Encoding JTC24 Product Identifiers for Digital Product Passports onto RAIN RFID Data Carriers

September 2026 | Version 1.0

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Version 1.0

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Executive Summary

RAIN RFID is an officially recognized, production-ready DPP data carrier under EN 18220 [3]. All five product identification schemes for the EU Digital Product Passport (DPP) as defined in EN 18219 [2] can be encoded on RAIN RFID tags, making RAIN technology a compliant DPP data carrier that is already deployed at scale. Standardised encodings for GS1 EPC are defined in TDS 2.3 [4] today and it is recommended to follow those (see Section 3.4.1). This document sets out the technical basis for guiding a shared, recommended encoding method for the remaining four identification schemes, facilitating potential future adoption by an international standards body.

Why it matters

EU Digital Product Passports are becoming mandatory under the Ecodesign for Sustainable Products Regulation (ESPR) [5] and further EU regulations, across product groups from textiles and tyres to toys, detergents, furniture, construction, and steel. Under the EU Product Act [6], Digital Product Passports eventually become mandatory for all products placed on the European market.

The European Commission requires harmonized technical standards for compliance; CEN/CENELEC JTC24 published these DPP standards in May and September 2026 [7].

With more than 50 billion tags shipped per year, RAIN RFID is the most widely deployed wireless data carrier. It is now an accepted DPP data carrier under EN 18220 and ISO/IEC 15459 [8] anchored item identifiers are accepted product identifiers under EN 18219.

Bottom line: Economic operators can meet DPP requirements with RAIN RFID infrastructure many already run today, choosing an encoding that fits their cost and technical requirements.

Inside this document

Section 1 — Introduction to the purpose of the document

Section 2 — RAIN encoding & reading basics. Tag memory banks, general encoding considerations, RAIN URI Template (RUT) [9], reading/resolving to a URL, and secure/verifiable identifiers.

Section 3 — The five DPP identification schemes on RAIN. Each with its standards basis, a worked encoding example, and the TEXT vs. RUT encodings.

Annex — Encoding examples. Detailed memory-usage examples for encoding specialists.

The five DPP identification schemes

1. **Web-enabled structured path/query** — ISO/IEC 15459 (including GS1 Digital Link URIs); the URL form of classic identifiers.
2. **Identification Link (IL) string** — A URL in compliance with EN IEC 61406 standard [10].
3. **W3C Decentralized Identifiers (DID)** — self-issued, cryptographic (did:web/ did:ethr/did:ebsi) based on W3C standard.
4. **Identification for products and product groups** — best for RAIN RFID (UHF RFID) data carriers as per ISO/IEC 18000-63 [11], identification based on ISO/IEC 15459 and encodings based on ISO/IEC 15961 [1] series, ISO/IEC 15962 [13], ISO/IEC 17360 [13] and GS1 EPC TDS 2.3.
5. **Digital Object Identifier (DOI)** — based on ISO 26324 [14] standard.

1. Introduction

A data carrier is the medium that holds the globally unique product identifier that resolves to a product's digital product passport (DPP). With over 50 billion tags shipped annually, RAIN RFID is already the most widely deployed technology for electronic item identification, making it a logical choice for DPP data carriers.

In the EU, digital product passports (DPPs) will become the main tool for product declarations and conformity assessment. These are set to become mandatory under:

- the EU Ecodesign for Sustainable Products Regulation (ESPR) for many product groups, including textiles, tyres, toys, furniture, and steel, among others, under
- several revisions of EU regulations, such as the battery, detergents, toys, construction regulation, and
- the new EU Product Act for all products placed in the EU,

When mandating a technical tool for compliance, the European Commission is obliged to provide "harmonized" technical standards for implementing it. The standards defining digital product passports were developed by the CEN/CENELEC joint technical working group No. 24 (short JTC24), have recently been made available, and have been cited in the Official Journal of the European Union.

The RAIN Alliance was actively engaged in defining the JTC24 standards, with several RAIN Alliance members representing RAIN technology throughout the effort. As a result, **RAIN RFID tags are an accepted data carrier for DPPs** (see EN 18220) and the RAIN identification schemes defined in ISO/IEC 15961 are accepted product identifiers (see EN18219).

In addition to data carriers, the JTC24 standards specify five product identification schemes. These define globally unique product identifiers that are encoded on the data carrier and resolve to the digital product passport on the web. For the RAIN industry, it is essential that a standardised method is defined for encoding each of these five schemes on RAIN RFID tags.

To initiate the standardisation work, this document gives a high-level introduction into RAIN RFID tag encoding and reading **(Section 2)**, provides a short overview of the five accepted product identification schemes with related information to their encoding on RAIN RFID tags **(Section 3)** and provides a technical **Annex** with detailed encoding recommendation for encoding specialists.

NOTE: All five identification schemes can be encoded on RAIN RFID tags to support Digital Product Passport use cases.

2. RAIN RFID tag encoding and reading

RAIN RFID provides high-speed, without light and line-of-sight identification of products over several meters, allowing mass reading and enabling full automation of operational processes. Therefore, their use in logistics, discovery, and sorting use cases are especially efficient. This section provides high-level information and guidance on RFID tag memory, encoding, and reading.

2.1 Encoding data to RAIN RFID tags

This section provides some background information and basic knowledge to understand encodings on RAIN RFID tags.

2.1.1. The memory banks of a RAIN RFID tag

A RAIN RFID tag has four memory banks (see Figure 1). Only the “UII/EPC” memory bank (MB 01) and the User memory bank (MB 11) are available for storing data. The Reserved memory bank (MB 00) and the Tag Identifier (TID) memory bank (MB 10) are reserved for other purposes.

