GS1 in Europe

The Global Language of Business

GS1 Standards enabling the EU digital product passport

Empowering industry's circular transformation and green product choices for consumers

Release 2.2, January 2025

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1 Introduction

GS1 welcomes the Ecodesign for Sustainable Products Regulation (ESPR), entered into force on 18th July 2024, as a key pillar of the EU Circular Economy agenda and of the EU 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, locations and entities in line with ESPR requirements.
3. Describe the GS1 data sharing principles and standards.
4. Outline the 2D barcode migration GS1 user companies are making to ensure one 2D 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 use 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 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.

Figure 1-1 below shows a basic picture based on preliminary understandings and many assumptions yet to be confirmed, some of which will be discussed. Particular attention is given to activities (yellow border) where GS1 standards play a pivotal role for those

[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.

industries impacted by the Regulation and who have implemented GS1 standards.

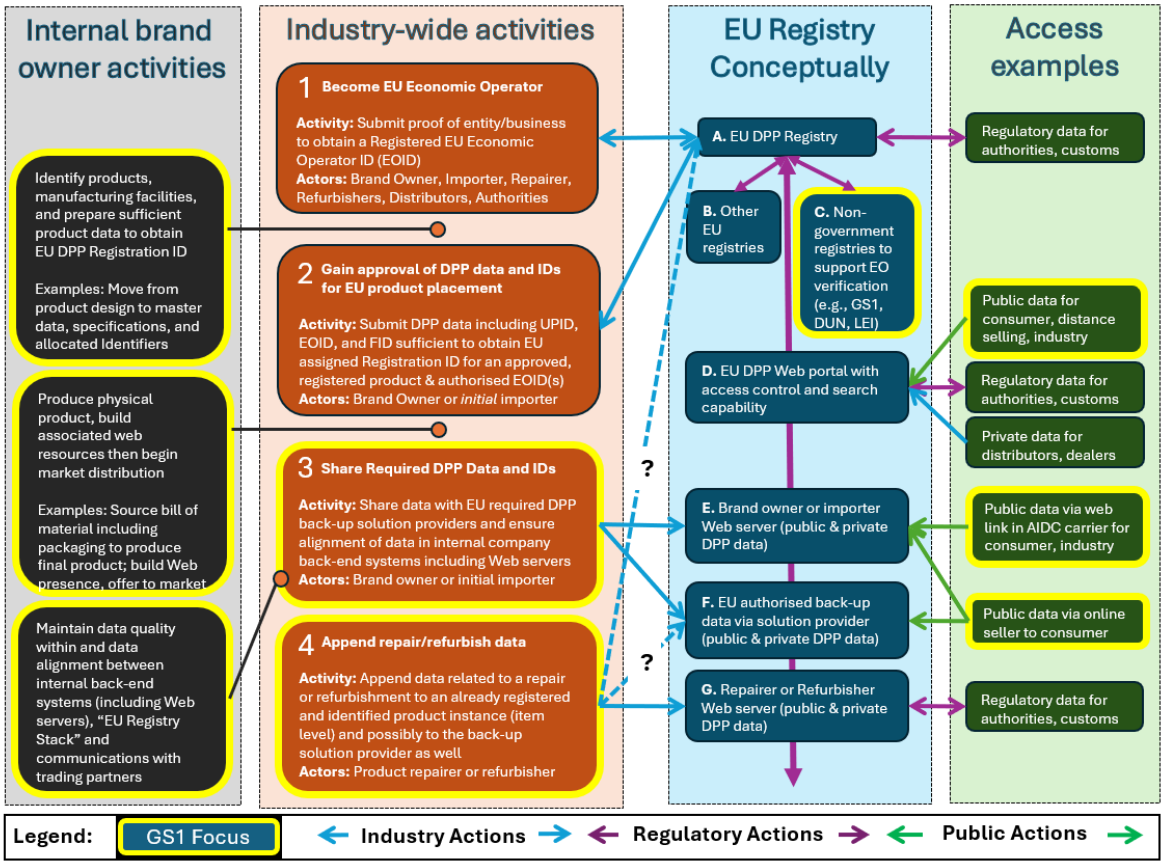


Figure 1-1

Internal brand owner activities:

Product manufacturers, referred to as brand owners in GS1 standards, are ultimately responsible to ensure the product, facility, and economic operator identifiers, product marking and/or packaging, DPP data complies. If the product is manufactured inside the Union, they will have additional obligations which will be discussed later. While Figure 1-1 is not comprehensive, it does explore high level activities of the brand owner where GS1 standards and ESPR requirements intersect. It also shows when these activities occur as it related to the industry wide DPP activities.

Internal brand owner activities are important to understand as they highlight the intersection of ISO/IEC 15459 conformant GS1 standards and DPP requirements. For example, more details can be found:

- See Section 2 to learn how brand owners identify their products using GS1 standards.
- See Section 3 to learn how brand owners are moving from 1D to 2D barcodes and/or RAIN RFID to enable supply chain transactions and using 2D for consumer engagement via the Web now and potentially RAIN RFID and NFC in the future.
- See Section 4 to learn how brand owners identify their manufacturing facilities and brand owners and other supply chain actors identify themselves using GS1 standards using GS1 standards.
- See Section 5 to learn how economic operators share data using GS1 standards.

Industry-wide activities:

Step 1 illustrates the need to verify a business entity and confirm the unique operator

identifier (UOI). Before any business entity can access the EU DPP ecosystem, they must provide sufficient information to verify they are a legitimate actor. Once this is achieved, they will receive confirmation of their unique operator identifier (UOI). The UOI may be used for access rights but also to associate multiple actors (e.g., subsequent importers authorised to import the product) with one product's DPP.

In **Step 2**, two actors, brand owners (for products manufactured inside the Union) and the *initial* importer (for products manufactured outside the Union) are responsible for submitting the brand owner data that was created in the brand owner activities column.

Step 2 assumes that for one product, there is one DPP record with one unique product identifier (UPI) and one DPP Registration Number (RN) assigned by the "EU system". This assumption is based on another, that the "EU system" will associate multiple unique facility identifiers (UFIs) and subsequent importers identified by UOIs with the UPI and RN. If these assumptions are true, market surveillance and customs clearance activities would rely on the UPI, RN, UFI, and UOIs to determine if the facility declared is approved for the product, what environmental impact there may be based upon the manufacturing facility location and if the economic operator is authorised to import it.

In **Step 3**, the brand owner (manufacturer inside the Union) or importer is responsible for populating the EU System, inclusive of back-up requirements with the required identifiers and data. This would include data and identifiers related to the product itself, identifiers and address information for all facilities where the product is manufactured, and the UOIs of the brand owner or importer. The brand owner and importer would also be responsible to ensure the data in their internal systems is and remains aligned with that in the "EU system". The brand owner would also be responsible for ensuring the AIDC carrier on the product links to information on their Web server that is and remains aligned with that in the "EU system".

In **Step 4**, downstream actors, also identified by an UOI are required to append (add to, not modify the Registered DPP). These actors include those who repair or refurbish a product subject to the regulation. In this case, instance (item) level identification would be required (e.g., serialised GTIN) as repairs and refurbishment will be associated with a specific product (e.g., laptop repair). It is unclear where and how these records will be registered, stored, and backed-up, hence dotted arrows in Figure 1-1.

EU DPP Registry Conceptually:

This column is labelled conceptually as it is not intended to establish any technical or architecture depiction of the "EU DPP System". The intention is to show expected components of the system as they relate to inputs (submission of data/IDs) and outputs (access to data via ID). This column raises some interesting intersections with GS1 standards as well as questions to be clarified. For example:

- Could non-government registries support verification checks for business entities and specifically for GS1, Verified by GS1's Party GLN registry?
- How will brand owner (manufacturer inside the Union) or importer maintain data alignment between internal systems, web servers, and the back-up DPP data with what was used to gain market authorisation?
- How will online "distance" sellers provide consumers with access to DPP data at least at the GTIN level using the same web link that appears in the AIDC carrier?
- How will repairers append service record data? Are they obliged to use a back-up solution provider for all records? Are they obliged to publish this data on the Web?

Actor interfaces with the EU DPP System:

When considering the various actors that interface with the EU DPP System, a depiction within a RACI (responsible, accountable, consulted, informed) chart is shown in Section 5.

2 Unique Product Identifier (UPI) and Web enabled, structured path identification

Among the various identification approaches, GS1's method aligns with ISO/IEC 15459 and ISO/IEC 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's 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 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 18975, 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 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 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 (UPI) 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 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 industrual 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.		

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 18975, one AIDC carrier can support business-to-business (B2B), business-to- government (B2G) and business-to-consumer (B2C) requirements.

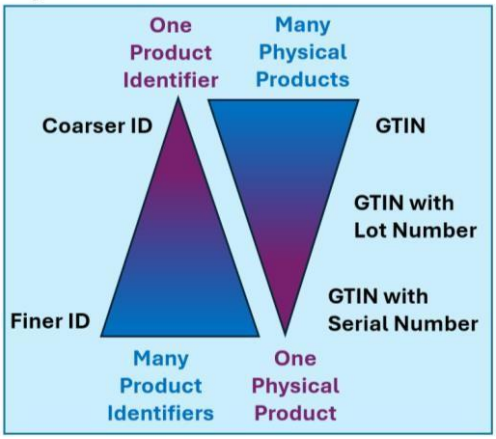
Interoperable per ISO/IEC 15459 compliance: ESPR Annex III (c) states, "*The Global Trade Identification Number as provided for in International Organization for Standardisation/International Electrotechnical Commission standard ISO/IEC 15459-6 or equivalent of products or their parts*"; and ESPR Annex 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 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.*

Figure 2.1-2



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.

