. If a product at what the ESPR refers to as the "model level" changes in a way that requires a new identifier per a Delegated Act, a new GTIN needs to be created to reach the new DPP data.
- Registry accessible: The identifier shall remain available including after an insolvency, a liquidation, or a cessation of the economic operator that created the product passport. By using permanently assigned identifiers in the Registry, this is enabled while also allowing the URL to change when additional data elements may be needed for non-regulatory requirements such as needing to add an expiration date, weight or measure in the AIDC carrier.
- Physically accessible: The identifier in the AIDC carrier shall remain available on the product, product packaging or documentation accompanying the product.

Web resolvable without an app: Standards mandate, Recital (9) states, "*The unique identifier and the corresponding identification system of the product passport are to allow*

interoperability with existing legacy identification systems, as far as possible. The product passport system is to allow a suitable assignment of data carriers to the product which should be accessible ***without the need for the download of additional software****. Moreover, all identifiers are to be portable and transferable through an open interoperable data exchange network without vendor lock-in, including their portability across resolver services or systems.*" Given the identifier should be used to access the DPP without the need of additional software, a consumer will need to scan/read the AIDC carrier using their smartphone and reach a Web resource with DPP information without needing to download additional software.

Openness: The Standards Mandate Recital (9) states, "*The unique identifier and the corresponding identification system of the product passport* ***are to allow interoperability with existing legacy identification systems, as far as possible****. The product passport system is to allow a suitable assignment of data carriers to the product which should be accessible without the need for the download of additional software.* ***Moreover, all identifiers are to be portable and transferable through an open interoperable data exchange network without vendor lock-in, including their portability across resolver services or systems****.*" And in Recital (15), "*European standards should be technology neutral and performance-based. They contribute to ensuring equal conditions of competition among relevant economic operators, in particular small and medium-sized enterprises. Indirectly those standards also contribute to lower production costs benefitting consumers, to increase the sustainability, to limit the energy consumption of the product passport system and to ensure technical interoperability.*"

The statements above are clearly aligned with the goals for a web-enabled, structured path identification method. This method encodes ISO/IEC 15459 GS1 identifiers in a GS1 Digital Link URI syntax that includes a URL with a domain address, followed by GS1 identifiers in a structured path and potentially additional data in a query string. This method is based on internationally recognised ISO/IEC and GS1 standards implemented by industry including small and medium enterprises, are developed per processes that require disclosure of known IP, avoid vendor lock-in and provide the transparency to ensure technical interoperability or to determine if it is not possible.

NOTE: Ensuring interoperability with legacy systems has been core to the years of careful planning around innovation of product identification. These efforts align with GS1 Architecture Principles and aim to balance backward compatibility for supply chain processes with forward-looking innovation that supports the sharing of rich and relevant data with regulators and consumers.

The goal is to avoid inconsistent national or regional approaches to identification and AIDC carriers as this would cause segmentation of inventory, out of stock conditions and would greatly increase the cost of products for consumers. By utilising structured ISO/IEC 15459 identifiers in the AIDC technology domain with the web-enabled innovation of ISO/IEC FDIS 18975, one AIDC carrier can support business-to-business (B2B), business-to-government (B2G) and business-to-consumer (B2C) requirements.

Interoperable per ISO/IEC 15459 compliance: ESPR Annex III (c) states, "*The Global Trade Identification Number as provided for in International Organization for Standardisation/International Electrotechnical Commission standard ISO/IEC 15459-6 or equivalent of products or their parts*"; and ESPR Annex III (l) states, "*…the unique product identifier referred to in point (b), … shall, where relevant for the products concerned, comply with standards ISO/IEC 15459-1:2014, ISO/IEC 15459-2:2015, ISO/IEC 15459-3:2014, ISO/IEC 15459- 4:2014, ISO/IEC 15459-5:2014 and ISO/IEC 15459-6:2014.*"

GS1 identification and automatic identification and data capture (AIDC) standards comply with ISO/IEC JTC1 SC31 standards for unique identifiers encoded in AIDC carriers used in the supply chain. ISO/IEC JTC1 SC31 standards for unique identification via AIDC technology are heavily implemented in the supply chain from upstream suppliers to manufacturers, from manufacturers to consumers, and downstream actors. ISO/IEC 15459 ensures that each Issuing Agency identifier will not conflict with any other and

establishes rules to facilitate interoperability. ISO/IEC JTC1 SC31 provides the baseline for international AIDC supply chain management and consumer communication in a broad array of industry sectors supported by tens of thousands of solution providers and systems integrators. By utilising these standards and embracing the innovation promised by ISO/IEC FDIS 18975, one barcode can support trade, consumers, and regulatory requirements and aligns with the retail 2027 2D migration program.