1. **The UII / EPC memory** includes the Toggle Bit (short T-Bit), which is an encoding type indicator. It indicates to the RAIN reading device what data construct is following.
    a. The T-Bit must be set to “1” when using ISO unique item identifier (UII) numbering systems. In that case, an ISO Application Family Identifier (AFI), as defined in ISO/IEC 15961-3, must also be encoded. The list of standardized AFIs is available in the ISO-IEC 15961-2 Data Constructs Register)
    b. The T-Bit must be set to “0” when a GS1 Electronic Product Code (EPC) is encoded (for details on EPC refer to Section 3.4.1). GS1 encoding of JTC24 identifiers **exclusively** uses the UII/EPC memory bank.
2. **the (optional) user memory**, which also starts with an encoding type indicator (here the Data Storage Format ID (DSFID) as per the ISO-IEC 15961-2 Data Constructs Register) and can then store any data related to the identifier and the product, such as the complete URL or human readable identifiers.

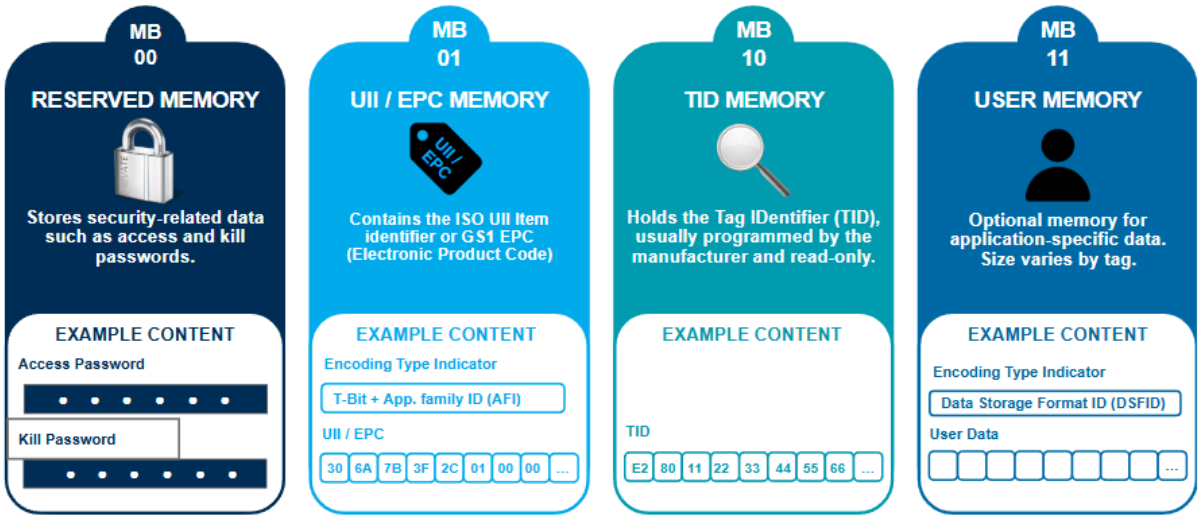

Figure 1: The four memory banks of a RAIN RFID tag

2.1.2. The Landscape of RAIN RFID Data Carriers

The RAIN RFID industry provides a range of different tags. They can be classified in two categorie**s:**

1. ***ID-only / low memory tags*** have a small UII/EPC memory size.

   ID-only / low memory capacity tags feature compact memory architectures typically limited to 96 to 128 bits of UII/EPC data and small or no user memory. Engineered for maximum cost efficiency at scale, they store minimal item information in the form of an electronic product code on-tag. This lightweight footprint makes them the industry standard for high-volume, cost-sensitive applications like retail apparel, parcel logistics, and supply chain inventory tracking.

2. ***Extended memory tags*** represent a group of tags with various UII/EPC and User Memory sizes.

   Extended memory capacity tags feature expanded memory banks, often ranging from 512 bits to several kilobits of user memory, enabling them to store detailed item attributes, maintenance logs, and lifecycle data directly on the asset itself. Rather than requiring an active network lookup for detailed item information, these data-rich tags act as portable, on-tag records. This makes them ideal for mission-critical, regulated, or offline environments such as aviation, healthcare, and industrial manufacturing. Where instant, decentralized data verification at the edge is essential.

Together, this variety enables every JTC24 product identifier scheme to be supported. Economic operators can therefore choose among different encoding approaches within the same RAIN RFID framework, suitable to their requirements for cost, ease of use, interoperability, and so on.

NOTE: All RAIN RFID encodings are specified in the ISO/IEC 15961 Data Constructs register which contains both horizontal and vertical encoding specifications, see https://www.aimglobal.org/registration-authority-iso-iec-15961.

2.1.3. Data encoding using RAIN URI Templates (RUT)

The **RAIN URI Template (RUT)** is a way to **represent RFID tag data as structured, machine-readable URIs** which uses less memory on the tag.

It is part of the broader effort of making RFID data interoperable across systems by turning raw tag identifiers into **uniform resource identifiers (URIs)** that software can easily process, link, and resolve. In the case of DPPs, this mechanism converts globally unique product IDs into resolvable Web URLs.

A RUT defines a **template** that can be filled with data while reading a tag. I.e. when reading a tag, the template and the data from the tag are combined and result, e.g. in a URL that leads to the DPP. This method reduces the needed memory on the RAIN tag and is one possible mechanism referred to in Section 2.1.4 General Encoding Considerations. A prerequisite is that the reader recognizes the RAIN URI and can interpret and process it accordingly.

