Chem-X Consortium

The Digital Material Identifier for the Chemical Industry Guideline

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1 Motivation

Today's life would not be the same without dedicated and specialised materials that keep us healthy, our food fresh, our clothes clean and durable and help us get transported. Chemicals are inputs for 95% of manufactured goods [1] and are, therefore, a key pillar for the economies of industrialised countries and for the sustainable transformation of our economy and society.

Since chemicals are manufactured on a large scale in many sites around the globe, a recurring question is how to identify them properly. Properly isn't the right term; a more precise term is uniquely, persistently, and scalable. And to answer this question, it is good to adopt at least two distinct views:

- the supply chain view with a strong focus on logistics, and
- the value chain view with a strong emphasis on product information.

Both are relevant to establishing a trusted exchange of chemical product information throughout the product lifecycle. This becomes more prominent in the green transformation as the linear extract-use-dispose system phases out and is replaced by a circular economy, keeping physical products in service as long as possible and applying relevant and viable R-Strategies [2].

Another aspect that must be mentioned is the efficiency potential that can be addressed using a unique digital MaterialID for chemicals in harmonising product information exchange through value chains, which is currently a patchwork of company-specific numbers or ambiguous material identifiers, such as the CAS (Chemical Abstract Service) number, resulting in recurrent information disruption. The MaterialID shall facilitate access to product information in the relevant process for multiple value chain actors, e.g., to ensure the right to sell while ensuring compliance. Unlike today's processes, where we establish trust in material information by manual work, as represented in Figure 1, the MaterialID shall provide a trust infrastructure and access to structured and machine-readable data sets so that the information exchange among the value chain partners can be automated, leveraging efficiency potentials by enhanced data quality, faster response times, etc.

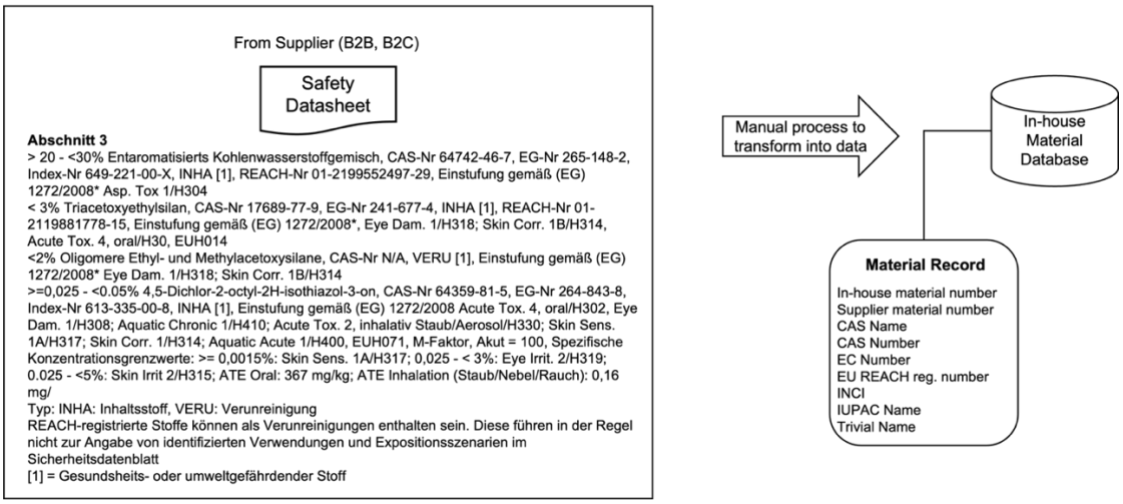

Figure 1Today, product information exchange is document centric, broken, and manual because of a lack of trust

1.1 Value Chain Communication

The chemical industry operates in a highly regulated environment, as some products can be harmful to humans, animals, and the environment if not handled safely. Therefore, product information communication in the value chain to economic actors is a key requirement for the right to operate and the right to sell chemical products. Such communication is mostly conducted using a document-based approach, e.g., with labels and safety data sheets (SDSs) required by [3] [4] [5]. These documents use different, region and segment-specific identifiers for chemical products such as

- CAS Number – globally recognised numeric identifier for chemical substances
- EC Number – identifier assigned by the European Commission (EC) to substances for regulatory purposes. The EC Inventory comprises three individual inventories, EINECS, ELINCS and the NLP
- REACH Registration Number - identifier assigned by the European Chemicals Agency (ECHA) to substances registered under the REACH regulation [5]
- UFI Number – unified formula identifier required for the notification of a hazardous mixture at a national poison center
- INCI Name – international identifier for cosmetic ingredients

This non-exhaustive list of identifiers for chemical products represents so-called speaking codes and provides human-readable information. The complication with such identifiers is the governance and maintenance across systems. Every so often, speaking codes do not meet the requirements laid out in sections 3.1 and 3.2. Hence, this report recommends including these identifiers in the digital material or product passport to foster compatibility with current business processes.

1.2 Out of Scope: Supply Chain Communication

Although out of scope, we shall briefly address identifiers that support global trade and are integrated in the backbone of many processes in international firms. These identifiers support the right to win by ensuring the delivery of the value in time and the quality expected by customers.