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 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

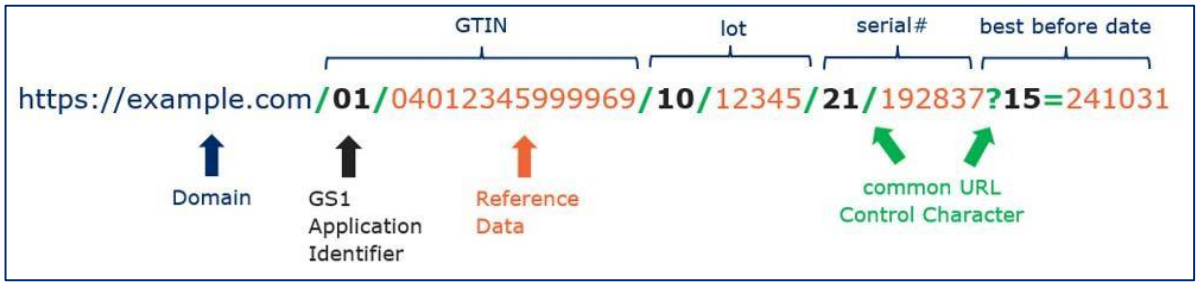
Method 1: The web-enabled, structured path identification method does not rely on the consumer to install any additional software or an app on their smartphone to make the Web link to DPP information. They simply use the smartphone to scan an AIDC carrier, land on a Web page, and then click on different 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 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 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.

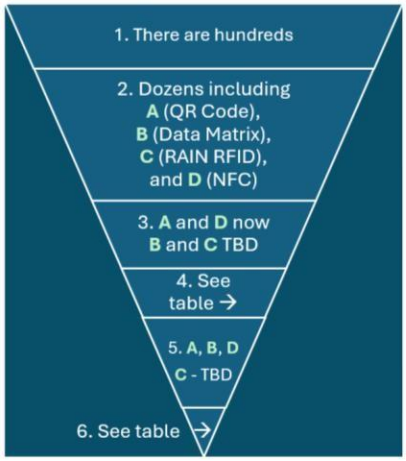
Once an AIDC data carrier becomes an option in one application standard, it is typically used in addition to the previous technology to balance innovation with backward compatibility. Once support for the new AIDC carrier reaches an implementation tipping point (again the 90% threshold), the entity can 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 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 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.

4 Unique Operator Identifier (UOI) and Unique Facility Identifier(UFI)

Unique identification is critical to maintaining operational efficiencies that consumers, business partners and governments rely on to exchange information in consistent ways, as well as ensuring the smooth operation of global supply and value chains. More specifically, the unique identification of parties and locations is critical for efficient logistic operations, traceability programs, recall readiness, and more. It is essential that accurate and up-to-date information on parties and locations can be readily shared to meet the consumer's and ESPR need to confirm the "who" and "where" of business to be reliably answered no matter the use case.

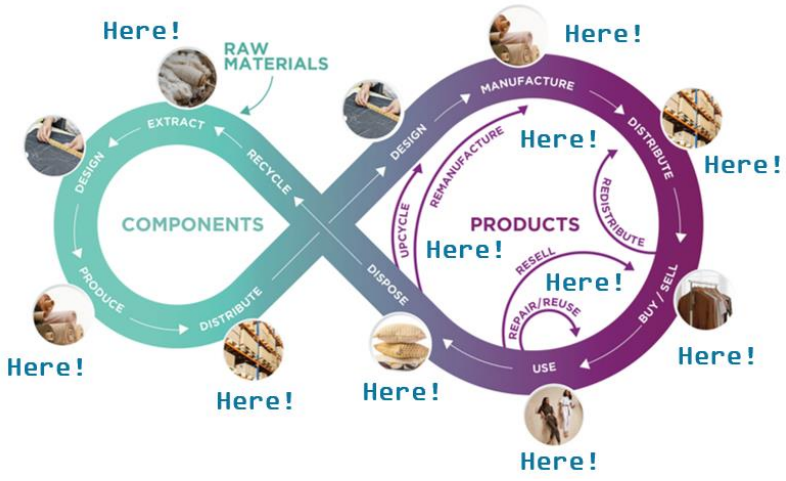
Traceability and transparency of a value chain can only be achieved through globally unique identification of products along with the parties responsible for the product and the locations that produced the products. The party, or Unique Operator Identifier (UOI), can be used to identify and trace the specific economic operators (such as a manufacturer, importer, repairer or distributor) responsible for a product throughout its lifecycle. The location, or Unique Facility Identifier (UFI), identifies the specific facility where a product is manufactured, assembled, or processed. This aids in tracing the origin of a product and understanding the environmental impact associated with its production. For example, to ascertain the carbon footprint of a product placed on the European market, knowing the facility where it was produced may be recorded in business transactions, customs declarations, and visibility event data. For data management and reporting, the use of UOIs

and UFIs facilitates the collection of accurate data regarding the environmental performance of products and, with this, DPP relevant data would be available. This data is essential for monitoring the effectiveness of the ESPR and for making informed policy decisions. By using GLN for UOI and UFI in combination with GS1 data sharing standards like EPCIS and EDI already in place today, reporting can be standardised across different operators and facilities, providing a means to compare data, assess trends, and identify areas where improvements in sustainability are necessary or possible. The UOI and UFI can enable better visibility into the supply chain, helping to ensure that all parties involved in the production and distribution of a product are adhering to sustainable practices. This is especially important in complex, global supply chains where products may be produced in different locations and pass through supply chain partners on their way to market.
Finally, for the consumers, knowing who produced the product and where it originated from helps build trust that the products are traceable and that operators and facilities meet environmental, usage (no allergens), and/or ethical sourcing expectations.

By reusing the already existing GLN identifiers deployed by industry for UOI and UFI, the needs of the regulation can intersect with the many other requirements for value chain visibility. If another identifier is used for UOI and UFI, GLN can still be used as an additional verification tool for business entity and be mapped to complement market surveillance activities. Within today's supply chain, master data, business transactions, and visibility event data support many complex business processes such as traceability, chain of custody, product recalls. At a high level, these processes utilise GS1 identifiers and date/time information to answer these high-level questions and answers. For example, as a product identified per Section 2 and marked with an AIDC carrier per Section 3 moves through locations, managed by various parties, the story of its life cycle is recorded. Sections 4 builds upon Sections 2 and 3 to illustrate the identifiers used for facilities and parties.

Here = Events

What is it? Use GTIN (unique product identifier or UPI) to identify the product
Whose is it? Use Party GLN (unique operator identifier or UOI) to identify the brand owner
Where is it? Use Location GLN (unique facility identifier or UFI) to identify the physical location
When did it move? Date/time



The GS1 standardisation process for Digital Product Passport (DPP) is underway and the following statements are based on the work in process at a high-level. At this stage, the use of Global Location Number (GLN) as part of the DPP digital record aligns with ISO/IEC 15459, ISO/IEC 18975 and ISO/IEC 6523-1 (Structure for the identification of organizations and organisation parts). The standards factors described in the points below are shared with a fair degree of confidence as these standards artefacts are used in transactions all around the globe and in all EU member states.

1. Use of Global Location Number (GLN) to identify the legal entities or parties responsible for the product. GLN identifies the economic operators placing products on the EU market in support of ESPR's unique operator identifier.
2. Use of Global Location Number (GLN) to identify the physical location producing the product supports ESPR's unique facility identifier.

3. 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 other than GS1. This means GLN SHALL begin with a digit and appear first in the full identification string when GLN and other data elements are stored as a concatenated string.
4. When a GLN is allocated to an economic operator and/or facility, it SHALL NOT be reallocated to another economic operator and/or facility, and all the identifiers above, once associated with a product subject to the ESPR, will never be reused to identify a different economic operator and/or facility, to safeguard uniqueness.

4.1 Unique Facility Identifier (UFI) utilising Physical Location GLN

GS1 standards provide an identifier, Global Location Number (GLN) for physical locations. This identifier conforms to ISO/IEC 15459-3 general rules and therefore is unique within the international domain for standards covering automatic identification and data capture in the supply chain. The GLN for a physical location may be used for a factory, a distribution center, a company headquarters, a sales office or any other location. In addition to the GLN for a physical location, there is also a serialised extension component that can be used to identify sub-locations within a facility. For example, the serialised extension component, when associated with the GLN for a manufacturing facility, could identify a packaging line or repack area, an inventory aisle, shelf, or bin.

The ESPR requirements align with the use of the GLN as the physical location identification level. This identifier would be a natural fit for Delegated Acts focused on GS1 standards users as many manufacturing facilities have or could easily be allocated a GLN. While the GLN extension component is not required by the ESPR, it is mentioned as it is also used by industry to locate or put up inventory for example. The GLN for facility will be associated with master data that pertains to a unique location, with business transactions, and EPCIS event visibility data provision.

Below please find a technical definition of Location GLN from the GS1 General Specifications.

3.7.9 Identification of a physical location - Global Location Number (GLN): AI (414)

The GS1 Application Identifier (414) indicates that the GS1 Application Identifier data field contains the Global Location Number (GLN) of a physical location (see section 2.4).

The GS1 Company Prefix is allocated by GS1 Member Organisations to the company that allocates the GLN – here the holder of the physical location (see section 1.4.4). It makes the number unique worldwide.

The structure and content of the location reference is at the discretion of the party who defined the location, in order to uniquely identify each location.

The check digit is explained in section 7.9. Its verification, which must be carried out in the application software, ensures that the number is correctly composed.