Standardisation of RUT: AFI (Application Family Identifier) is a single-byte code defined under ISO/IEC 15961-2] and ISO/IEC 15961-3 to select specific classes of RFID tags. An AFI has been allocated for encoding RAIN URIs. RAIN URI Templates (RUTs) **values** (the RUT list) have been published by the RAIN Alliance. Please consult the RAIN Alliance Web Site for the latest RUT list specification at docs.therainalliance.org.

RUT values used in this document are published in the RUTlist. The encoded values are illustrative.

If an actor along the value chain, such as a customs inspector, waste sorter, or consumer, uses a standard, legacy, or generic reader without this specific RUT configuration file available, the device will successfully capture the raw binary information, but will fail to construct the DPP URL.

2.1.4. General Encoding Considerations

This section discusses general considerations for the encoding of DPP identifiers:

1. **Storage of the globally Unique Product Identifier (UPI)**: ISO/IEC 18000-63 standard (which aligns with GS1 EPC Gen2), recommends that the globally unique identifier for an item or object (in the case of DPPs the product identifier) is stored in the UII (Unique Item Identifier) / EPC memory bank (MB 01).
   NOTE: All GS1 DPP encodings take place here.

2. **Technical impact on read throughput:** While sequential reading of multiple memory banks (UII/EPC, User Memory, and TID) increases the data payload associated with each inventory cycle and extends air-interface communication time, such reads only happen when the full DPP information is to be accessed. As a result, the maximum achievable tag read rate (tags per second) may be reduced in such scenarios. In operational environments where throughput is a key performance requirement, such as high-speed logistics, automated POS systems, and rapid supply chain processing, only the strictly needed amount of information, typically the UII/EPC, will be read, and no additional communication overhead will impact overall system efficiency. Since RAIN RFID technology is often

deployed to support high-throughput applications, consideration should be given to optimizing memory bank access to help minimize potential performance constraints.

3. **Model and batch level encodings:** In the use case of inventory control and stock counts, when readers scan and detect model / batch level identifiers, they should also read and store e.g. the item level unique serial number. Without a unique serial number captured, RAIN RFID based stock counts will be inaccurate, and therefore inventory renders inaccurate.

4. **DPP URL encoding.** Where the link to the DPP consists of two or more parts, such as a globally unique product ID plus a domain name, the encoding can be split between:
   - **the UII/EPC memory**, which contains the encoded globally unique product identifier; and
   - **the User memory,** which contains additional information to compose the URL, i.e. a top level domain to create the link that resolves to the digital product passport.

   Where the globally unique identifier is the entire DPP URL (as with the Identification Link, see Section 3.2. Identification scheme 2: Identification Link (IL) for products (based on EN IEC 61406)), it should be fully encoded in the UII/EPC memory, however RAIN URI Templates (RUT) can be used for lowering the encoded bits on the tag (see Section 2.1.3).

   NOTE: This option is not allowed for GS1 globally unique product identifier encodings for digital product passports.

5. **System consideration.** The core trade-off is between:
   a. ID-only / low memory capacity tags, that typically cannot support a full URL and potentially need external information to resolve to a DPP; and
   b. Extended memory tags that provide more UII/EPC memory for larger values/the full DPP URL plus optional product attributes in User memory, at a potentially higher unit cost. Please consult your RAIN RFID tag supplier for a cost indication.

NOTE: RUT encoding can potentially fit a full URL onto a low memory capacity tag. This solution requires the reader to recognise and process the RUTs following the defined templates.

2.2. Reading DPP identifiers from RAIN tags

Reading a Digital Product Passport (DPP) identifier from a RAIN RFID tag depends on the encoding scheme stored on the tag and the decoding capabilities of the reading device.

To access a Digital Product Passport, the globally unique product identifier on the RAIN RFID tag needs to be read, decoded, interpreted, and processed into a form that takes the user to the digital product passport on the web. According to the JTC24 standards all product identifiers need to be representable as URLs that are accessible on the web.

How the URL is obtained depends on the identification scheme and encoding used:

- Where the globally unique identifier is encoded, whether using the RUT approach or a GS1 EPC++ scheme (see section 3.4.1), decoding and transformation logic needs to be applied to the tag data which creates a URL as result.

- Where the URL is encoded as free text, no further interpretation or additional logic is required.

In both cases, the resulting URL must then be handed over from the RAIN RFID reading device to a web browser that leads the user to the digital product passport.

2.3. Secure & Verifiable Identifiers on RAIN tags

ISO/IEC 20248 [15] (commonly known as **DigSig**) defines a standardized way to digitally sign the data stored in a RAIN RFID tag or barcode. Rather than only encoding an identifier, such as the globally unique Product identifier, the issuer generates a cryptographic signature over the identifier and other selected data (e.g. the TID of the RAIN tag) using a private key.

Anyone with access to the corresponding public key certificate can verify the signature, even offline. Verification confirms that the data has not been altered and that it originated from the claimed issuer. Where the signature includes a secure chip or tag identifier, it further confirms that the data is associated with the original physical RAIN RFID tag rather than a cloned copy.

For identifiers encoded on RAIN chips, ISO/IEC 20248 can be applied to JTC24 ID schemes. It adds a layer of trust by providing data integrity, authenticity, and protection against tampering and cloning without requiring the tag itself to perform cryptographic operations. This makes it well suited for Digital Product Passports, supply chain traceability, product authenticity, and other applications where trusted product identity is essential.