Identifiers used for Business Partners are:

- DUNS – International business entity identifier issued by Dun and Bradstreet
- LEI – International business entity identifier issued by the Global Legal Entity Identifier Foundation
- GLN – Global Location Number assigned to a physical location or entity issued by GS1

As for Materials following identifiers are used:

- EAN – International Article Number issued by GS1. Part of the GTIN specification
- DUNS – International business entity identifier issued by Dun and Bradstreet
- LEI – International business entity identifier issued by the Global Legal Entity Identifier Foundation
- GLN – Global Location Number assigned to a physical location or entity issued by GS1
- GTIN – Global Trade Item Number issued by GS1
- UPC – Universal product code issued by GS1. Part of the GTIN specification

For supply chain communication and related documents and messages, the non-exhaustive list of product, location, and organisational identifiers is essential to ensure seamless processes and integration of EDI-based protocols with CRM, ERP, PIM, and other business process-relevant systems and integrated in processes such as Order to Cash (OTC) or Purchase to Pay (P2P).

2 Objective

This report aims to outline the method and architecture for defining and structuring a digital Material Identifier for chemical products[1].

A digital Material Identifier targets to identify a chemical product and, unlike known material identifiers such as CAS-Number, INCI Name, EC-Number, UFI Number, etc., provides a link from the physical product to its digital representation and its product information made available as a digital material passport (DMP) or digital product passport (DPP). The Material Identifier shall be an opaque identifier with no significance, as outlined in the GS1 architecture principles [6]. Having said that, it becomes clear that the scope of the digital Material Identifier is value chain communication —the business-value side that creates and delivers value to the value chain actors.

3 Requirements

In this section, we want to lay out the fundamental requirements from Chem-X viewpoint of a Material Identifier that aims to link a physical chemical product to a digital representation of its product information represented in the digital material or product passport.

3.1 Technical Requirements

- Global Uniqueness – Ensure the identifier is distinct across all systems and domains. For example, there should be no duplicates or reused identifiers.
- Persistence – Ensures the identifier remains associated with one chemical product and unchanged over its validity or the product life cycle.
- Validity – Ensures the availability of the status (e.g. valid, invalid, revoked) of an identifier
- Integrity – Ensures the identifier is genuine and not altered or corrupted
- Scalability – Ensures the identifier can be issued in the required numbers in a timely manner
- Authenticity – Ensures the identifier's origin and legitimacy
- Privacy – Ensures the implementation of different visibility of the identifier

3.2 Business Requirements

- Regulatory Compliance – Ensures the identifier is compliant with regulations [7] and standards [8]
- Interoperability – Ensures the identifier is actionable (e.g. CRUD) in different systems

[1] Chemical products have many synonyms, such as material, chemicals, packaged goods, unpackaged goods, etc. For the sake of simplicity, we name them chemical products in this guideline. A stringent definition of these terms can be found in the

- Granularity – Ensures the identifier represents and addresses different granularity levels, such as model, batch, and item, following [7]
- Sovereignty – Ensures that the control of the identifier is with the economic operator or its legal representative [5]

4 Related Standards and Dataspaces

This chapter describes the existing designs offered by Data Spaces, standards, and regulation, that are influencing the Material Identifier.

4.1 EU DPP Framework Standards

prEN 18219:2025 of CEN/CLC/JTC 24 [8] proposes five identifier schemas:

- Web-enabled, structured path and query ID for products
- Identification Link (IL)
- Decentralised identifiers (DID) for products
- Product and group identification
- Digital Object Identifier (DOI) for a product has the biggest impact on the structure/semantics of a Material Identifier. As a standard proposal, the results of prEN 18219:2025 [8] should be considered.

These schemas are described in more detail in Chapter 5 of prEN 18219:2025 [8].

4.2 Dataspaces

As the ecosystem of available data spaces expands, this document focuses on a limited number of selected examples. Catena-X is the most advanced, Manufacturing-X shares different Material schemes, and IDSA is a non-X-Dataspace.

4.2.1 Catena-X

Catena-X uses a decentralised registry to provide a unique identifier for a DPP in the form of a UUID, e.g.

```
urn:uuid:123e4567-e89b-12d3-a456-426614174000.
```

In Catena-X, a DPP includes additional material identifiers. The EU DPP registry must serve as a single point of contact/knowledge for creating or resolving a DPP identifier.

4.2.2 Manufacturing-X

Manufacturing-X allows multiple identifier schemes for the DPP using a port concept. Example implementations are "Leo," "Hercules," and "Orion".

Leo uses the IEC 61406-2 ID Link concept to identify a DPP. In contrast, Hercules uses a UUID identification scheme in combination with the Data Space Protocol / Decentralised Claims Protocol based on an open-source EDC.