Figure 3.7.9-1. Format of the element string

GS1 Application Identifier	GS1 Company Prefix →							← Location reference				Check digit
4 1 4	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	N_{13}

4.2 Unique Operator Identifier (UOI) utilising Party GLN

Identification is the foundation of data sharing. As it relates to economic operator and facility identification there are various identification systems or domains. To clarify, we can use a very simple example, a person. Everyone is identified in different ways in different domains. For example, they have a legal name and may have a driver's license number, a passport number. It is appropriate to have various identifiers, but where machine to machine data sharing is required (e.g., passport control, driving records), the identifier must be unique

within that domain. In the world of UOI and UFI there are various identification system domains. For example, financial transactions, supply chain transactions, national healthcare reimbursement and more. The level of rigour related to the allocation and use of these identifiers is dependent on the system. For example, to obtain an identifier that authorises payment or access to a secured area of a building, great rigour is required. So, the first question is what identifier makes sense for UOI and for UFI as "the" identifier associated with a DPP?

There are various identification approaches being considered for UOI to support ESPR, but this Section will discuss the approach already supported by GS1 users should it meet the rigour required. And even if not, as was stated earlier, use of the GLN as an additional means to verify business entities and to tie value chain visibility event data and business transactions to the UOI is worthy of serious consideration. In the next release of this paper, more technical information regarding GLN will be provided, but in this release, we explore considerations of the various actors that interface with the EU DPP System. A depiction is provided within two RACI (responsible, accountable, consulted, informed) charts below. The first table focuses on the DPP for a new product.

New Product	Responsible to allocate identifiers and create data	Accountable to submit identifiers and back-up data	Responsible to authorise placement	Consulted	Informed
Brand owner		If domestic			
Importer		If imported			
EU					
Authorities /Customs					Private data
Upstream supplier				To provide data	
Distributor					Private data
Online seller					Private data
Consumer					Public data

The second table focuses on a scenario where a product, post-sale, is repaired or refurbished. Again, the assumption here is the repair or refurbishment service provider may, depending on Delegated Acts, be required to append information to the DPP. It is unclear at this time if the repair or refurbishment service provider will be required to back-up the service records and how consumers and industry actors will retrieve them. One thing is clear and that is manufacturers will be required to generate serialised product identifiers for any product where downstream actors must append data to the existing DPP.

Repaired product	Responsible to append service record data	Accountable to submit record to back-up data	Responsible to authorise economic operator	Consulted	Informed
EU					
Authorities /Customs					Private data
Repairer /Refurbisher		Unclear if this is required			
Distributor					Unclear how this would occur
Online seller					
Consumer					

Based upon these roles, we see an intersection of regulatory need for economic operator ID (EOID) and Party GLNs that already exist today to support data sharing covered in Section 6. This section will discuss the intersection of economic operator identification and the GS1 Party GLN ID will be discussed, but three considerations should be mentioned in summary here.

1. All economic operators who must submit DPP data or identifiers or who must access private DPP data must have a globally, unique economic operator ID (EOID).
2. Economic operator identification (e.g., GS1, DUNs) allocated based upon ISO/IEC 15459-2 and -3 will be unique one versus another and GLN provides the benefit of already being used for other business processes such as traceability, recall.
3. Independent of the identifier used for Economic Operator ID (EOID) within the EU DPP System, existing economic operator identification registries may prove beneficial to support verification of economic operators.

Below please find a technical definition of Party GLN from the GS1 General Specifications.

3.7.12 Party Global Location Number (GLN): AI (417)

The GS1 Application Identifier (417) indicates that the GS1 Application Identifier data field contains the Global Location Number (GLN) of a party. The GS1 Company Prefix (GCP) is allocated by GS1 Member Organisations to the company that allocates the GLN. The GCP makes the number unique worldwide. The structure and content of the party reference is at the discretion of the party in order to uniquely identify themselves.

The check digit is explained in section 7.9. Its verification, which must be carried out in the application software, ensures that the number is correctly composed.

Figure 3.7.12-1. Format of the element string

GS1 Application Identifier	GS1 Company Prefix →						← Location reference						Check digit
4 1 7	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	N_{13}

5 Data Sharing

5.1 Principles of Data Sharing

Before discussing GS1 data sharing standards, several principles, embraced by the GS1 user community over time and developed in collaboration with the communities represented at ISO/IEC are outlined.

1. **Decentralise where possible, centralise where necessary**: 'Decentralise' is a shorthand for the principle of keeping and managing data where it is, rather than requiring multiple stakeholders to put all their data in one place. By managing data in its original location owners are in greater control over access rights and can more easily update and correct any errors by still respecting applicable laws. Owners also preserve investments already made in their information systems and associated data management. The common and understandable human instinct to keep data within the company except where there is a clear need to do otherwise, is aligned with the decentralising approach. Recital (41) of the ESPR states: "*To ensure that the digital product passport is flexible, agile and market-driven and evolves in line with business models, markets and innovation, it should be based on a decentralised data system and be set up and managed by economic operators.".* In a decentralised infrastructure, where data are under the control of the owner, the persistence and integrity are crucial, allowing the users accessing data to be sure that no tampering has occurred, especially on data that have legal relevance in the activities of the Economic Operator. This integrity can be achieved leveraging Verifiable Credential, as described in the section 8. Data storage, integrity and persistence

This business-friendly principle is strongly supported by the GS1 community. However, as the ESPR stipulates in Recital (38) and Article 10(4), there is a need for a backup. That is, a copy of the DPP to be stored in a certified repository that is operated by a third-party.

The ESPR further stipulates in recital (44) and Article 13 that the product identifier be registered with the European Commission. It is anticipated that this role will be taken by EU CSW-CERTEX.

The interplay between the Economic Operator's own system, the backup repositories and the central register is discussed in 5.2 Information discovery below.

2. **Product descriptions and certificates with common semantics:** To share DPP data between business partners, consumers and regulators, it is essential that data is interoperable. This requires the use of common semantics. That is, terms used in the data must be either the same or map to a common vocabulary. The semantics of an individual term can be defined in the abstract and might be realised as data in a variety of syntaxes and formats.

   It is reasonable to expect Economic Operators to share their product description data and certificates of conformance openly without restriction. This occurs naturally, especially as part of online retail, as this data is an essential component in product discovery, retailer differentiation and consumer empowerment.

   See the section on Common **semantics** for a more detailed discussion of this point that suggests that schema.org be the "semantic anchor" to achieve the kind of interoperability required by the regulation.

3. **Open sharing of commercially sensitive data would harm competitiveness:** Industry cannot be expected to share commercially sensitive data openly as this damages competitive advantage and ultimately leads to increased costs. Nothing in the ESPR construct makes us think this will happen by regulatory demand as of today, but the delegated acts and other legal initiatives regarding access rights, and the EU registry set up, will need to confirm this foundational principle.

4. **Use existing IT infrastructures:** For the DPP to become a reality quickly and smoothly, any business will need to be able to rely on its IT infrastructure for the creation, management and distribution of its data and of its DPPs. For micro-businesses, the 'IT infrastructure' might be a single laptop computer. For large businesses, the IT infrastructure is substantial. Industry should be able to use its existing IT infrastructure without the need to upgrade its equipment, run custom software or use a specific software package from a specified vendor (that would create vendor-lock). The World Wide Web is already pervasive in all modern computing systems and so it is the obvious starting point for any data sharing. Saving the investments on the IT infrastructure means also being allowed to leverage the already preserving the already applied standards in data sharing, limiting the disruption and reducing the costs to be compliant with DPP requirements.

5. **Data security:** It was noted above that while product descriptions and certifications should be publicly available without restriction, some of the data needed to enable the circular economy is commercially sensitive. The commercially sensitive data (only) should therefore be subject to access control. There are multiple methods to achieve this, from the familiar username and password combination through Multi-Factor Authentication and Federated Identity to the use of Verifiable Credentials (VCs) to prove that a holder has the necessary authorisation. Economic Operators will have access control methods in place and GS1 suggests that they should be built upon without requiring wholesale replacement, thus minimising supply chain disruption.

6. **Data exchange and Application Programming Interfaces (APIs)**: There are many different data formats in use today as well as different approaches to API development; however, the dominant format and API approach on the web today is JSON/JSON-LD files exchanged securely over HTTPS using RESTful APIs. API calls are documented using either the Open API/Swagger specification, or Postman that, through widespread use, are expected and well understood by developers. As well as the primary format used for online product descriptions (see Structured/formatted **data**), JSON-LD is the data format used in Verifiable Credentials. This means that should industry choose to issue DPPs as a Verifiable Credential, as the UNTP specifies, or should regulation require it, the relevant data format would already be in use.

   Other data formats, most notably XML, are used in many environments and can be just as easily exchanged following RESTful API if there is a business need to do so. Non-RESTful protocols, that is, 'stateful' protocols in which a given request depends on the outcome of the previous one, such as the ISO 20000 (Web Services) series, are widely regarded as outdated.

7. **Inheritance is preferred over duplication:** Data about products, organisations and facilities always has a natural hierarchy. In the current context, facts can be asserted about a product or a version of a product, a batch of a product and an individual product. In information science terms, these are class, subclass and instance respectively. General information about a product can be asserted at the uppermost class level. This is relevant to procurement and identified in the GS1 system by the Global Trade Item Number - GTIN. To enable recycling or what facility produced the product, it's likely that batch-level data will be required and products in the batch *inherit* all the facts asserted about the GTIN (class) level. That is, everything that is true at the GTIN level is also true at the batch level and does not need to be duplicated. Finally, it's important to be able to record facts about repairs at item/instance level that can inherit the data from the higher levels.