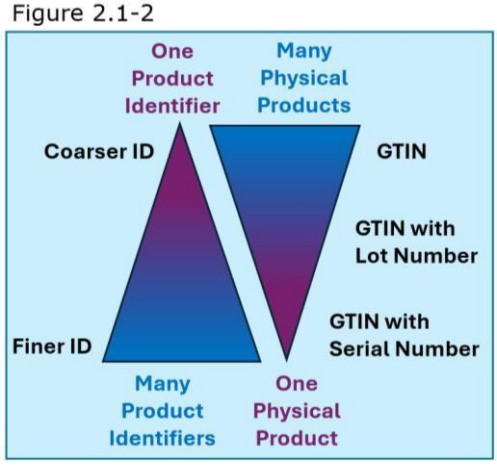
Demand for ISO/IEC 15459 compliance in the context of DPP comes also from the fact it reflects all aspects of a well deployed standard: it is international, has been in place for decades, is widely implemented, continues to expand for additional Issuing Agencies, requires all Issuing Agencies to follow Common Rules (described later in the document), and thus is trustworthy and cost efficient.

Granular product identification: The ESPR Article 10 (1) (f) states, "*The data included in the digital product passport shall refer to the **product model, batch or item** as specified in the delegated act adopted pursuant to Article 4;*" and the Standards Mandate Section 1.4 states, "*The unique product identifier shall always allow the possibility to include the three different granularity levels, i.e. model, batch, or item. This is needed because product passports of products sold online will only be available at model level, while product passports may need to be available at batch level with the item level. The move from batch to item level will also be necessary for product groups for which updates of product passports will be expected, for example due to repair activities. In addition, in some cases, for instance batteries covered by Regulation (EU) 2023/1542, the granularity level for the product passport is at item level.*

The GS1 identification granularity required differs for supply and value chain processes such as:

- B2B order fulfilment
- B2C order fulfilment (including online distance selling)
- Product traceability or recall
- Product warranty, repair, refurbishment, remanufacture, recycle, etc.

Figure 2.1-2



For example, moving from the coarsest to the finest level of granularity for a product, GTIN for order fulfilment, GTIN plus consumer variant to communicate about product changes without impacting fulfilment systems, GTIN plus lot/batch number for recall, GTIN plus serial number for traceability, maintenance, or warranty return). This is illustrated in Figure 2.1-2. The web enabled, structured path identification approach of ISO/IEC FDIS 18975 accommodates the need for addressability of various granular identification data elements by allowing AIDC systems to pass the identifier element(s) called for by the application.

NOTE: While GS1 users do not use ANSI MH10.8 Data Identifiers (DIs), it is our understanding this standard, used by other ISO/IEC 15459 Issuing Agencies, provides DI qualifiers for non-GS1 identities at the model, lot/batch, and item level.

Extensible (modifiable): In the supply chain of GS1 user companies, the ability to add additional information in an AIDC carrier is a commonplace requirement. For example, a product might appear in the supply chain today with a product identifier like GTIN with a lot/batch or serial number in the AIDC carrier, but later, based on a new regulatory, trading partner, or consumer requirement, the manufacturer might be required to add other data elements like a date, a weight, or a measurement in the AIDC carrier. This flexibility must be accommodated without impacting the registered DPP product identifier of GS1 user companies.

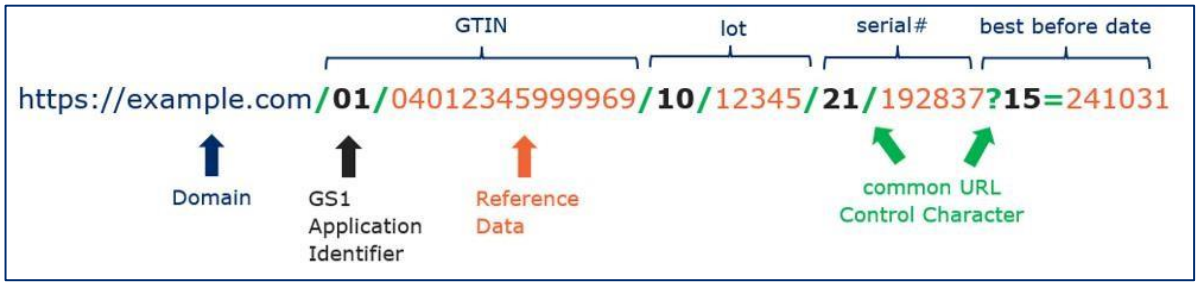
2.2 Product identification methods summary