4.2.3 IDSA

The International Data Spaces Association (IDSA) recommends using the IEC 61406 standard for Unique Product Identification (UID) in industrial data spaces. However, more broadly and fundamentally, IDSA data spaces rely on a semantic and interoperable identifier scheme built around the following components:

- Decentralised Identifiers (DIDs) (e.g., companies, services, connectors)
  - in a Format:

    `DID:<method>:<unique-id>`
  - Purpose: To uniquely identify participants (e.g., companies, services, connectors) in a decentralised and verifiable way
  - Standard: Based on the W3C Decentralised Identifiers (DID) specification
  - Examples of DID methods used:
    - DID:web – Identifier based on HTTPS URLs
    - DID:indy – For identity based on distributed (indy) ledgers
    - DID:key – For identifiers based on cryptographic keys
- URI/URN/URL-based identifiers
  - Often used for data assets, contracts, and policies
  - Example:

    `urn:ids:data:my-company.com:asset123`
- UUIDs
  - For internal tracking and correlation within connectors or clearing houses.
- IEC 61406 family
  - Recommended for identifying physical products or assets in combination with their digital twins (especially in industrial or manufacturing settings).

4.3 Asset Administration Shell (AAS)

An Asset Administration Shell (AAS) is a standardised digital representation of an asset, such as a machine or component, used in Industry 4.0 for interoperability. It bundles all necessary information and functionalities of an asset into a structured digital model, consisting of modular "submodels," to enable secure and standardized data exchange between different systems. This provides a technological foundation for digital twins, enabling different companies and systems to communicate seamlessly [9] [10] [11] [12].

Key aspects of the AAS are:

- **Digital twin foundation**: The AAS serves as the technological foundation for the digital twin, providing a standard for describing and managing industrial assets.
- **Modular structure**: It uses submodels to structure the data, where each submodel describes a specific aspect of the asset, like its technical data, status, or capabilities.
- **Standardised information**: It provides a standard, machine-readable way to describe assets, their properties, and functions. This is crucial for enabling interoperability across different manufacturers and systems.
- I**nteroperability**: The core goal is to enable seamless, standardised communication between different systems, software, and components in a connected industrial environment.
- **Lifecycle management**: An AAS can accompany a product throughout its lifecycle, from manufacturing through use in operations.

- **Examples of assets:** a single piece of equipment, such as a sensor, a complex machine, or an entire factory.

The AAS supports the following standardised identifier types:

- IRI (Internationalised Resource Identifier):
  Example:
  `urn:example.org:asset:12345`
- IRDI (International Registration Data Identifier): Commonly used in ECLASS and IEC 61360 CDD (Common Data Dictionary) standard
- Custom (Short/Local). Locally unique identifiers (less preferred for interoperability).

4.4 Decentralised Identifier (DID)

Decentralised Identifiers (DIDs) are globally unique identifiers defined by W3C, designed for cryptographically verifiable, privacy-preserving identity data. A DID resolves to a DID document containing public keys, verification methods, and optional service endpoints. DID methods specify where/how that document is obtained.

DID:web is one such method that says: host the DID document at a predictable HTTPS URL under your domain. It's frequently highlighted in DPP/Digital Identity discussions as the "lightweight, non-DLT" option alongside methods based on distributed ledger technologies, such as DID:ethr and DID:ebsi. It combines the developments from Web3.0 with the robustness and scalability of Web2.0. For a deep dive into DID:web, please refer to Appendix A.

5 Assessing different ID schemas

The Material Identifier refers to an identifier of a DMP/DPP that can address and identify chemical products in different natures, e.g. bulk (unpackaged goods) and articles (packages goods) and at different granularities required by the ESPR [7] mentioned in the Material Declaration Guideline. The identifier can be formatted using different schemas. This chapter compares different suggestions from the Chem-X consortia against the schemas of prEN 18219:2025 [8].

5.1 Key criteria used for comparison

JTC24 with prEN 18219:2025 [8] provides principles, requirements, and guidelines around identification use cases, which are covered by six key areas:

- global uniqueness
- persistence
- syntax
- semantics
- interoperability
- openness

These key areas and the requirements for each are described in chapter 4 of prEN 18219:2025 [8], while chapter 5 describes the 5 identification schemas in detail.

Appendix B of the standard draft compares the five schemas, focusing on (but not exclusively) the six key areas mentioned above.

Based on the discussion of Chem-X members, the following key criteria are selected for the evaluation of the identifier schemas in addition to those of prEN 18219:2025 [8]:

1. Compatible with existing and future standards or regulations: The Identifier meets future regulatory requirements (see above).
2. Using existing technology: The Identifier can be used today “out of the box” based on mature standards.
3. Assigning a maximum of control over material identifiers to the manufacturer itself: The identifier is owned and controlled by the manufacturer / economic operator, enabling full control over credential issuance, presentation, and revocation, rather than being locked into vendor-managed IDs.
4. Serving the functional demands of the chemical industry with its unique role at the centre of multiple manufacturing value chains: The identifier is multi-functional, reflecting the various functions the chemical industry has in different value chains, resulting in a Material Identifier that can serve both DMP and DPP related use cases of a product. The identifier itself is a non-speaking or opaque identifier. Use of the DMP identifier is based on Catena-X's “one up / one down” visibility principle.
5. Decentralisation & User Control: organisations can own and manage identifiers independently, enabling full control over credential issuance, presentation, and revocation, rather than being locked to vendor-managed IDs.

5.2 Evaluation of schemas

As mentioned before, prEN 18219:2025 [8] provides 5 schemes for the Material Identifier, which will be the focus of the evaluation. Appendix B of prEN 18219:2025 [8] will be considered as well. It contains an evaluation of the identifier schemes against the key criteria mentioned at Chapter 5.1. Appendix B can be summarised as every identifier scheme fulfils the key criteria.