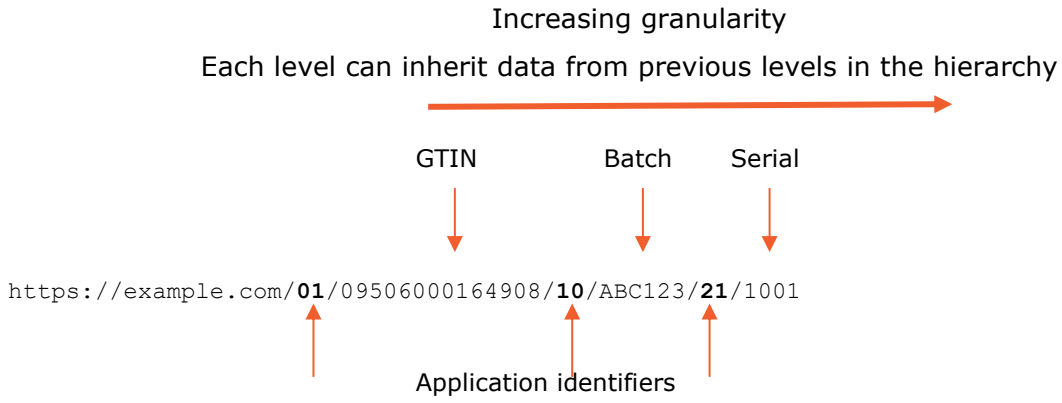


Figure 5.1-1 The hierarchical structure of a GS1 Digital Link, conformant with the structured path approach defined in ISO/IEC 18975.

This hierarchy is reflected in the structured path identification method detailed in the product identification and automatic identification and data capture (AIDC).

We suggest that future requirements consider these principles and support a hierarchy in data structures avoiding duplication of data and ensuring that it is managed efficiently at the most appropriate level.

8. **Data storage, integrity and persistence:** Economic Operators will have security measures in place to ensure, as far as possible, that their data is not corrupted. All data related to the DPP should be automatically backed up as a matter of routine. As the saying goes: *If you don't back up your data, you don't own it, you're just leasing it from fate.*

   There are two principal methods to ensure that data received over the web has not been tampered with:

   1. By always getting data from an authoritative source that has trusted mechanisms in place to counter malicious attacks. The overwhelming majority of online interactions are now conducted over HTTPS, as distinct from HTTP, which prevents 'man in the middle' attacks.
   2. The need to make frequent calls to a central database can be avoided if the data is made available as a Verifiable Credential (VC). The key features of the VC technology are that the encapsulated data comes with cryptographic proof of the data's origin and that it has not been tampered with. These facts remain true wherever the Verifiable Credential is found and the verification process does not require a 'call home' every time.

   A third possibility would be to use blockchain technology. Given its technological agnostic nature, GS1 regards such use of blockchain as entirely a choice for industry.

5.2 Information discovery

Structured path URIs, as defined in ISO/IEC 18975 and expressed in GS1 Digital Link URI syntax, contain GS1 identifiers in a way that achieves two things:

1. The precise structure is defined efficiently so that product identifiers, batch numbers, serial numbers and more can all be extracted by scanner software *without* any need for an online lookup. In that sense they operate in exactly the same way as traditional barcodes, including those scanned at point of sale, and so is backwards compatible with existing systems.
2. It is a URL: an entry point for digital information about the item, enabling both the retrieval of structured data about the identified product, product version, product batch/lot or product instance – and also using that URL within JSON-LD / Linked Data so that there is no ambiguity about which facts apply at each level of granularity – e.g. ingredient information that applies for every instance of that product GTIN, but recycling information can be specific to a product version or batch that is specific to an individual serialised instance or to a specific batch or lot of the product. Inclusion of such structured URL identifiers within the data makes it straightforward to also request / retrieve further data about related objects (such as higher-level logistics units or transportation containers or manufacturing facility location) when they also use such structured URL identifiers.

The DPP is an important example of "digital information about the item" but it is not the only experience that a brand owner or retailer would like to offer. They will want to present retail promotions, background information, instructions, tips and ideas, video messages and more and this topic will be subject to regulatory directions.

There are two possible approaches to connecting a physical product to multiple pieces of information: apply multiple data carriers to the product and assign a single use for each one (**Figure 5.2-1:**); or, connect a single data carrier to a location from which multiple sources of information are linked (**Figure**).

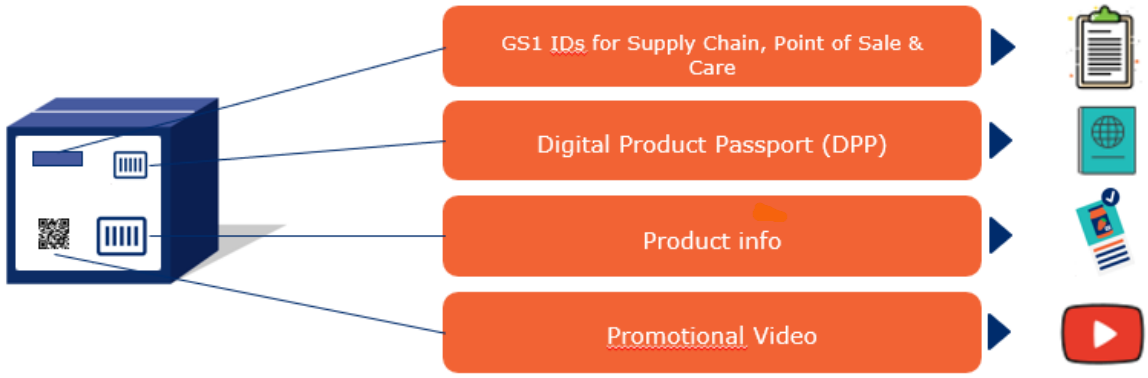


Figure 5.2-1: Multiple data carriers, all serving exactly one purpose

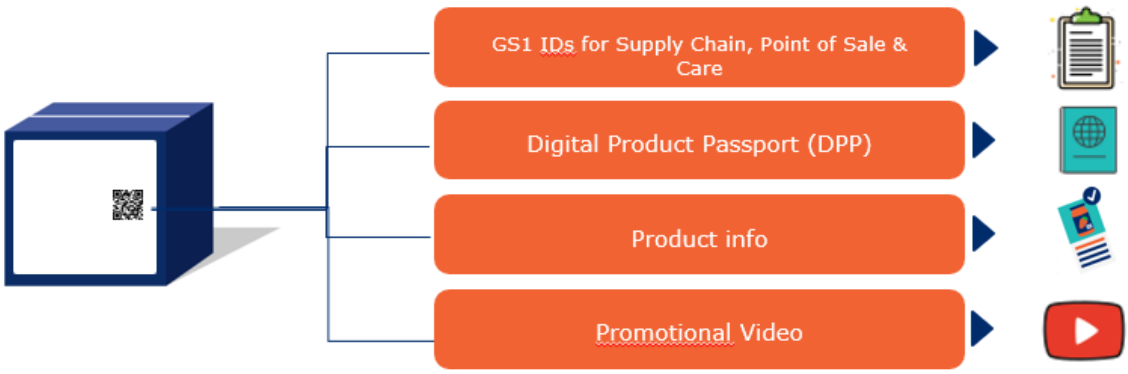


Figure 5.2-2: A single data carrier that is connected to multiple pieces of information

The advantages of using a single data carrier to achieve multiple functions are clear:

1. Space taken up on the pack is minimised.
2. Confusion for consumers, retailers and regulators as to which one to scan is also minimised.
3. Additional barcodes mean additional costs in time spent deciding what goes into each barcode, who manages the data for each barcode, where it will be printed, the potential need for multiple print heads, and in ensuring that any dynamic data, such as batch or serial numbers, are accurately encoded in each barcode where it's necessary.
4. There is complete flexibility – links to information sources can be added or updated at any time without any need to change the data carrier on the item.

To summarise:

- Figure 5.2-1**:** shows "select then scan" – select the relevant data carrier from the multiple ones available and then scan it
- Figure shows "scan then select" – scan the one data carrier and select the desired information from the available choices.

The GS1 community strongly favours the second option, **scan then select**.

It is noted that official texts, although not explicitly requiring the association of multiple, distinct URLs with a single data carrier, may be interpreted as supporting this approach. For example, ESPR recital 34 suggests linking future information requirements to the ESPR's

provisions; Article 27 discusses the need for *instructions* ***in digital format concerning the product ('digital instructions')*** *in a language that can be easily understood.* This is understood to be distinct from the machine-readable, interoperable data of the DPP. Finally, SREQ Annex II Part A 2.3: *The data carrier shall contain* ***links*** *to the product passport. The data carrier shall act as a reference to both the public and the restricted DPP-data*. Both public and restricted DPP data can be made available from a single source but, equally, could be made available separately. These clauses and others covering conformance certificates, including CE certification, all support the notion that a single data carrier, the primary purpose of which is to identify the product itself, should be the starting point for multiple links to multiple sources of information that comprise the DPP.

Connecting a data carrier to a set of links, rather than a single target, is covered by ISO/IEC 18975 (which is in its final approval phase). It states that if this is done, then the IETF's Linkset standard, RFC 9264, should be used to make the links machine-discoverable. Linksets provide not just the links themselves but descriptive attributes such as the language and format of the linked resource. Most importantly, it provides a machine-readable label for the *type* of information available at the target. This means it is possible for both humans and machines to find the link labelled "DPP".

Linksets can be published as JSON/JSON-LD files or they can be embedded in a web page in the same way that product descriptions can be embedded without affecting the look and feel of the page as seen by humans. This does not require any specialist software or the use of any app on the scanning device. A scan of a QR Code that contains a URI that conforms to ISO/IEC 18975 will lead to a web page just like any other URL. Publishing a web page with an embedded linkset allows search engines, artificial intelligence agents and other crawlers to discover the data associated with the product. For emphasis, this means that the DPP itself is machine-discoverable by means other than scanning the product.