Method 1: The web-enabled, structured path identification method does not rely on the consumer to install any additional software or an app on their smartphone to make the Web link to DPP information. They simply use the smartphone to scan an AIDC carrier, land on a Web page, and then click on different sources of information per their interest (e.g., DPP data, instructions for use). By using these identification elements independent of the domain address and never reallocating them once assigned, the persistence of product identification is assured. All of this occurs by encoding the domain address of the manufacturer before the GS1 identifiers in a structured, web-enabled syntax.

GS1 user companies support the use of a URL with ISO/IEC 15459 conformant GS1 identifiers (e.g., GTIN, GTIN with lot and/or serial numbers) encoded in the ISO/IEC FDIS 18975 conformant GS1 Digital Link URI syntax because this method:

1. Allows EU registration of structured, persistent product identifiers that ensure uniqueness and interoperability between ISO/IEC 15459 Issuing Agency identifiers.
2. Enables consumers to open a web site using their smartphone's native camera to scan a 2D barcode and then access regulatory or other information (e.g., instructions for use) from links on the landing page.
3. Does not utilise a domain address for product identification as a domain address is not always persistent and would duplicate identifiers used in today's supply chain.
4. Allows GS1 users to add additional structured data elements to the AIDC carrier, as needed, such as an expiration date, weight or measure without compromising the unique identifier that is comprised of other structured identification data elements.
5. Aligns with a seven-year, international retail program (2020-2027) to use one, multifunctional 2D to support supply chain transactions, consumer communication, and regulatory compliance.

Figure 2.2-1: Method 1: Web-enabled, structured path, GS1 identifiers



As it relates to ISO/IEC 15459-3 Common Rules, a unique identifier complies with ISO/IEC 15459 when *"An organization can claim that it is compliant with ISO/IEC 15459 (all parts or a specific part) if it can allocate and process identities according to the rules defined in ISO/IEC 15459-3, Common rules, ISO/IEC 15459-2, Registration procedures and all or any other part."*

Method 1 is compliant because:

1. The identifier shall be assigned to an individual entity whether product, product/production lot/batch, product/production item.
2. GS1 Application Identifiers shall be used as the qualifier method.
3. The structured path product identifier shall begin with GS1's Issuing Agency Code (0, 1, 2, 3, 4, 5, 6, 7, 8, or 9) followed by a Company Identifying Number (GS1 Company Prefix).
4. Each structured product identifier element (e.g., GTIN, lot/batch#, serial #) shall conform to the GS1 General Specifications specified format per each GS1 Application Identifier.
5. The structured product identifier elements, once allocated to a product, shall never be allocated to another product.
6. Each identifier qualifier (GS1 Application Identifier) shall enable the elements to

be stored in a database field, carried by a message, or used in a search. It shall determine the maximum length of the identifier element and the characters that can be used.

7. After the domain, the minimum number of identifier elements (e.g., GTIN or GTIN with consumer product variant, lot/batch, and/or serial number) shall be used to keep the encoding length as short as possible.
8. The identity shall use characters from the invariant set of ISO/IEC 646.

For recognising a GS1 Digital Link URI, regular expressions can be used as a plausibility check. The regular expression test determines whether the string of characters conforms to GS1 Digital Link URI per *"A scanner working within the GS1 system that recognises GS1 Digital Link shall only pass on the scanned string if it has determined that it is plausibly a conformant GS1 Digital Link URI."*[2]

Method 2: The element string syntax method encodes a GS1 Application Identifier following by an identifier. For example, AI (01) then a GTIN or AI (10) and a lot/batch number. This method, pervasively implemented within scanner systems in the supply chain, is utilised by product types across the many ISO/IEC 15459 Issuing Agencies such as automotive, blood and tissue, electronics, chemical, retail consumer products, pharmaceuticals, medical devices, publishing, rail, and construction. Method 2 is not resolvable to a Web address by scanning a barcode using the consumer smartphone's native camera, but Method 1 and supported AIDC carriers (as described in Section 3) permit this for GS1 Application Identifiers per ISO/IEC FDIS 18975.