5.2.1 Web-enabled structured path/query string for products

The Web-enabled structure path/query string is an identifier issued by an agency.

Openness is limited to the consumer site; an operator must pay a fee to the provider. Most agencies do not provide an identifier for a serialised item, but for an item. Example: a brown bottle measuring 500ml filled with Sodium Chloride. A serialised item is a single (unique) brown bottle. (A brown bottle vs this brown bottle). The ID itself is nonspeaking, can be accessed using actual technologies and is quite common in the Chemical Industry.

Example for a structured Link:

- Path:
  `https://example.com/01/09524000059109/22/2A/10/ABC123/21/12345XYZ?11=251121`
- Query:
  `https://www.example.com/?.25P=QCELMI12345&.S=654321`

5.2.2 Identification Link (IL)

A Web-enabled structure path/query string is also an identification link, but an identification link can be issued by a company itself instead of a provider agency. The identification link is bound to the domain of the provider. Only the query-based Identification Link supports the model,

batch, and item as granularity levels, whereas the path-based Identification Link supports only item-level granularity. There is actually no major usage of the Identification Link in the Chemical Industry.

Example of an Identification Link:

- Path (item only)
  `https://www.example.com/freetext`
- Query (model, batch, item)
  `https://www.example.com/?.S=freetext&.10B=freetext`

5.2.3 Decentralised identifiers (DID) for products

DID is an open standard defined by the W3C. Based on the method, it is bound to a ledger or a domain. The identifier itself is defined by the method, in case of DID:web it can be any Charset, which is URI encoded.

Example of a DID, DID-URL and DID resolving using the universal resolver

- DID:
  `did:web:example.com:model4TR`
- URL:
  `https://resolver.io/did:web:example.com:model4TR/?service=item-dpp`
- universal-resolver
  `https://dev.uniresolver.io/#did:web:identity.foundation`

5.2.4 Product and group identification

Product and Group Identification are physical tags on an object and can be used in combination with other identifiers.

Example:

- Data carrier like **RFID** in combination with:
  - EDC Tag
  - GS1 Digital Link
- Data carrier like **2D code** in combination with:
  - Data Identifier encoding
  - Issue Agency Code

5.2.5 Digital Object Identifier

The DOI is managed by a non-profit organization. Local provider agencies are responsible for the retainment of the centrally defined rules and requirements. The payment of the agency happens on the provider site, the consumer can interact with the DOI free of charge. The common use case of DOI are academic and scholary publications.

Example:

- DOI:

https://doi.org/10.1000/N44APB7E

5.3 EvaluationComparison of the different ID schemas

The product and group identification cannot be used as an identifier by itself. Any of the other identifiers needs to be combined with a physical carrier. So the product and group identification will be used as physical data carrier on the object itself.

DOI is not commonly used by the Chemical Industry. The home turf are academic publications, In addition the openness is only on consumption side, a provider needs to pay the issuing agency. The main differentiator between an identification link and a structured path is the issuing type. The structured path is managed by an issuing agency as the identification link is self-issued. Especially for SME the costs of a number of providers can be challenging, although the processes for establishing such a provider have not established so far.

Information Link, as well as DID, required a corresponding resolver to provide the corresponding DMP or DPP data for a request. The advantages of DID:web in comparison to the Information Link are:

- Persistence: changes at the EDC infrastructure cannot be compensated by an Information Link, which leads to the corresponding DMP Data. The service structure of a DID Document allows the update and the resolution of DMP Data even if the underlaying EDC infrastructure has changed.
- An Information link can only resolve the DMP or DPP data, based on the DID Document service section, different entries could be resolved to the public DPP and the secured DMP data
- The service structure of a DID Document although allows the usage of different service protocols. A DMP can be established as protected link, which needs to be requested by an EDC, as the DPP could be access as public REST endpoint.

For further information, please refer to Appendix B

5.4 Recommendation: DID:web for Material Identification

The provisioning of a DID Document per Material is not foreseen, as well as an own private / public key pair. Instead, the DID Document and the cryptographic key materials of the business partner will be used.

A DID consists of three elements,

1. The URI scheme identifier è did
2. The identifier of the DID method è web
3. The DID method specific identifier

The third element will be the BPN number of the economic operator, enhanced by a query parameter referencing the material identifier. This identifier should be an enterprise internal, company owned, non-speaking Id, like a UUID, it could be the AAS / Shell-Id.

Example DID:

did:web:company.org:BPNL000000001234?service=edc1&assetId=urn:uuid:53fb5462-fcce-48c5-b302-aaa533e2415e

The query parameters must be an ASCII string, as foreseen by the standard [13].

To request a DMP using an EDC, three parameters are required

- the BPN of the provider
- the address of the providing EDC
- the asset Id (=material Identifier)

The EDC used for provisioning must be part of the provider's DID Document at the services section, and as the asset Id is part of the DID:web address, a data consumer must have all details available.

The DID Standard is already in use at Catena-X in the area of Business Partner Identity [13] and is foreseen to be reused in Chem-X. [14]

We suggest reusing this standard for Material Identification as well.