3. JTC24 identification schemes encoding guidance

JTC24 has specified five product ID schemes in the DPP standard EN18219 and three different data carriers in EN18220, RAIN RFID among them. The five product identification schemes are described briefly in the subsections of this chapter.

Identification schemes 1 and 4 are both based on ISO/IEC 15459, but scheme 4 is particularly well suited for RAIN RFID (UHF RFID) tags as per ISO/IEC 18000-63.

Because Digital Product Passports (DPPs) are still an emerging application, the encoding is already standardized and tested for some identification schemes but not yet for others. E.g. RAIN URI Template (RUT) values for each scheme have newly been specified by the RAIN Alliance and must now demonstrate their robustness in global deployments.

Although all five JTC24 schemes can be encoded on RAIN RFID tags, ISO/IEC 15459 and EPC-based identifiers remain the current preferred approach for large-scale industry deployments due to their compatibility with existing RAIN RFID infrastructures, ID-only/low-memory tags, and high-volume operational processes.

NOTE: An extensive comparison of DPP identification schemes can be found in the standardisation document EN18219.

3.1. Identification scheme 1: Web enabled, structured path and query ID for products

This ID scheme ensures globally unique identification based on ISO/IEC 15459-4 (individual products) and ISO/IEC 15459-6 (grouped products). It is an ISO/IEC 15459 based product identifier using a URL encoding of ANSI DIs (data elements which form the product identifier). It provides direct access to the DPP.

NOTE: For GS1 encodings please refer to ID Scheme 4, Section 3.4.1.

EXAMPLE

- Query string encoding: `https://example.com?.25P=QCELMI12345&.S=654321`

Applicable encoding methods

Method	Description	Advantages	Disadvantages
TEXT	The product ID is encoded as a full free TEXT URL	+ Simple + Human readable after encoding	- Does not work with low memory capacity *tags*, i.e requires more than 128 bits memory on the tag. - Does not have a fixed length.
RUT	The URL is encoded using a RAIN URI template (RUT)	+ Requires less memory on the tag. + Potentially fits on a cheaper low memory capacity tag.	- The decoder needs to have the RAIN URI Template (RUT) list to interpret the tag data (see also Section 2.1.3 and 2.1.4). - Does not have a fixed length.

EXAMPLE with RUT encoding of the query string example above.

- The RAIN URI Template (RUT) is: `"https://*.com?.25P=*&.S=*" where each * is a placeholder for the data on the RAIN tag.`
- The tag encodes in **UII/EPC memory:** "`example`", "`QCELMI12345`" and "`654321`", where "`QCELMI`" is the ISO/IEC 15459 economic operator identifier, "`12345`" is the part number, and "`654321`" is the part serial number.

This reduces the encoding from 46 8-bit characters (368 bits) to 31 6-bit characters (186 bits).

Standardisation status: The RUT for this ID scheme can be found at [docs.therainalliance.org]

3.2. Identification scheme 2: Identification Link (IL) for products (based on EN IEC 61406)

ID scheme 2 specifies two URL methods:

1. **Unstructured identifier:** The unstructured identifier is a string defined by the economic operator, and the URL string starting with the domain is the product identifier. The URL resolves to a web service, specified by the economic operator, that interprets the unstructured identifier string.
2. **Structured identifier:** The structured identifier provides a model, batch, or serial (item) number using ANSI Data Identifiers.

Both provide direct access to the DPP.

EXAMPLES
In this identification scheme the full DPP URL equals the globally unique product identifier.

- The structure of the globally unique product identifier /DPP URL is: `example.com/freetext` where "`freetext`" is specified by the economic operator.
- The structure of the model, batch, or serial (item) number using DI 10B (following the ANSI MH10.8.2 Data Identifiers) is: `example.com?.10B=batchtext&.S=serialnumber` where "`batchtext`" and "`serialnumber`" are specified by the economic operator.
- The structure of a verifiable identifier (following the ISO/IEC 20248 Standard) is: `https://example.20248.io?wJgJlkAFUeEABIEZzW5783c46LdZpCkTGjpYuxYqyX_AihgSUVl0dCBgyEa1uUHJvdGVjdGVkIGRhdGE` which is binary encoded.

Applicable encoding methods

Method	Description	Advantages	Disadvantages
TEXT	The tag is encoded with the full URL using TEXT.	+ Simple + Human readable after encoding	- Does not work with *low memory tags*, i.e requires more than 128 bits UII/EPC memory - Does not have a fixed length.
RUT	The URL is encoded by using a RAIN URI template (RUT).	+ Uses less memory on the tag. + Potentially fits on a cheaper low memory capacity tag + Enforces URI format	- The decoder needs to have the RAIN URI Template (RUT) list to interpret the tag data (see also Section 2.1.3 and 2.1.4). - Does not have a fixed length.

EXAMPLE RAIN URI encoding of the free TEXT identifier string above.

- The RAIN URI Template (RUT) is: "`https://*.com?*`"
- The tag encodes in **UII/EPC memory**: "`example`" and "`freetext`", where "`freetext`" is the economic operator issued product identifier.

This example encoding fits into a 96-bit low memory capacity tag.

EXAMPLE RAIN URI encoding of the model, batch or serial (item) number identifier above.

- The RAIN URI Template (RUT) is: "`https://*.com?.10B=*&.S=*`"
- The tag encodes in **UII/EPC memory**: "`example`", "`batchtext`", and "`serialnumber`" where "`batchtext`" and "`serialnumber`" are the economic operator issued product batch number and serial (item) number.