It's possible to go further and create a simple API for the 'select' operation. ISO/IEC 18975 outlines the definition of a 'resolver'. The concept of a resolver is cited in SREQ recital (9) and in Annex II Part A 2.11. ISO/IEC 18975 defines a resolver as a service that accepts a conformant URI in which product identifiers are encoded, optionally appended by a request for a specific type of information. The resolver selects the relevant target resource from the linkset and redirects the query to it. Use of such a resolver service, beyond a simple 'default response' *does* require the use of an app or other software. So, for example, an app, following ISO/IEC 18975, could ask specifically for the DPP and so the user would not need to make a manual selection.

The GS1 Web Vocabulary, managed under the GS1 Global Standards Management Process, defines a range of link types suitable for use in linksets associated with products, organisations and facilities. The GS1-Conformant resolver standard is fully consistent with ISO/IEC 18975 and enjoys significant implementations by solution providers, brands and GS1 Member Organisations. Free, open-source resolver software is available under a fully permissive licence.

5.3 Primary data source, backup repository and central registry

The ESPR foresees four distinct actors in providing data relevant to a product's DPP:

1. The Economic Operator (brand owner/manufacturer (or importer)) that makes a product available on the EU market is responsible for providing the DPP (ESPR Art. 27.1c and Art. 29.2c). See also the section about Data sharing requirements along the Value Chain. They are the primary source of information to support the circular economy and create the DPP. Under a distributed system the data remains with them (or their designated agent). In order to discover the DPP for a given product, all that's necessary is to *scan then select* and the DPP will be returned from the original source [ESPR recital 44, SREQ recital 11].
2. Recognising that data systems can fail for a variety of reasons, including but not limited to the insolvency of the publisher, DPP publishers are required to place a copy with a registered back up repository [ESPR recital 38 and Article 10.4, SREQ Part A, 2.1 (h)].

Although not explicitly stated, it seems self-evident that provision of the backup must be entirely independent of all parts of the system that provides the primary information.

3. A digital product passport service provider that acts on behalf of Economic Operators to process and make available the DPP data and control access rights (ESPR recital 38, defined in Article 2 (32)).
4. The central register of product identifiers [ESPR recital 41 and Article 13].

GS1 fully supports this four-service approach and recognises its ability to meet a wide range of scenarios.

Simple case

In the simple case, a device (likely a mobile phone camera) scans the data carrier (likely an ISO/IEC compliant QR Code) and the user then selects the DPP which is retrieved directly from the Economic Operator's system.

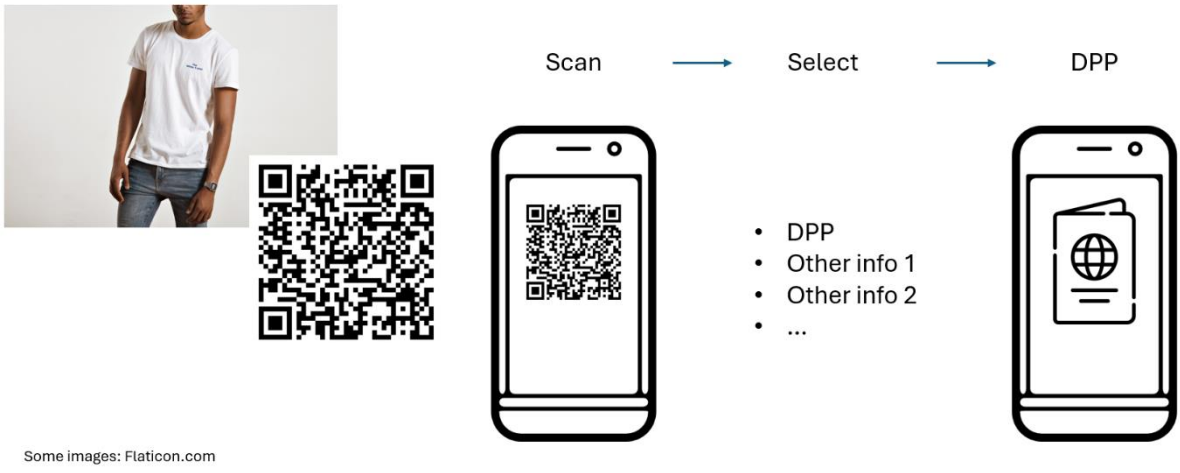


Figure 5.5-1 The simplest scan + select scenario to retrieve the DPP during normal operation

In this simple scenario neither the backup repository nor the registry is used because the primary discovery mechanism performs its function. The data may come directly from the Economic Operator or a DPP service provider.

Distance selling

When the product is being offered by a retailer operating at a distance from the consumer (such as online), there is no possibility of scanning the product itself. ESPR Article 10.3 (a) and (b) require the Economic Operator to make a digital copy of the data carrier or a webpage link available to online sellers. We assume that the webpage link is exactly what is encoded in the data carrier. Thus, by clicking a link on an online retailer's website, the user is directed to the primary data source for the DPP as if they had scanned the product itself.

DPPs for component parts and products/systems that incorporate them

When a product is sold, the DPP travels with it. It's effectively given to the new owner as part of the product. If that product is then incorporated into another product or system, then that new product or system will have its own identifier and its own DPP, drawing on the data in the constituent DPPs. The component manufacturers will likely not be responsible for the operation of the upper-level product. This is the flow already seen in some industries and depends in

large part on a DPP service provider, or network of providers. It is predicated on two key assumptions, both of which are reasonable, however, it is worth highlighting them:

1. That the service provider network and the URLs that point to it are themselves persistent. Assuming that the network holds the original and backup DPPs, the lookup network must itself be persistent and resilient.
2. That the management of data, especially the merging of component parts' DPPs into the upper-level DPP is carried out without loss or corruption of data. Verifiable Credentials would be an ideal technology for ensuring that the data from the component's DPP had not been tampered with and can be traced back to its source when included in any upper-level DPP. This would be consistent with Article 11 (g) and (h) that requires data to be secure. This is consistent with ESPR recital 32 and Article 11 (f).

Repairs

The previous section describes a workflow that is well-suited to technical industries where components are incorporated into bigger systems in a way that is expected and understood by all. However, there will be other cases where the DPP remains under the control of the Economic Operator and where third-party repairers will not be authorised to update the DPP by the Economic Operator. In such a scenario there are two ways this could be handled.

The simple solution is that the original DPP only applies to the original product and any repair makes that DPP void since the original Economic Operator is not responsible for the result of any repairs. Due to the repair carried out the information within the original DPP may or may not still be true, especially if parts have been replaced.

A more sophisticated way would be for the repairer to create their own DPP for the product, retaining the original (serial) identifier, updating the data accordingly, and then providing that new DPP. ESPR Article (d) says that *where a new digital product passport is created for a product that already has a digital product passport, the new digital product passport* ***shall*** *be linked to the original digital product passport or passports.*

It is to be seen whether all brand owners will be willing to update their DPP to link to a third party's DPP as the ESPR intends. However, until one or more delegated acts provides real-world scenarios this is not discussed further.

Backup data

As noted already, the ESPR does not rely on a single source for the DPP. It is assumed that some Economic Operators will cease to trade before the date when the DPP is no longer required, and this requires there to be a backup system of some kind.

One option is that DPP service providers are connected so that if one cannot provide the DPP, another can take over. This approach is realised in GS1-Conformant resolvers that can redirect to each other to find the relevant information. The service provider itself will have links to backups, redundant data stores and so on. Even if this is done, however, there remains a single point of failure which is the original Web link. If the service at that location is not in operation, for whatever reason, then no amount of federating and backing up will make the DPP directly discoverable.

This is where some consistency is helpful. An important and unique feature of the structured path approach defined in ISO/IEC 18975 is that the internet domain name is *not* part of the identifier. This means that, for example, https://example.com/01/09506000164908 and https://brand.example/01/09506000164908 both identify the *same product* despite being on different internet domain names. The product (and batch and serial number) can be extracted from the URL and it is those identifiers, not the URL itself, that is the key identifier. Therefore, if the first URL fails for any reason, if the user is aware of an alternative source of the DPP, they can simply replace the domain name and try again.

If an alternative lookup service is not known, then the central registry can play a role as a lookup service of last resort (the domain name dpp.eu has been suggested). There are three ways that can work:

1. The registry records the link to both the original and backup DPP associated with the product identifier. If a request to the primary source fails, a request can be sent to the backup location. It is noted that in ESPR Article 13 (5) states: *Upon the uploading by the economic operator of the data referred to in paragraphs 1 and 2 in the registry, the registry shall automatically communicate to that economic operator a unique registration identifier associated with the unique identifiers uploaded in the registry for a specific product in accordance with paragraph 4. That communication by the registry shall not be deemed to be proof of compliance with this Regulation or other Union law.* The unique identifier could be a Decentralised Identifier (DID), signed by the registry, that included the registered product identifiers and listed the URLs of the primary and backup DPP as Service Endpoints in the DID Document.
2. The registry keeps a list of certified DPP service providers. If the first one in the list fails, the second can be queried and so on.
3. Although not envisaged by the ESPR, it is possible that a future version of the registry would store a copy of the DPP that could be provided on demand but perhaps not as openly and quickly as the primary source and backup (i.e. you might have to request the copy of the DPP and receive it after some sort of verification process).

A simple way to connect to the back-up DPP would be a web App provided by the registry or some other backup service. For clarity, a web app is a regular web page that requires no installation and is seen in the browser but that is highly functional and can include, for example, a scanner.