Example DID and DID Document:

DID-Address:

```
did:web:company.org:BPNL000000001234?service=edc1&assetId=urn:uuid:5
3fb5462-fcce-48c5-b302-aaa533e2415e
```

DID-Document

All the values in this DID document are example values and can be replaced

```
{
  "id": "did:web:company.org:BPNL000000001234",
  "service": [
    {
      "id": "did:web:portal-backend.beta.cofinity-
x.com:api:administration:staticdata:did:
did:web:company.org:BPNL000000001234#CredentialService",
      "type": "CredentialService",
      "serviceEndpoint": "https://dis-agent-
prod.eu10.div.cloud.sap/api/v1.0.0/dcp/holder/7cc7ad46-cec0-49d4-9693-
9d100841af3f"
    },
    {
      "id":"edc1",
      "type": "DataService",
      "serviceEndpoint":"https://edc1.company.org/.well-known/dspace-
version"
    },
    {
      "id":"edc2",
      "type": "DataService",
      "serviceEndpoint":" https://edc2.company.org/.well-known/dspace-
version"
    }
  ],
  "@context": [
    "https://www.w3.org/ns/did/v1",
    "https://w3id.org/security/suites/jws-2020/v1",
    "https://w3id.org/dspace-dcp/v1.0/dcp.jsonld",
    "https://w3id.org/dspace/2025/1/context.jsonld"
```

```
  ],
  "keyAgreement": [],
  "authentication": [
    "did:web:portal-backend.beta.cofinity-
x.com:api:administration:staticdata:did:BPNL000000001234#keys-21918519-
03e8-431e-a787-d0c7cf25cf79"
  ],
  "assertionMethod": [],
  "verificationMethod": [
    {
      "id": "did:web:portal-backend.beta.cofinity-
x.com:api:administration:staticdata:did:BPNL000000001234#keys-883356f5-
1bc2-4866-8cf5-cf2f2a26b193
      "type": "JsonWebKey2020",
      "controller": "did:web:portal-backend.beta.cofinity-
x.com:api:administration:staticdata:did:BPNL000000001234",
      "publicKeyJwk": {
        "x": "883356f5-1bc2-4866-8cf5-cf2f2a26b193",
        "y": "7cc7ad46-cec0-49d4-9693-9d100841af3f",
        "crv": "secp256k1",
        "kty": "EC"
      }
    }
  ],
  "capabilityInvocation": []
}
```


Further examples can be found under reference DID Document Property Extension

5.5 Example: DID Resolver

Chem-X would use the DID:web followed by the domain where the corresponding company wallet is provided.

If a company brings their own wallet this would be

`did:web:company.org`

followed by an identifier, in case of a hosted wallet, e.g. like the Chem-X sandbox provided by Cofinity-X, the did address would be

`did:web:portal-backend.beta.cofinity-x.com:api:administration:staticdata:did:BPNL000000001234.`

The identifier of a DMP / DPP is split into the Business Partner Id and a UUID for the material.

`BPNL000000001234?dmp=5277d11e-168b-4f4a-9a0c-dcbe357cc765` respective

`BPNL000000001234?dpp=5277d11e-168b-4f4a-9a0c-dcbe357cc765.`

The DID Document of the Chem-X Business Partner is the leading for the DMP/DPP identification, there will not be a separate DID Document for a model/batch or item.

5.5.1 DPP

A DPP can be resolved using a link to a service endpoint which is part of the services section of the DID Document of the Business Partner.

`did:web:company.org:BPNL000000001234#dpp?id=5277d11e-168b-4f4a-9a0c-dcbe357cc765.`

With the corresponding resolver, this deep-link will directly provide the DPP.

An URL containing the link to the resolver, including the DID needs to be placed on the physical object, e.g. as data of a QR Code.

5.5.2 DMP

The DMP is used in B2B environment where typically not the physical item itself but the documents like delivery note are the source of information. (Not every single item on a pallet will be scanned at the inbound warehouse, but the information regarding batch, model are available on the delivery note. Serialized Item information, if required by the regulator are part of a track and trace solution.

To receive a DMP on the batch or Item level, the information on the delivery note needs to be enhanced so that the DMP Id can be used by the EDC communication.

Information of the used EDC and the BPN needs to be provided beforehand, will be part of the delivery note as well.

The information BPN, EDC and DMP Id (== Asset ID) is sufficient to trigger a request to fetch the DMP.

6 Conclusion

This report is based on a discussion of design choices based on four major requirements:

- Compatible with existing and future standards or regulations
- Using existing technology
- Assigning a maximum of control over material identifiers to the manufacturer itself.
- Serving the functional demands of the chemical industry with its unique role at the center of multiple manufacturing value chains

While there are more established Material Identifier schemas than DID:web for other industrial applications – at least outside the chemical industry - we propose that the key advantage of designs based on DID:web is the high level of control a manufacturer receives over the identifier at issuance and during deployment. In addition, the design supports semantic interoperability by integrating other identifiers into the DID document, addressing the unique challenge of the chemical industry at the centre of so many manufacturing value chains.

A DID:web based Material Identifier can use a UUIDv4 as identifier. The UUID is managed locally by the economic operator or a DPP provider.