NOTE: According to EN IEC 61406, the complete URL (excluding the scheme) is the globally unique identifier, i.e. the UII, which may be too long to fit in MB01. A RAIN URI Encoding RUT can be used to compress the identifier.

Application of DigSigs (ISO/IEC 20248) to this ID Scheme: EN IEC 61406 already foresees ISO/IEC 20248.

Use of TID for serialisation: Identification Links may not fit into a low memory capacity tag. However, when the Tag Identifier (TID) is used as the item serialisation (RAIN_serial) and RAIN URI templates are used, it can fit. The RUT for this option then is:

"`https://*.com?.10B=*&.S={RAIN_serial}`"

Standardisation status: The RUT for this ID scheme can be found in the RAIN Alliance RUT list at docs.therainalliance.org

3.3. Identification scheme 3: W3C Decentralized Identifiers (DID) for products

W3C Decentralized Identifiers (DID) define a self-issuing system where economic operators generate globally unique product -, company -, or facility identifiers autonomously, without needing an issuing agency. DIDs support cryptographic authentication and privacy preserving information management by design.

A DID can represent any level of product granularity (model, batch, and item).

EXAMPLE

- The globally unique product identifier structure is:
  “`did:<did-method>:<method-specific-identifier>`”
- `A concrete example is`
  “`did:web:abc.com:model4TR`”

  where “`abc.com`” represents the domain of the economic operator and “`model4TR`” the product identifier that is unique to the domain “`abc.com`”.

Allowed DID methods under the current JTC24 standards in the context of products are `did:web`, `did:ethr`, and `did:ebsi`. Each method defines its own DID creation, read, update, and delete

mechanism. To lead the user to a web resource (URL) DIDs are resolved using a DID resolver service (such as uniresolver.io).

If **a specific resolver service** must be used, the full DID URL needs to be encoded on the RAIN tag. It follows the structure:

DID DPP URL:
https://<resolver>/did:<method>:<method-specific-identifier>?<optional parameters>

EXAMPLE 1+2

- did:web DPP URL Example:
  https://uniresolver.io/did:web:abc.com:model4TR?service=item-dpp or
- did:ethr DPP URL Example:
  https://uniresolver.io/did:ethr:0xf3beac30c498d9e26865f34fcaa57dbb935b0d74

If **any DID-resolver service** can be used, only the DID and optional parameters need to be encoded on the RAIN tag. It follows the structure:

EXAMPLE 3+4

- did:web DPP Example:
  did:web:abc.com:model4TR?service=item-dpp or
- did:ethr DPP URL Example:
  did:ethr:0xf3beac30c498d9e26865f34fcaa57dbb935b0d74

Note: The DIDs did:web:abc.com:model4TR and did:ethr:0xf3beac30c498d9e26865f34fcaa57dbb935b0d74 here are the globally unique product identifiers. According to ISO/IEC 18000:63, only that part needs to be encoded in UII/EPC memory. The resolver and service part may be encoded in user memory using RUT. Whereas the pure DID gives back the DID-Document that can lead to the structured DPP data for automated processing, the service parameter “item-dpp” returns the human readable DPP according to JTC24 standards.

DIDs have two possible encoding alternatives (see table below).

Applicable encoding methods

Method	Description	Advantages	Disadvantages
TEXT	The tag is encoding the full DID URL in UII/EPC memory using TEXT.	+ Simple + Human readable after encoding	- Requires more than 128 bits in UII/EPC memory - Does not have a fixed length.
RUT	The DID URL is encoded in text using a RAIN URI template (RUT).	+ Requires less memory on the tag. + Potentially fits on a low memory capacity tag. + Enforces the URL and DID format	- The decoder needs to have the RAIN URI Template (RUT) list to interpret the tag data (see also Section 2.1.3 and 2.1.4) - Does not have a fixed length.

EXAMPLE 1 RAIN URI encoding of `did:web` above.

- The RAIN URI Template (RUT) is: `https://*/did:*?service=*"`
- The tag encodes: "`uniresolver.io`", "`abc.com:model4TR`" and "`item-dpp`" in **UII/EPC memory.**

EXAMPLE 2 RAIN URI encoding of `did:ethr` above.

- The RAIN URI Template (RUT) is: "`https://*/did:ethr:*0x{UIIserial}?*`"
- The tag encodes in **UII/EPC memory**: "`uniresolver.io`", as TEXT, followed by an empty field and then "`f3beac30c498d9e26865f34fcaa57dbb935b0d74`" as hex using the UII-serial method (see RAIN URI encoding spec).

EXAMPLE 3 RAIN URI encoding of `did:web` **without** the resolver service domain.

- The RAIN URI Template (RUT) is: "`did:*?service=*"`
- The tag encodes: "`abc.com:model4TR`" and "`item-dpp`" in **UII/EPC memory.**

EXAMPLE 4 RAIN URI encoding of `did:ethr` **without** the resolver service domain.

- The RAIN URI Template (RUT) is: "`did:ethr:*0x{UIIserial}?*`"
- The tag encodes in **UII/EPC memory**: as TEXT, followed by an empty field [seperator] and then "`f3beac30c498d9e26865f34fcaa57dbb935b0d74`" as hex using the UII-serial method (see RAIN URI encoding spec).