Method 3: This method is like method 2 but includes the mandatory use of an additional data element, a 'URL stub' (https://example.com), qualified by AI (8200) (or Data Identifier (34L) for Issuing Agencies that utilise DIs). This method requires a consumer to install an app (additional software) within their smartphone to extract the identification data element(s) then append them in a sequence to generate a URL to find online info. GS1 standards do not support this method for DPP because: 1) GS1 AI (8200) requires additional software on consumer smartphones, 2) can only support GTIN (does not support GTIN with variants, lot/batch numbers, or serial numbers in a structured way) and 3) AI (8200) is not used for new application standards of GS1 like DPP. All new applications for GS1 use Method 1. ANSI MH10.8 Data Identifiers, including (34L), are not used by users who utilise GS1 standards and so any assessment of DI (34L) must be performed by other Issuing Agencies.

Method 4 (IEC 61406-1) and Method 5 (Decentralised Identifiers): These methods are not used nor supported by users of GS1 standards-conformant, automatic identification and data capture (AIDC) systems. For this reason, GS1 has not assessed their fitness to meet ESPR requirements, conformity to international ISO/IEC JTC1 SC31 (AIDC technology) standards, or their current or planned implementation levels in AIDC technology systems. If they are appropriate for product types that are not using GS1 standards and are interoperable with the international AIDC standards in Annex A, GS1 users cannot speak for others who have implemented these methods in their AIDC systems and consumer devices.

[2] https://ref.gs1.org/standards/digital-link/uri-syntax/, chapter 6.1, p. 38.

3 AIDC carrier landscape

AIDC carriers used by GS1 users are carefully selected, some for pervasive adoption, others for niche adoption. Over the 51 years since IBM's EAN/UPC barcode was selected by an industry committee, GS1 has added three linear (1D) barcodes (ITF, Code 128, GS1 DataBar), two 2D barcodes (Data Matrix, QR Code), and RFID for use in open application environments.

Approval of additional AIDC carriers over this long history comes when an industry requirement within an application area is unmet by existing technologies or is better met by a new technology, however the goal is to allow any company to put a barcode on their products, returnable assets, logistic units, etc. that can enter the open supply chain and be scanned or read by the AIDC systems installed by millions of companies. For this reason, GS1 has a Policy for their adoption, approved by the GS1 General Assembly, that sets the criteria that must be considered such as 90% pervasive support for the technology, its license position being known and acceptable, etc.

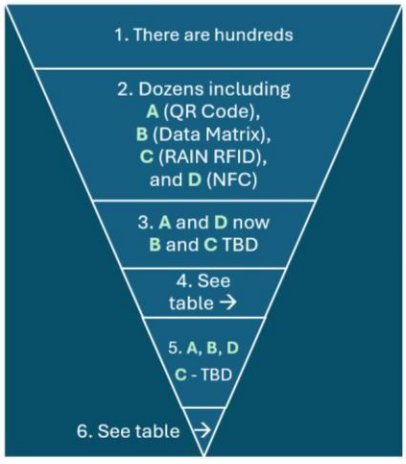
Once an AIDC data carrier becomes an option in one application standard, it is typically used in addition to the previous technology to balance innovation with backward compatibility. Once support for the new AIDC carrier reaches an implementation tipping point (again the 90% threshold), the entity can be identified with the new AIDC carrier instead of the previous one. To achieve this, GS1 users, Member Organisations, and AIDC solution providers (design software, printing systems, print quality verification systems, scanners, processing software) work together to communicate the reason for change, measure the progress of change, then use the reported progress to make decisions on when the tipping point is reached.

Fortunately, the retail industry began the effort for 2D AIDC carriers and GS1 Digital Link URIs four years ago and industry's aspirational goal of 2027 aligns with the ESPR implementation timeline and requirement to encode a "unique identifier" defined by the ESPR as a "*unique string of characters for the identification of a product that also enables a web link to the digital product passport*." Even so, as the GS1 Mission Specific Work Group working on Circularity/DPP progresses, there are still data carrier assessments and decisions that must be weighed. This section discusses the current state of play for AIDC carriers used by GS1 users as it relates to the ESPR.