The attributes of the proposed material identifier are laid out in **Error! Reference source not found.**. are summarised in Figure 2

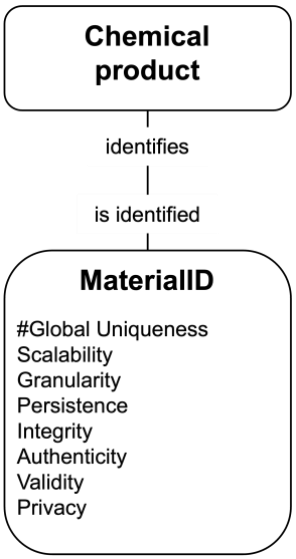

Figure 2 MaterialID and its attributes

7 Glossary

Term	Definition	Note to source
CAS Number	CAS (Chemical Abstracts Service) Number. A globally recognized numeric identifier for chemical substances	
Chemical products	a manufactured good whose principal functional or structural components are one or more chemical substances, mixtures, or REACH articles produced, transformed, or combined through chemical processes. Synonyms are chemicals, materials, (un)packaged goods	Chem-X Material Declaration Guideline
CRM	A Customer Relation Management System, short CRM, is a ICT system to manage and structure the business relationship and interaction with the customers of an economic operator.	
CRUD	Create, Read, Update, Delete action done on dedicated	
Digital Material Passport (DMP)	A structured digital record that contains detailed information about – and not limited to - a product's lifecycle, materials, components, and sustainability attributes. It focuses on intermediate materials which may not be subject to regulation, but whose data are required to enable the issue of regulated Digital Product Passports (DPPs). DMPs are designed to interoperate with one or more DPPs.	Chem-X Sustainability Guideline
Digital Product Passport (DPP)	A structured digital record that contains detailed information about a product's lifecycle, materials, components, and sustainability attributes. It focuses on a regulated final product in the value chain. Both its information content and technical requirements follow regulatory requirements and/or standards delegated by the legislator to designated standardization bodies.	Chem-X Sustainability Guideline
DUNS	Data Universal Numbering Systems by Dun & Bradstreet to identify global business entity or organization	
Economic Actors	An economic actor is any organization or individual that performs a commercial, regulatory, or operational function within the lifecycle of a physical product.	
ECHA	European Chemical Agency	ECHA
EC Number	Identifier assigned by the European Commission (EC) to substances for regulatory purposes. The EC Inventory comprises three individual inventories, EINECS, ELINCS and the NLP	ECHA
EDC	Eclipse Dataspace Connector	

EDI	Electronic data interchange protocol is a set of standards to enable automated machine to machine information exchange between legal entities, e.g. purchase orders, invoices, shipping notices, etc.	
EINECS	European Inventory of Existing Commercial chemical Substances	ECHA
ELINCS	European List of Notified Chemical Substances	ECHA
ERP	Enterprise Resource Planning is an ICT system helping organizations streamline their core business processes such as order to cash (OTC) or purchase to pay (PTP)	
GTIN	Global Trade Item Number issued by GS1. It is a set of specifications and a standard family ISO/IEC 15495	
GLN	Global Location Number is an identifier for a location or an entity in a business network issued by GS1	
Term	Definition	Note to source
IDSA	International Dataspace Association	
INCI Name	International Nomenclature Cosmetic Ingredient Name – international identifier for cosmetic ingredients	
IRDI	The international registration data identifier (IRDI) is an internationally unique identifier for a data element used, e.g. in the IEC common data dictionary (CCD).	
IRI	Internationalized Resource Identifier	
LEI	Is a Legal Entity Identifier issued by the Global Local Entity Identifier Foundation (GLEIF) under the direction of the G20 and the Financial Stability Board (FSB)	
NLP	No-Longer Polymers	ECHA
PIM	Product Information Management	
REACH	REACH stands for Registration, Evaluation, Authorization and Restriction of Chemicals [5]	ECHA
SDS	Safety Data Sheet. Regulatory required document [4] [5] [3] to ensure save handling, use, storage and disposal of chemical products	
Supply chain communication	The “logistics” side – moving goods, money, and information from supplier to customer. Typically handled by electronic formats such as EDI (electronic data interchange)	-
UFI Number	Unified formula identifier required for the notification of a hazardous mixture at a national poison center	ECHA
UPC	Universal product code issued by GS1. Part of the GTIN specification	
URI	Uniform Resource Identifier a unique sequence of characters that identifies an abstract or	

	physical resource such as a webpage, e-mail-address, etc.	
URL	Uniform Resource Locators as defined in RFC 1738	
URN	Uniform Resource Name is a URI that uses the URN scheme.	
UUID	Universally Unique Identifier is 128-bit number identifier normally generated by random numbers	
Value chain communication	The “business value” side – creating and delivering value to the end customer. Essentially delivering product information such as quality or technical information, sustainability information, etc.	

8 Bibliography

[1] A. Gambarin and H. Galloway, “The Global Chemical Industry: Catalyzing Growth and Addressing Our World's Sustainability Challenges,” The International Council of Chemical Associations (ICCA), 2019.