Standardisation status: The two different selectors (with or without resolver URL) for the right RUT of this ID scheme can be found in the RAIN Alliance RUT list at docs.therainalliance.org

3.4. Identification scheme 4: Identification for products and product groups

This scheme is suitable for limited capacity data carriers, namely RAIN RFID (UHF RFID) per ISO/IEC 18000-63, that utilize resolvers to access DPP. It is the predominantly used item identifier used in logistics. The method ensures globally unique identification using ISO/IEC 15459-4 (individual products) and ISO/IEC 15459-6 (grouped products).

Data is structured and encoded for RFID applications based on the ISO/IEC 15961 series, ISO/IEC 15962, ISO/IEC 17360 and GS1 EPC TDS 2.3. The scheme standardizes application communication with data processors and operates independently of the RAIN RFID (UHF RFID) per ISO/IEC 18000-63. It supports offline processing of product details and follows ISO/IEC 15459-2, ISO/IEC 15459-3 and ISO/IEC 15418 for identifier allocation and syntax.

For additional security, the economic operator may optionally apply ISO/IEC 20248 [15] for digital signatures (DigSigs). DigSigs provide increased security for product authenticity, i.e. that a product is actually coming from the Economic Operator. Those verifiable product identifiers can be used in two ways:

- encoding the primary product identifier with a verifiable URL using a data construct.
- as a wrap that includes the product identifier with a verifiable URL

3.4.1. Encoding GS1/EPC identifiers

GS1 identifiers, compliant with EN 18219 ID Schemes 1 and 4, and encoded in RAIN tags as an EPC (Electronic Product Code), are widely deployed across manufacturing, logistics, and retail systems. EPC formats and their encoding and decoding algorithms are normatively specified in GS1's EPC Tag Data Standard (TDS) [4]. which references the carrier-neutral GS1 identifiers defined in the GS1 General Specifications. TDS is augmented by its companion, the EPC Tag Data Translation Standard (TDT), which provides a machine-readable version of the EPC encoding/decoding rules, and is intended to help EPC translation software support new EPC schemes in a modular way.

NOTE: The optional on-tag encoding of domain name information in UII/EPC memory (MB01), to enable seamless translation of the EPC into a resolvable Web URI, is normatively specified in the EPC++ schemes added to TDS 2.3.

Important: GS1 identifiers for Digital Product Passport are solely stored in UII/EPC memory.

3.4.2. Encoding of ISO identifiers

ISO/IEC 15459 identifiers are already in wide use for automotive parts, electronic components, in the assembly industry, in the steel industry, among others. Encoding them in a way that keeps the identifier in UII/EPC memory provides direct interoperability with barcodes and interoperability with existing infrastructure since the URL is encoded in user memory.

Applicable encoding methods

Method	Description	Advantages	Disadvantages
TEXT	The tag is encoding the full DPP URL in UII/EPC memory using TEXT.	+ Simple + Human readable after encoding	- Requires more than 128 bits in UII/EPC memory - Does not have a fixed length.
RUT	The DPP URL is encoded using a RAIN URI template (RUT)	+ The classic identifier can be used on its own + Enforces the URL format + The economic operator specifies which resolver is to be used + Can fit a 96-bit tag with a 32-bit user memory	- The decoder needs to have the RAIN URI Template (RUT) list to interpret the tag data (see also Section 2.1.3 and 2.1.4)

EXAMPLE

A globally unique product identifier following ISO/IEC 15434 and ISO/IEC 17360 for the RAIN UII encoding is "`25PQCELMI12345^S654321`", where

- "`25P`" is the Data Identifier (DI) for a "part number as issued by a CIN holder" and in this case has the meaning "part model number" as the identifier also has the DI "S" providing a part serial-number;
- "`QC`" is the issuing agency code for the Euro Data Council (EDC) who assigned the CIN;
- "`ELM1`" is the Company Identification Number (CIN) as assigned by EDC. The identifier is globally unique as QCELMI is globally unique according to ISO/IEC 15459, and the "part number" is unique within the domain of "QCELMI".
- "`12345`" is "part model number" as issued by "QCELMI",
- "`^`" is used to indicate the non-printable UTF-8 group-separator character, and
- "`S`" determines that what follows is a serial-number. Here the concrete serial (item) number is "654321".

The derived DPP URL is:

- When the reader does not know how to decode ISO/IEC 17360 identifiers, then the UII and AFI are sent to the resolver in hex:
  https://example.com?RAIN_AFI=a1&RAIN_UII=cb54110c530d271cb3d35793db5d33cb1840

  NOTE: The AFI=a1 tells you how to decode the UII. AFI is in UII/EPC memory bank 01 (see Figure 1).

"https://example.com" is obtained by encoding it to user memory using the RAIN URI Encoding (RUT).

- When the reader knows how to decode ISO/IEC 17360 identifiers, then the URL is: https://example.com?.25P=QCELMI12345&.S=654321

  "https://example.com" is obtained in one of two methods:

  - By performing a ISO/IEC 15459 lookup.
  - By encoding it to user memory using the RAIN URI Encoding (RUT)

Encoding with a RUT:

- The ISO/IEC 15434 DI barcode string '25PQCELMI12345^S654321' is encoded to the RAIN tag in **UII/EPC memory** 25PQCELMI12345^S654321.
  UII encoding: cb54110c530dc72cf4d5e4f6d74cf2c61000 (144 Bits)
- The RUT is: "https://*?*".
- The RUT value is: "example.com" which is encoded to **user memory** using text.
- The derived URL is: https://example.com?RAIN_AFI=a1&RAIN_UII=cb54110c530dc72cf4d5e4f6d74cf2c61000

NOTE: To be able to decode the URL in this example, the Web Server "example.com" must be able to follow the decoding specified by ISO/IEC 17360 as indicated by the AFI 0xa1.