Upcoming EU delegated acts may specify which data carriers may be suggested or accepted and we underline that the due diligence to foster their approval and most importantly smooth implementation takes many years to achieve and that with GS1/ISO compliant data carriers, this will be already completed or well underway.

A summary of DPP useful AIDC carriers is found in Table 3.1-1 with details following it.

Table 3.1-1 Assessment of AIDC carrier candidates



1. All Automatic Identification and Data Capture (AIDC) Carriers includes:	Anything that automates identification and data capture (e.g., 1D barcode, 2D barcode, RFID, NFC, biometrics, watermark)
2. ISO/IEC, AIM or NFC Standard AIDC Carriers includes:	ISO/IEC JTC1 SC31 or AIM standards (e.g., QR Code (QR), Data Matrix (DM), UHF RFID, NFC, GS1 DataBar, Code 39, Code 128, EAN/UPC, ITF)
3. Pervasive smartphone support – ISO/IEC 18975 AIDC carrier by 2027 without additional software includes:	Yes: QR code, NFC Maybe: Data Matrix (requires software upgrade across all smartphones), RAIN RFID (requires additional hardware, software, and ETSI certification)
4. Multi-purpose (B2B, B2C, B2G) AIDC carriers include:	B2B: Barcodes and RAIN RFID (supply chain) and NFC (financial transactions) B2G for ESPR: Barcodes and RAIN RFID (NFC TBD) B2C: QR Code and NFC (RFID & DM TBD)
5. Isolation of one AIDC carrier/ item by smartphones includes:	Yes: Barcodes and NFC To be determined: RAIN RFID
6. Producible & persistent include:	TBD per space or memory, encoding/marking

Starting from the "funnel top" above, the following explanations are provided:

1. There are hundreds of AIDC carrier technologies in the world.
2. Of those, a few dozen have advanced to attain international standards designation.
3. Of those, four have been discussed by GS1 users as candidate technologies for product identification for DPP based on their existing use in the supply or value chain. Three, QR Code, Data Matrix (another 2D barcode symbology), and RAIN RFID are currently GS1 approved AIDC carriers, and one, NFC, is not currently approved for use. Of those, the level of native consumer smartphone capability (that does not require the consumer to download software) range from: practically ubiquitous (QR Code), heavily implemented (NFC), unevenly implemented (Data Matrix), to not currently supported (RAIN RFID).
4. The industry strategically requires a single data carrier on a product that supports supply chain communication, consumer interaction, and regulatory processes. Currently, the use of GS1 Digital Link URI with structured GS1 identifiers in AIDC carriers is essential to achieving this goal.
5. Barcodes require the consumer to aim the camera at it and NFC requires the consumer to place the product next to the smartphone to ensure the consumer receives the DPP data that pertains to the intended product. One of RAIN RFID's advantages in certain use cases is readers can read all the tags within a large read range. This advantage in those applications can be very helpful in creating greater visibility for many supply chain applications. Some of these will enable B2B data sharing of DPP data or even the unique capability to build DPP data about products and components upstream. As it pertains to B2C use, GS1 has learned that the RAIN Alliance will research if it is possible to isolate the intended tag using consumer smartphones and looks forward to collaborating with them in the standards process.
6. The DPP covers a broad range of product types, many of which are produced by GS1 user companies, many in very high volumes at very high production line speeds. For this reason, it is critical that the AIDC carrier be producible. There are too many factors to list here, but for example: How will an AIDC carrier fit on a small, curved surface of a cosmetic pencil, be printed in line for shampoo bottles at hundreds per minute, be etched on a metal part used in a rail car? What is the impact of the data required on the tag memory?

3.1 Quick Response (QR Code)

QR Code encoding product identifiers in the GS1 Digital Link URI syntax meets the requirements of the regulation (QR Code is specifically cited by the ESPR), is supported ubiquitously by consumer smartphone native cameras, can be conformant with ISO/IEC 15459 and ISO/IEC FDIS 18975, and is central to industry's 2D/GS1 Digital Link adoption plans for 2027. For these reasons, QR Code with GS1 Digital Link URI syntax is highly likely to be approved by the MSWG for use in the GS1 AIDC Application Standard for DPP.