[2] J. Potting, M. Hekkert, E. Worrell and A. Hanamaaijer, “Circular Economy: Measuring Innovation in The Product Chain,” PBL Netherlands Environmental Assessment Agency, The Hague, 2017.

[3] *Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on Classification, Labelling and Packaging (CLP) of Substances and Mixtures,* Official Jounal of the European Union, 2008.

[4] Globally Harmonized System of Classification and Labelling of Chemicals (GHS), New York and Geneva: United Nations, 2023.

[5] *Regulation (EC) No 1907/2006 of the Europan Parliament and the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH),* Official Jounal of the European Union, 2006.

[6] A. Osborne, D. Buckley and H. Barthel, “GS1 Architectural Principles,” GS1, June 2022. [Online]. Available: https://ref.gs1.org/architecture/principles/. [Accessed 6 November 2025].

[7] *Regulation (EU) 2024/1781 of the European Parliament and the Council of 13 June 2024 establishing a framework for setting of ecodesign requirements for sustainable products,* Official Jounal of the European Union, 2024.

[8] *prEN 18219:2025 Digital product passport - Unique identifiers,* DIN, 2025.

[9] C. Diedrich, “Asset Administration Shell,” 17 January 2024. [Online]. Available: https://www.i40.ovgu.de/i40/en/Asset+Administration+Shell.htm. [Accessed 10 November 2025].

[10] J. Neidig, A. Orzelski and S. Pollmeier, “Asset Administration Shell Reading Guide,” Industrie 4.0, Berlin, 2022.

[11] M. Benndorff, Asset Administration Shell – Industry 4.0’s Standard for Connected Assets, [Online]. Available: https://soffico.de/en/use-cases/asset-administration-shell.

[12] F. Schloz, “How the Asset Administration Shell Is Shaping the Future of Digital Twins,” 08 Mai 2024. [Online]. Available: https://www.mhp.com/en/insights/blog/post/asset-administration-shell. [Accessed 10 November 2025].

[13] “DID:web Method Specification,” W3C, 31 July 2024. [Online]. Available: https://w3c-ccg.github.io/did-method-web/. [Accessed 2025 October 2025].

[14] Chem-X Consortium, The Business Identity Guideline.

[15] Catena-X e.V., “CX-0049 DID Document v2.2.0,” 2025. [Online]. Available: https://catenax-ev.github.io/docs/standards/CX-0049-DIDDocumentSchema. [Accessed 06 January 2026].

[16] M. Sporny, D. Longley, D. Chadwick and I. Herman, “Verifiable Credentials Data Model v2.0,” W3C, 15 May 2025. [Online]. Available: https://www.w3.org/TR/vc-data-model-2.0/. [Accessed 27 October 2025].

[17] “Decentralized Identifiers (DIDs),” W3C, [Online]. Available: https://w3c.github.io/did/. [Accessed 27 October 2025].

[18] “DIF Universal Resolver,” [Online]. Available: https://dev.uniresolver.io/. [Accessed 27 October 2025].

[19] K. Hamilton-Duffy, R. Grant and A. Gropper, “Use Cases and Requirements for Decentralized Identifiers,” W3C, 17 March 2021. [Online]. Available: https://www.w3.org/TR/did-use-cases/. [Accessed 27 October 2025].

[20] M. Sporny, D. Longley, M. Sabadello, D. Reed, O. Steele and C. Allen, “Decentralized Identifiers (DIDs) v1.0,” 19 July 2022. [Online]. Available: https://www.w3.org/TR/did-1.0/. [Accessed 27 October 2025].

[21] “Decentralized Identifiers (DIDs) v1.0,” 19 July 2022. [Online]. Available: https://www.w3.org/TR/did-1.0/#did-resolution. [Accessed 27 October 2025].

A Decentralised Identifiers (DIDs) Deep Dive

DID stands for Decentralised Identifier and is a W3C Standard . The Abstract defines the functionality, design, and scope: "Decentralized identifiers (DIDs) are a new type of identifier that enables verifiable, decentralised digital identity. A DID refers to any subject (e.g., a person, organisation, thing, data model, abstract entity, etc.) as determined by the controller of the DID. In contrast to typical federated identifiers, DIDs have been designed to be decoupled from centralised registries, identity providers, and certificate authorities. Specifically, while other parties may be used to facilitate the discovery of information related to a DID, the design enables the controller of a DID to prove control over it without requiring permission from any other party. DIDs are URIs that associate a DID subject with a DID document, allowing trustable interactions associated with that subject. Each DID document can express cryptographic material, verification methods, or services, which provide a set of mechanisms enabling a DID controller to prove control of the DID. Services enable trusted interactions associated with the DID subject. A DID might provide the means to return the DID subject itself, if the DID subject is an information resource such as a data model. This document specifies the DID syntax, a common data model, core properties, serialised representations, DID operations, and an explanation of the process of resolving DIDs to the resources that they represent." The DID basic representation is shown in Figure A1, and the basic overview of its architecture in Figure A2.