This encoding can be used for UII/EPC memory read only (e.g. for retailers) and additionally create a URL using a combination of UII/EPC memory and the User Memory using RUT. This allows for continuity in e.g. logistics processes (that only reads the UII/EPC memory) and the use as a DPP data carrier pointing the user to the passport URL.

Standardisation status: The RUT for this ID scheme can be found in the RAIN Alliance RUT list at docs.therainalliance.org

3.5 Identification scheme 5: Digital Object Identifier (DOI) for products based on ISO 26324

This ID scheme, based on ISO 26324, enables unique identification of products using Digital Object Identifiers (DOI) in URL format, consistent with the structured path approach.

EXAMPLE

- https://doi.org/10.1000/N44APB7E,
  "10.1000" is the DOI issuing agency code, and "N44APB7E" is the unique product identifier.

Note: The DOI (here: 10.1000/N44APB7E) is a globally unique product identifier. According to ISO/IEC 18000:63, only that part must be encoded in UII/EPC memory only. The https://doi.org URL part may be encoded in user memory using RUT. This leads to two possible encoding alternatives (see table below).

Applicable encoding methods

Method	Description	Advantages	Disadvantages
TEXT	The tag is encoded with the full DOI URL using TEXT.	+ Simple + Human readable after encoding	- Requires more than 128 bits in UII/UPC memory.
RUT	The DOI URL is encoded as TEXT using a RAIN URI Template (RUT)	+ Enforces the URL and DOI format + Can be encoded into a low capacity memory tag	- The decoder needs to have the RAIN URI Template (RUT) list to interpret the tag data (see also Section 2.1.3 and 2.1.4)

EXAMPLE RAIN URI encoding of `DOI` above.

- The RAIN URI Template (RUT) is: "`https://doi.org/*?*`"
- The tag encodes in **UII/EPC memory**: '`10.1000/N44APB7E`'.

Standardisation status: The RUT for this ID scheme can be found in the RAIN Alliance RUT list at docs.therainalliance.org

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Annex A: RAIN tag encoding recommendations

This Annex shows detailed memory usage when storing **non-GS1** DPP product identifiers on RAIN tags.

Examples of GS1 encodings can be found in section E.3 of GS1's EPC Tag Data Standard (TDS) and the GS1 TDS / TDT 2.x encoder can be found at https://gs1.github.io/TDT/TDT_2_3_demo/

Important: Regardless of the encoding scheme selected, the tag manufacturer should confirm that the chosen encoding fits within the memory capacity of the selected RAIN RFID tag. Verifying this in advance avoids compatibility problems and potential technical issues during tag programming and operation.

For clarification or comments on the document or Annex, please contact

operations@therainalliance.org

Section / Example Method		**MB01 (UII/EPC)**			**MB11 User Memory**	
		Toggle Bit (T-Bit)	**UII**	**Encoding length in bits**	**DSFID+data**	**Encoding length in bits**
Section 3.1: https://example.com?.25P=QCELMI12345&.S=654321 RUT encoding: [selector 36][RVS][example][RVS][qcelmi12345][RVS][654321]						
UTF-8 text		T=1, AFI=0x03	68747470733a2f2f6578616d706c652e636f6d3f2e3235503d5143454c4d493132333435262e533d36353433323100	384	-	
RAIN URI Template (RUT)		T=1, AFI=0xBD	91e15804d40c15e44314c349c72cf4d5edb5d33cb100	186		
https://example.com?.25P=QCELMI12345&.S=654321&.6R=_opUnDI_QnEAVLWpKddIfepGsH-3rd2jU326-bCozHAdDFSd-p2-K-FM						
RUT plus a DigSig verifier code		T=1, AFI=0xBD, DSFID=0x11	91e15804d40c15e44314c349c72cf4d5edb5d33cb100	186	11FE8A549C323F42711706B3BA5D2D6A7B3AA70CCC8A71A1057280751893D068EDBC5F29DA15D89D69C15400	352
Section 3.2: https://example.com/freetext						

6-bit text		T=1, AFI=0x02	68747470733a2f2f6578 616d706c652e636f6d3f 2e3235503d5143454c4d 493132333435262e533d 36353433323100	384	-	
UTF-8 text		T=1, AFI=0x03	91e15804d40c15e44314 c349c72cf4d5edb5d33c b100	186	-	

Section 3.2 DigSig: https://example.com?_opUnDI_QnEXBrO6XS1qezqnDMyKcaEFcoB1GJPQaO28XynaFdidacFU						
DigSig		T=1, AFI=0x92	FE8A549C323F42711706 B3BA5D2D6A7B3AA70CCC 8A71A1057280751893D0 68EDBC5F29DA15D89D69 C154	352	-	