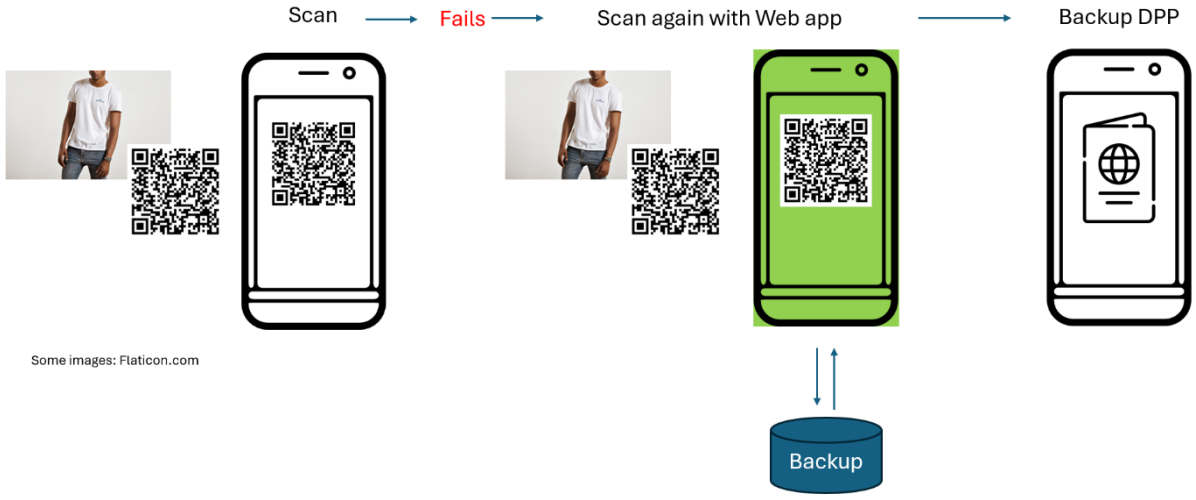


Figure 5.3-2 A web app is used to access the backup data after the original has failed

The web app would be made available and easy to find through search engine optimisation. There can be several such web apps either connected to the central registry or a DPP service provider. Ideally the DPP service providers are all connected/federated so that their web app can access each other's systems. Using the app, the original data carrier can be scanned. If the primary source is available, then the experience is exactly the same as if a mobile phone's camera had been used. However, if the scan fails for any reason – something the web app can readily detect – it can then indicate to the user that it will now redirect to the backup.

5.4 The power of layers

The architecture of the DPP system could comprise 6 distinct layers that exists individually but connect to create a single experience. The justification for taking a layered approach can be expressed very succinctly: flexibility. Each layer is defined in its own terms with the manifestation of each layer – the definitions and technical implementations – readily updated as the delegated acts are created, brought force and updated over time.

Each layer is discussed below.

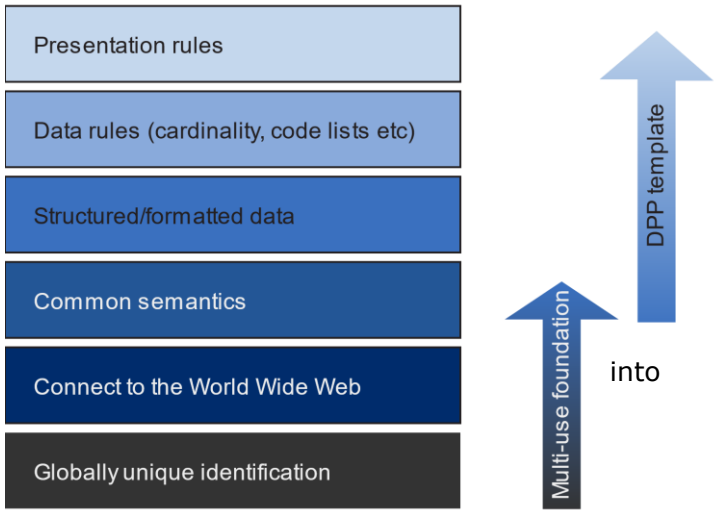


Figure 5.4-1: The layered approach

5.4.1 The multi-use foundation

Any business will want to maximise the return on their investment. One way to achieve this is to ensure that, as far as possible, processes and assets can be used to meet multiple needs. The proposed foundation layers meet those criteria as globally unique identification, use of the web and widely understood semantics are at the heart of almost all business processes related to supply chains and retail. For example, these elements are useful for the provision of detailed product descriptions to retailers and online platforms, multilingual usage instructions and safety advice for consumers, reviews and more. Seen from that viewpoint, the DPP is just one possible outward-facing channel for the pool of data, one that can be readily brought into existence with minimal changes to existing operations.

Globally unique identification

This topic is covered in detail in Section 2.

Connect to the World Wide Web

Following ISO/IEC 18975, identifiers that are globally unique and persistent can be connected to one or more sources of related information. This is consistent with ESPR recital 36: Unique identification of products is a fundamental element as regards enabling traceability across the supply chain. Therefore, the ***digital*** product passport should be linked to a unique product identifier.

ISO/IEC 18975 defines two approaches for encoding identifiers in Web addresses. The URI is simply used as a syntax for identifiers that are defined elsewhere and managed to ensure that they are globally unique in their own right. Identifiers defined within the framework of ISO/IEC 15459 are particularly relevant but ISO/IEC 18975 does not require their use.

The methods for encoding independent identifiers within an ISO/IEC 18975-conformant URI allow for a degree of flexibility but this is limited by the need to meet two primary requirements:

1. That the syntax is specific enough to allow the independently unique identifiers to be easily identified and extracted from the URI *without an online lookup*. That is, it's possible for point-of-sale scanning software to treat the data carrier just like any other barcode with no need for any call to the Web for it to be useful. This means there is no slowdown at the point of sale and no dependency on the internet for business-critical operations.

2. The full URL provides a convenient starting point for the discovery of digital information *about* the identified item so that it can be scanned without any specialist software. It follows that where specialist software is used, the independent identifiers can be used in any other URL.

The GS1 Digital Link URI Syntax standard is fully conformant with ISO/IEC 18975 and is an important pillar in the global migration to 2D barcodes. To support its open, royalty free standards, GS1 makes freely-licensed open-source software available that parses the URI to retrieve the encoded identifiers and pass them on to their host system in *exactly* the same way as in other syntaxes. It is being used in commercially available, production-grade barcode creation, print scan and verification equipment. Brands and retailers around the world, including many household-names in Europe and elsewhere, are at various stages of piloting and rolling out their 2D barcode implementations with the majority relying on the GS1 Digital Link URI syntax standard. Twenty-six major companies have expressed their public support for the programme. Four more have expressed their support at the time of writing.

Linking from one item to a single source of information is easy. However, as discussed elsewhere in this paper, the usefulness and therefore business-friendliness of a data carrier is increased greatly if it can be connected to *multiple* sources of information. Options for achieving this range from a simple redirect from the ISO/IEC 18975-conformant URI to a single web page from which a user selects the DPP, through to more sophisticated options including using a resolver. The ISO/IEC standard leaves the method chosen up to the implementer but does specify that *if* multiple sources of data are to be connected, the list of links to those sources should be formatted in accordance with IETF's Linkset standard, RFC 9264. This makes the links machine discoverable (by crawling the web page). A resolver can use that linkset to provide a simple, standardised API though which the links can be selected by software.

The GS1-Conformant resolver standard is also fully in line with ISO/IEC 18975 on this point. Again, GS1 provides freely licensed open-source software for this, multiple solution providers and brands have used this and their own implementations to create conformant resolver services.

Common semantics

The need for common semantics – that is, for one party to understand the data received from another – is a must. ESPR recital 36 makes it explicit: "...the ***data should be transferable through an open interoperable data exchange network without vendor lock-in.*** Article 10 goes further to state: "(d) all ***data*** included in the ***digital*** product passport shall be based on open standards, developed with an interoperable format, and shall be***, as appropriate,*** machine-readable, structured, ***searchable, and transferable through an open interoperable data exchange network without vender lock-in,"***

The text encourages the use of a single vocabulary for all data exchange, using a single format. Experience at GS1 suggests that this will be difficult to achieve. Everyone wants to use the terms they already use. It is inevitable that different sectors will have different ideas about which terms to use to fulfil the requirements of DPP provision. It's easier where new data is being created and curated for the first time. For example, ESPR article 7 foresees details such as a 'repairability score' and a 'durability score' but drawing on existing data structures can be hard.

Even given that expected variability, semantic interoperability between disparate sets of terms *can* be achieved by mapping such terms to those already present in one or more vocabularies that are:

- Already in widespread use,
- Managed independently following a recognized change management process,
- Rigorous in their definitions but accepting of mappings from similar concepts,
- Open to all sectors,

- Supported by long-term commitments to their continued existence, and
- Able to absorb new terms.

Vocabularies that meet these criteria do not come about easily, however, there are some important ones in existence.

According to its homepage, schema.org is used on '50 million websites' but those websites include some of the biggest in the world, so it underestimates the total usage.