3.2 RAIN RFID (also referred to as UHF RFID)

This technology has the capacity to carry GS1 Digital Link URI in a binary string and, therefore, is to be considered for supply chain use cases. For these reasons, RAIN RFID with GS1 Digital Link URI syntax is very likely to be supported in the GS1 AIDC Application Standard for DPP. However, the binary string is not natively supported by smartphones to produce a web result, and it is unclear how a consumer's smartphone would read and isolate the "intended" tag versus all tags "available within its read range". GS1 has learned the RAIN Alliance is working on how these questions could be addressed and looks forward to collaborating with them in the standards process.

3.3 NFC

NFC is used in addition to barcodes on some products manufactured by GS1 user companies, but it is not currently an approved GS1 data carrier. This means to be prepared, GS1 should begin the assessment of NFC per GS1's Policy on Data Carrier adoption in the event NFC is specified as an AIDC carrier option within a Delegated Act. Even so, this technology has the capacity to carry GS1 Digital Link URI and is natively decoded by smartphones to produce a web result. NFC also enables the consumer to isolate the "intended" tag as the tag "available within its read range" is typically limited to the one held next to the smartphone. The assessment will occur only if the GS1 standards group establishing which AIDC carriers will be used by GS1 user companies requests NFC or unless there is a clear regulatory requirement for it.

3.4 Data Matrix

Data Matrix 2D barcodes encoding product identifiers in the GS1 Digital Link URI syntax (conformant with ISO/IEC FDIS 18975), meets the requirements of the regulation, and is supported by industry's 2D/GS1 Digital Link adoption plans for 2027. With that said, Data Matrix is not ubiquitously support by the cameras resident in consumer smartphones. This means that adoption would require smartphone support for this technology across Europe by 2027. This then raises the question, why would Data Matrix be considered if QR Code is already natively supported by smartphone camera connection to the Web? The primary factors both relate to Data Matrix's capability versus QR Code on some small, cylindrical products where equivalent error correction (~30%) is required of either barcode type.

1. Data Matrix has a size advantage over QR Code at the same level of error correction check (ECC) as the data expected for DPP AIDC carrier encoding should be around 40-70 characters maximum.
2. Rectangular Data Matrix, helpful on small or cylindrically shaped products, is supported by supply chain scanning devices where rectangular QR support is quite low.

If the GS1 standards group establishes these benefits warrant it, an initiative regarding consumer smartphone readiness could be warranted.

Annex A: GS1 user companies require the following international AIDC Standards to be included in the European Standards Mandate list

ISO/IEC JTC1 SC31 Standards

- ISO/IEC 15418: *Information technology; AIDC techniques;* GS1 Application Identifiers and ASC MH10 Data Identifiers and maintenance
- ISO/IEC 15459-2: *Information technology; AIDC techniques;* Unique identification, Registration procedures
- ISO/IEC 15459-3: *Information technology; AIDC techniques;* Unique identification, common rules
- ISO/IEC 15459-4: *Information technology; AIDC techniques;* Unique identification, Individual products and product packages
- ISO/IEC 15459-6: *Information technology; AIDC techniques;* Unique identification, Groupings
- ISO/IEC 15434: *Information technology; AIDC techniques;* Syntax for high-capacity AIDC media
- ISO/IEC FDIS 18975: *Information technology; AIDC techniques;* encoding and resolving identifiers over HTTP
- ISO/IEC 15424: *Information technology; AIDC techniques;* data carrier/symbology identifiers.
- ISO/IEC 16022: *Information technology; AIDC techniques;* Data Matrix bar code symbology specification, as it pertains to GS1 DataMatrix.
- ISO/IEC 18004: *Information technology; AIDC techniques;* QR Code bar code symbology specification
- ISO/IEC 15415: *Information technology; AIDC techniques;* bar code print quality test specification; two-dimensional symbols.
- ISO/IEC 15426-2: *Information technology; AIDC techniques;* bar code verifier conformance specification - Part 2: Two-dimensional symbols.
- ISO/IEC TR 29158: *Information technology; AIDC techniques;* direct part marking (DPM) Quality Guideline.
- ISO/IEC 18000-63: Information technology — Radio frequency identification for item management, Parameters for air interface communications at 860 MHz to 960 MHz Type C

GS1 Standards

- GS1 General Specifications (as normatively referenced by ISO/IEC 15459 parts 1-6, ISO/IEC 15418, ISO/IEC 15424, ISO/IEC 15434)
- GS1 Digital Link URI Standard (as informatively referenced by ISO/IEC FDIS 18975)