Section 3.3 DID:WEB: https://uniresolver.io/did:web:abc.com:model14TR?service=item-dpp RUT encoding: [selector 3][uniresolver.io][RVS][abc.com:model4tr][RVS][item-dpp]						
UTF-8 text		T=1, AFI=0x03	68747470733a2f2f756e 697265736f6c7665722e 696f2f6469643a776562 3a6162632e636f6d3a6d 6f64656c3454523f7365 72766963653d6974656d 2d647070	512 Too big for UII!	-	
RAIN URI Template (RUT)		T=1, AFI=0xBD	0d53894854cf316152b8 93de0420ee0cf37a34f1 0533451278950536d110 4000	256		
https://uniresolver.io/did:web:abc.com:model14TR?service=item-dpp&DigSig=_opUnDI_QnEAVLWpK ddIfepGsH-3rd2jU326-bCozHAdDFSd-p2-K-FM						
RUT plus a DigSig verifier code		T=1, AFI=0xBD, DSFID=0x1 1	0d53894854cf316152b8 93de0420ee0cf37a34f1 0533451278950536d110 4000	224	11FE8A549C323F4271170 6B3BA5D2D6A7B3AA70CCC 8A71A1057280751893D06 8EDBC5F29DA15D89D69C1 5400	352
Section 3.3 DID:ETHR: https://uniresolver.io/did:ethr:0xf3beac30c498d9e26865f34fcaa57dbb935b0d74 RUT encoding: [selector 2][uniresolver.io][SFE][f3beac30c498d9e26865f34fcaa57dbb935b0d74]						
RAIN URI Template (RUT)		T=1, AFI=0x03	0953894854cf316152b8 93dbf3beac30c498d9e2 6865f34fcaa57dbb935b 0d74	256	-	

Section 3.4.2: 25PQCELMI12345^S654321 Derived URL - reader knows ISO/IEC 17360: https://example.com?.25P=QCDEMO12345&.S=654321 Derived URL - server knows ISO/IEC 17360: https://example.com?RAIN_AFI=a1&RAIN_UII=cb54110c530dc72cf4d5e4f6d74cf2c61000 RUT encoding: [DSFID 0x24][RUT selector 0][example.com]						
ISO/IEC 17360 DI encoding		T=1, AFI=0xA1	cb54110c530dc72cf4d5e4f6d74cf2c61000	144	-	
ISO/IEC 17360 DI encoding with RUT		T=1, AFI=0xA1, DSFID=0x24	cb54110c530dc72cf4d5e4f6d74cf2c61000	144	24006578616d706c652e636f6d00	112

Section 3.5: https://doi.org/10.1000/N44APB7E RUT encoding: [selector 1][10.1000/n44apb7e]						
6-bit text		T=1, AFI=0x02	2145104FABEF10F26E3D21EFC70BB1C30C2F3B4D01402DC5	192	-	
RAIN URI Template (RUT)		T=1, AFI=0xBD	071c2ec70c30bced340500b71400	112	-	
https://doi.org/10.1000/N44APB7E&DigSig=_opUnDI_QnEAVLWpKddIfepGsH-3rd2jU326-bCozHAdDFSd-p2-K-FM						
RUT plus a DigSig verifier code		T=1, AFI=0xBD, DSFID=0x11	071c2ec70c30bced340500b71400	112	11FE8A549C323F42710054B5A929D7487DEA46B07FB7ADDDA3537DBAF9B0A8CC701D0C549DFA9DBE2BE14C00	352

Abbreviations

Abbreviation	Meaning
AFI	Application Family Identifier (ISO/IEC 15961-3)
ANSI DI	ANSI Data Identifier (ANSI MH10.8.2)
CIN	Company Identification Number (ISO/IEC 15459)
DID	Decentralized Identifier (W3C)
DigSig	Digital signature as defined in ISO/IEC 20248
DOI	Digital Object Identifier (ISO 26324)
DPP	Digital Product Passport
DSFID	Data Storage Format Identifier
EPC	Electronic Product Code (GS1)
ESPR	Ecodesign for Sustainable Products Regulation (EU) 2024/1781
EN	European Norm
EU	European Union
ID	Identifier
IEC	International Electrotechnical Commission
IL	Identification Link (EN IEC 61406)
ISO	International Organization for Standardization
JTC 24	CEN/CENELEC Joint Technical Committee 24
MB	Memory Bank of a RAIN RFID tag (MB 00 to MB 11)
RAIN	RAdio frequency IdentificatioN
RFID	Radio-Frequency Identification
RUT	RAIN URI Template
TDS	EPC Tag Data Standard (GS1)
TDT	EPC Tag Data Translation Standard (GS1)
TID	Tag Identifier, held in memory bank MB 10
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
UII	Unique Item Identifier, held in memory bank MB 01 (ISO)

About the RAIN Alliance

The RAIN Alliance enables organizations to improve traceability, effectiveness, and sustainability by simplifying, standardizing and accelerating the adoption of RAIN technology through global collaboration and innovation. Its global membership consists of companies and organizations which develop and deploy RAIN technology solutions across many vertical markets.

RAIN is a standards-based wireless technology that enables businesses and consumers to identify, locate and authenticate billions of items connected to the Internet of Things. RAIN technology uses the ISO/IEC 18000-63 protocol (also known as GS1 UHF Gen2).

For more information, please visit therainalliance.org

About this document

This document was prepared by the RAIN Alliance to help the existing market demonstrate its readiness for the EU Digital Product Passport.

Its starting point is the work of CEN/CENELEC JTC 24, where RAIN RFID is recognized among the accepted data carriers. What the JTC 24 standards do not fully specify is how each of the five identification schemes should be encoded on a RAIN RFID tag to guarantee seamless access across the supply chain. This document presents the current landscape by mapping each scheme according to its recommended encoding.

It is an informative guidance document rather than a normative specification. Where an encoding is already standardized, GS1/EPC encoding in particular, this document refers directly to existing standards. RFID encodings using the RUT list is a *new specification* published by the RAIN Alliance following the procedures of ISO/IEC 15961-2. This encoding allows full URI/URL encodings on RAIN RFID tags.