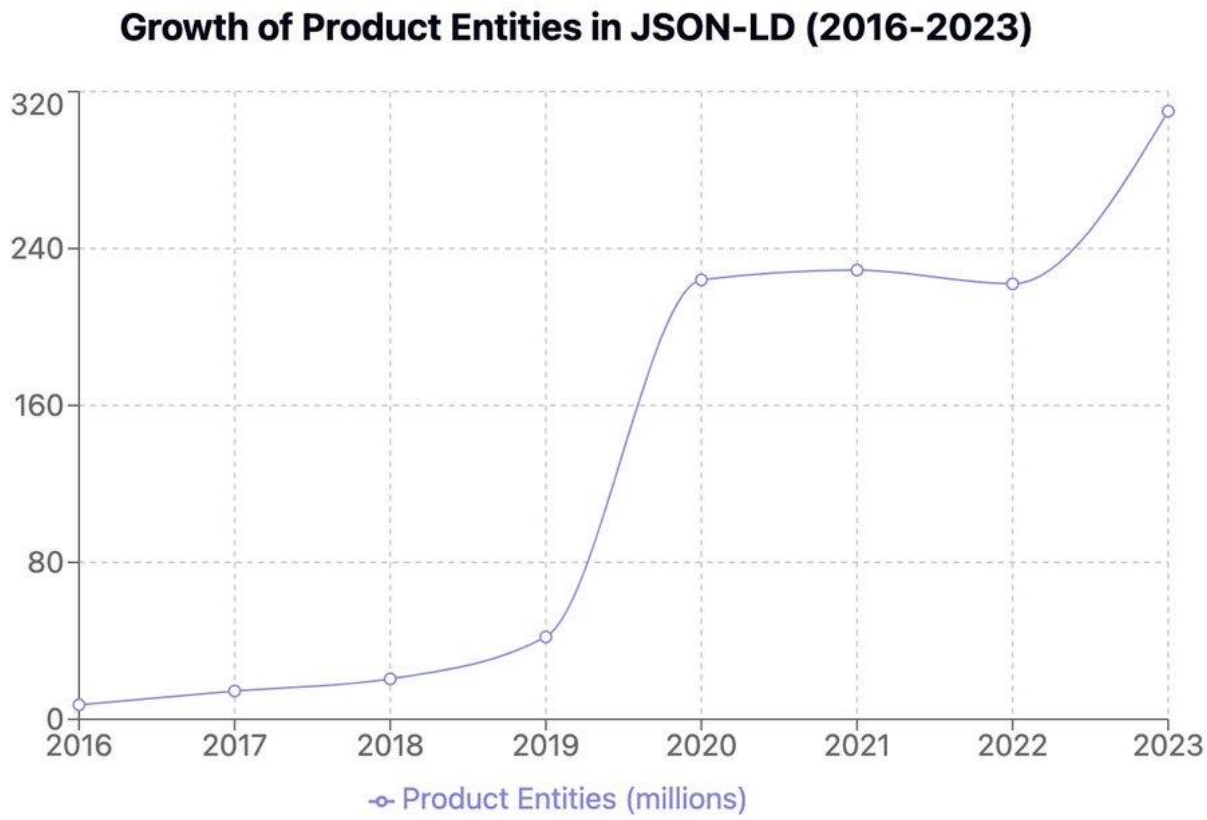


Figure 5.4.1-1 The use of JSON-LD to describe products online as discovered by the Common Crawl. The number has gone from 7.38M in 2016 by a factor of 42 to 310M in 2023. The statistics refer specifically to data about entities typed as schema:Product.

A better measure comes from the Common Crawl, a community activity that crawls the web and analyses the data found. As Figure shows, the number of products described using JSON-LD using schema.org is rising rapidly and reached 310 million in 2023. Similar growth was seen for postal addresses, local businesses and reviews. Schema.org is managed using the infrastructure and processes of W3C. Through this process, new terms can be proposed and discussed with the community. Schema.org has a long history of absorbing other vocabularies either in part or in whole. For example, the terms used for product descriptions, retail offers and reviews was originally developed as the Good Relations Vocabulary; the terms for describing datasets was imported from the W3C standard (DCAT), a profile of which, DCAT-AP, is used by the EC's Joinup platform, the terms for describing certificates are taken from GS1's Web Vocabulary (compare https://schema.org/Certification and https://ref.gs1.org/voc/CertificationDetails).

At the time of writing, the UN Transparency Protocol is in the process of mapping its DPP data model to schema.org. The Traceability Vocabulary developed by the Verifiable Credentials community, also at W3C, has already done such a mapping.

Schema.org's product class has many useful properties including schema:hasEnergyConsumptionDetails and schema:itemCondition that takes one of 4 values

from the relevant code list DamagedCondition, NewCondition, RefurbishedCondition and UsedCondition. There is explicit provision for GS1 identifiers to be used, including GS1 Digital Link URIs, but *any* identification system can be used with schema:identifier.

A further reason to suggest schema.org be used as a 'semantic anchor' is that its definitions, while rigorous, are very forgiving. For example, schema.org:material can take text, a URL or a pointer to another schema:Product as its value.

Notice that all the terms given as examples in the previous paragraphs are hyperlinked to their definitions. The terms are for computer – computer interaction and are fixed. The human-language definitions can be in multiple human languages, all attached to the same term at the same URL.

GS1's Web Vocabulary is built as an extension to schema.org offering more detailed descriptions for products, locations and organisations. Where similar terms are used, they are mapped directly to schema.org. For example, gs1:brand is defined as a sub-property of schema:brand.

The other vocabularies that can also provide a basis for common semantics are the ones the European Commission's SEMIC Core Vocabularies [SREQ recital 22] developed as part of Interoperable Europe. The Core Business Vocabulary and Core Location Vocabulary are worthy of special note. Semantic interoperability can be achieved by either using these vocabularies directly to describe Economic Operators and facilities or using other terms that are explicitly and machine-readably mapped to them. Further existing vocabularies are discoverable through the Linked Open Vocabularies service.

Separate from product descriptions, event data entails snapshots of process steps focussed on products and assets in the supply chain, including but not limited to commissioning, packing and unpacking, shipping and receiving, and selling or dispensing. Access and distribution of event data is at the discretion of the party which captures and maintains the data in a decentralised manner. Event data is not expected to be made public, but the party that has captured the event data can choose to provide business partners and downstream customers with access to a relevant subset of events.

GS1's open standard for event data, initially published in 2007, is EPCIS, supplemented by its companion standard, the Core Business Vocabulary – CBV (not to be confused with the SEMIC Core Business Vocabulary). Since 2015, EPCIS and the CBV have also been published as ISO/IEC 19987 and 19988, respectively. EPCIS event data includes the "what", "when", "where", "why" and "how" of business process steps and locations in a product's lifecycle, enabling visibility at varying levels of granularity from manufacturing to consumption. EPCIS also supports capture of Transformation events, which can help provide visibility of upstream raw materials in the production process, as well as the refurbishment of goods intended for a second life.

5.4.2 DPP templates

Having established the foundations, we can now move up the layers towards the DPP itself. These application-specific layers build on that foundation by selecting, formatting, validating and presenting the relevant data for both machine and human consumption.

Selection of the data required in the DPP will be determined by the delegated acts. These could potentially include semantic definitions of the data elements to be included.

Structured/formatted data

Once the necessary data has been selected from the available pool of data, it needs to be formatted as machine-readable data. The preferred data format for data exchange on the web is JSON (also known as ECMA-404. The JSON Data Interchange Syntax and ISO/IEC 21778). The code libraries and built-in functions used by web and app developers are primarily designed for use with JSON. The documentation around the Fetch API, available natively in all Web browsers, is a good example. It can handle any kind of data but almost all the examples

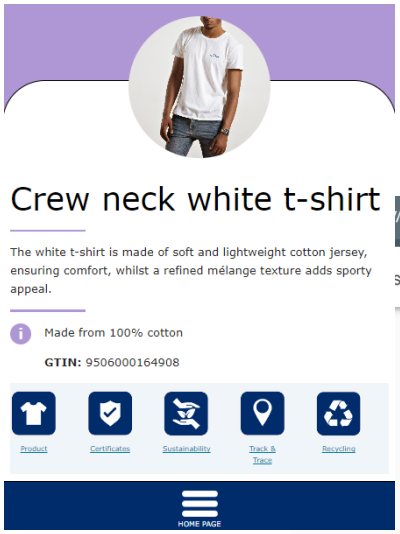
and built-in functions assume JSON. Browsers and scripting languages besides JavaScript all have built-in functions to stringify, parse and work with JSON data.

There remains a significant amount of data exchanged in XML, however, academic studies, such as Comparison of JSON and XML Data Interchange Formats: A Case Study (Nurseitov *et al* 2009) show distinct advantages for JSON. It's a more lightweight format that is more efficiently processed, much easier to parse and for developers to work with. Standardization work on XML technologies ended in 2016.

On its own, JSON is powerful; however, it is made more powerful when used to encode Linked Data (a simple kind of knowledge graph). JSON-LD (standardised at W3C) uses 'context' files to transform the basic JSON data into a (very simple) knowledge graph and to associate data elements with their semantic definitions. It's possible therefore to have data formatted in JSON from different sources that use different terms to mean the same thing. To take a trivial example, what one dataset calls 'hue' and another calls 'shade' can both use context files to machine-readably map those different terms to schema:color.

JSON Linked Data is the primary, web-native data format used for schema.org descriptions and several GS1 standards now have associated JSON schema files and JSON-LD context files (EPCIS, GS1-Conformant resolver). Like the SEMIC Core Vocabularies, The GS1 Web Vocabulary is published as JSON-LD but also rendered in human-friendly format.

An important feature of Linked Data in general is that it's possible to mix terms from different vocabularies so it's easy to foresee DPP data provided as a set of terms with semantics defined by schema.org, the SEMIC Web Vocabularies, the GS1 Web Vocabulary, the UNTP DPP Data Model, the W3C CCG's Traceability Vocabulary and more.



Note that embedding structured data within a webpage does not affect what humans see.

Figure 5.4.2-1 shows that a machine sees embedded in this web page for example.

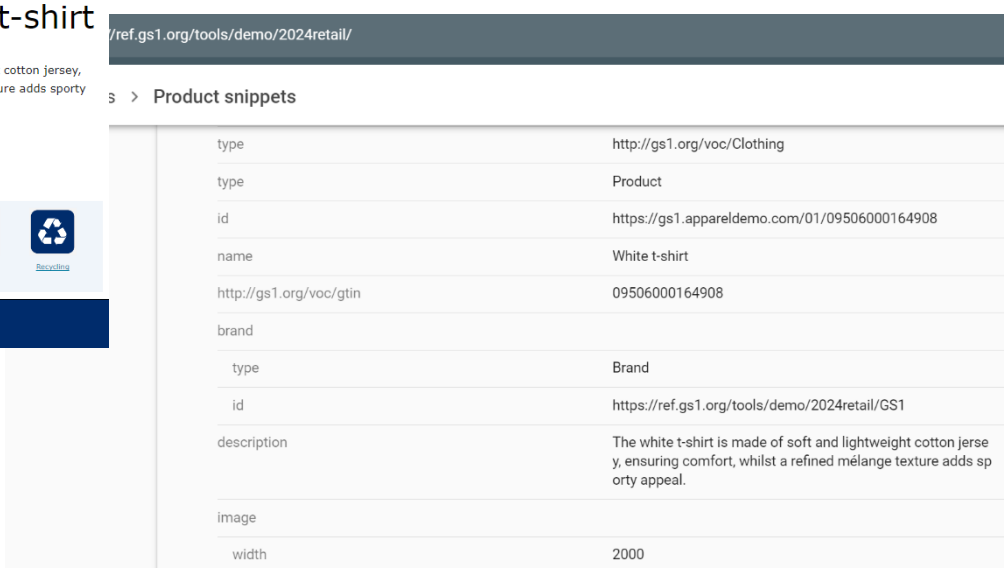


Figure 5.4.2-1 "Rich Snippets" view of some of the structured data embedded in the White t-shirt demo page

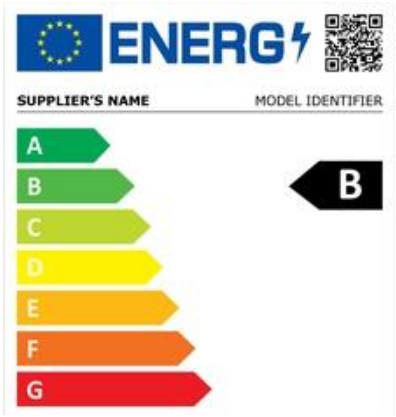
Data rules

JSON schema is the *de facto* standard that allows syntactic validation for JSON data, including cardinality and use of defined values from an enumerated code list in the same way that XML schema does.

Graph datasets (specifically those encoded using the Resource Description Framework, RDF) can be validated using SHACL. Since the same graph can be represented in multiple ways, a further standard exists to canonicalize graph data so that it can be hashed and verified against a reference dataset where applicable.

GS1 is committed to working with industry to identify or create and maintain the relevant code lists, JSON schema and JSON-LD context and SHACL files to aid the provision of DPP data using these vocabularies. This can be done in such a way that use of GS1 identifiers, while certainly possible, is not required.

Presentation rules



One of the challenges that will be faced in rolling out the DPP is improving consumer understanding. The energy rating system used for white goods is simple to understand and for consumers to use then when making their purchase choices. One of the aspects that makes it successful is that the information is presented in a consistent manner.

As with the data rules, GS1 is committed to working with industry to develop and maintain such visual templates as HTML, CSS and JavaScript files that will create a consistent representation of the underlying DPP data for human consumption. This is consistent with ESPR Article 16 that stipulates that the delegated acts will specify the content and layout of the labels. The article concerns the printed labels but intelligibility is enhanced if the digital matches the printed.

5.5 Data exchange through API infrastructures

As outlined in the section Data exchange and Application Programming Interfaces (APIs), the API technology can constitute a very effective data exchange infrastructure in the DPP distributed context.

For instance, the principle of having a link set returned by a resolver, may include API endpoints that could be leveraged by an APP to collect DPP data for a consumer or by an ERP system to load or update DPP relevant info into the system.

Some main functionalities to be supported can be:

- **DPP data creation/maintenance/access on DPP platforms**: adopting the REST API terminology, all the CRUD (Create, Read, Update, Delete) operations are made available by the DPP services (primary and backup)
- **Exchange of DPP data between EO**: according to lifecycle of a product along the supply chain, an economic operator may have the need to collect DPP data from another operator. The use case may be an importer retrieving the data from a manufacturer outside the EU or a manufacturer collecting DPPs of components or raw materials.
- **Collect master data, visibility or transactional data relevant to EUDR requirements**: examples of this kind of APIs are the EPCIS interfaces for capturing and querying visibility events.

The use of REST API provides many advantages, in terms of simplification and accessibility of the technology, with respect to other traditional data exchange protocol and allows the implementation of exchanges based on open standards, avoiding the specific vendors or specific infrastructure.

Interoperability, both in terms of API design and in payload content, is a core requirement.

From the design perspective, the use of OpenAPI may support the development of consistent interfaces.

An additional option is the definition of an API design guide, like the UN/CEFACT **OpenAPI Naming and Design Rules** document, detailing the minimum set of methods and return codes to support.

The interoperability of the payload requires that data are structured in a standardised format that is correctly processable and interpretable by both the systems generating and accessing the information.

Whilst a REST API can support many different formats, including XML or, even, EDIFACT or X.12, the natural solution widely adopted is to have payloads in JSON or JSON-LD.

The use of linked data, based on a common semantic anchor, as described in the **common semantics** section, is the key element in granting the interoperability of data. All the data exchanged will be correctly interpreted being uniquely defined by the common semantics.

5.6 DPP Data Sharing Summary

The ESPR outlines a rich ecosystem of data transfer between business partners, third party businesses, regulators and consumers. These interactions are precisely the ones that many industries have chosen to standardise at GS1 for more than 50 years. Those standards have evolved as industry has evolved – the web didn't exist 50 years ago, nor did the mobile phone. Furthermore, they have informed and been informed by ISO/IEC standards.

The provision of the DPP can largely be achieved as an evolution of existing business practices and IT infrastructures. In particular, data should be shared via the World Wide Web using the Web's native (graph) data format of JSON-LD. As far as possible, data should be accessed where it is currently stored and managed, that is, a decentralised approach is preferred. For a limited number of operations, particularly around fail-safes, a centralised data service is necessary, but this should not be part of the normal data flow.

Product descriptions and conformance certificates are expected to be shared openly, in line with existing practices for online selling. However, commercially sensitive information should only be shared by private means as to share it openly would harm competitiveness. Security and access control techniques are important to any data involved in any business operation but are out of scope for the current discussion.

Data about batches and serialised items should make use of the hierarchy available in the relevant identification standards. These include ISO/IEC 18975 and the ISO 1736* series. This means that data about a batch or an individual item can inherit data from the product type rather than duplicate it.

As regulatory and business use cases proliferate for linking a physical product to digital information about that product, it is increasingly important that a *single data carrier* is used to encode the identifier of the product itself. Following the *Scan then select* paradigm, this single data carrier can support multiple purposes including, but not limited to, providing the DPP. Selection can be by user interaction or software. This is strongly preferred to the complex and expensive alternative of printing multiple single-purpose data carriers on the product. ISO/IEC 18975 refers to the IETF's Linkset standard to achieve this, optionally made available as a simple APIs via a resolver. This is realised in the GS1 Digital Link URI and GS1-Conformant resolver standards.

The use of identifiers for *the product itself* being encoded is also important for ensuring that the identification is persistent as it is independent of any data system or internet domain name. This is a unique feature of the ISO/IEC 18975 standard for encoding identifiers within web links. In the event of a failure, perhaps because the Economic Operator is no longer in business, the persistent product identifier can be used in an alternative system with no dependency on the data system in the original web link.

Using product identifiers that do not depend on an internet domain name or a specific data system for persistence provides a solid foundation on which to build the DPP.

For DPP data to be interoperable between different industry actors who may have no business relationship with each other, it is necessary to have a common semantic framework. It is

unrealistic to expect all stakeholders to use the same vocabulary terms in all their transactions. Imposing such a requirement would create a significant cost for many businesses. However, it *is* reasonable for each set of terms used by a business to be semantically mapped to a small set of independent vocabularies. The SEMIC Core Vocabularies, ISO/IEC 19987 (EPCIS), ISO/IEC 19988 (CBV) and, in particular, schema.org are ideal candidates as they enjoy very substantial existing implementation, are persistent and professionally managed. The GS1 Web Vocabulary, the UN Transparency Protocol (UNTP) and the W3C traceability vocabulary are all examples of vocabularies that map to schema.org.

Using those vocabularies as a 'semantic anchor', the data itself can be made available in any number of formats. The use of JSON-Linked Data (JSON-LD) as one of those formats has significant advantages in terms of supporting precisely the kind of semantic mapping needed, creating a mini knowledge graph for each product with links to Economic Operators, facilities, certificates and more. It can be provided "as is" or embedded within web pages in such a way that humans don't see it, but machines can. Of note for potential future evolution of the DPP, JSON-LD is the format of the payload of Verifiable Credentials which is one possible way to achieve data exchange at scale with proof of authenticity.

It has been emphasised throughout this discussion that provision of the DPP can be seen as an extension of broader data provision that is an essential part of doing business today. Selecting DPP data from the bigger data pool can be achieved using data templates. Expressed as JSON schema and SHACL files, such templates can evolve over time as the regulations evolve with little or no additional engineering required to meet the regulation.

Finally, DPP data should be presented to consumers and industry using a consistent format. This can be achieved as a presentation layer with defined colour schemes, fonts, graphics and layout that sit on top of the data templates.

Annex A: GS1 user companies require the following International 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 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 18975)