Figure A1 A DID consists of a schema, a method, and an identifier, separated by columns

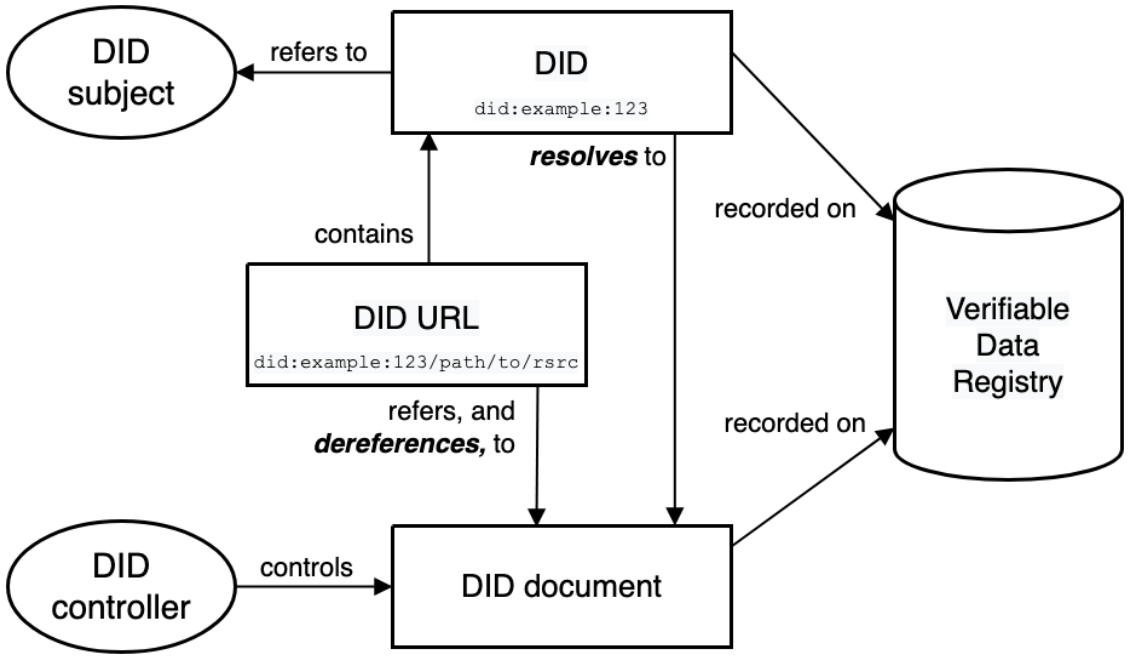

Figure A2 Basic overview of the DID architecture

A.1. DID Controller

The W3C standard defines a DID controller as an entity that is authorised to change the content of a DID Document. Typically, the DID Controller is mentioned as a controller entity on the DID document itself, but it is an optional property. The DID method determines the authorisation process of a DID Controller. It is possible to delegate the control or share the responsibility of a DID Document to/with a 3rd party. W3C documentation describes the DID Controller as "An entity that has the capability to make changes to a DID document. A DID might have more than one DID controller. The DID controller(s) can be denoted by the optional controller property at the top level of the DID document. Note that a DID controller might be the DID subject."

A.2. DID Subject

The subject of a DID is the entity associated with the DID, so in other words, a DID Subject is the entity identified by a DID and described by a DID document. Anything can be a DID subject: person, group, organization, physical thing, digital thing, logical thing, etc. A DID subject can have multiple identifiers for different purposes, or at different times. The assertion that two or more DIDs (or other types of URI) refer to the same DID subject can be made using the alsoKnownAs property.

A.3. AlsoKnownAs

A DID subject can have multiple identifiers for different purposes, or at different times. The assertion that two or more DIDs (or other types of URI) refer to the same DID subject can be made using the alsoKnownAs property. This property is optional, but if available of type URI.

A.4. DID - Method

A definition of how a specific DID method scheme is implemented. A DID method is defined by a DID method specification, which specifies the precise operations by which DIDs and DID documents are created, resolved, updated, and deactivated. It also documents all implementation considerations related to DIDs as well as Security and Privacy Considerations.

Chapter 8 of the DID standard [17] defines a DID Method as the means by which implementers can realise the features described by this specification. DID methods are often associated with a particular verifiable data registry. New DID methods are defined in their own specifications to enable interoperability between different implementations of the same DID method.

- DID:key
- DID:web
- ledger-based

Comparison of DID Methods

A.5. DID scheme

The formal syntax of a decentralised identifier. The generic DID scheme begins with the prefix DID: as defined in DID Syntax. Each DID method specification defines a specific DID method scheme that works with that specific DID method. In a specific DID method scheme, the DID method name follows the first colon and terminates with the second colon, e.g., DID:example:, DID:web, DID:web:managed-identity-wallet.preprod.cofinity-x.com:BPNL000005551C9G. Note that the path is an optional parameter that resolves to a path on the web-domain where the did.jason document is expected to be returned.

The ABNF Rules of a DID are:

did = "DID:" method-name ":" method-specific-id method-name = 1method-char method-char = %x61-7A / DIGIT method-specific-id =(idchar ":") 1idchar idchar = ALPHA / DIGIT / "." / "-" / "_" / pct-encoded pct-encoded = "%" HEXDIG HEXDIG

A.6. DID Document

The DID Document contains information about the entity (the object) identified by the DID. Typically, the expressed information can be associated to verification methods or services. Additionally, a generic section is foreseen in the DID Document.

Services determine how to interact with the DID Subject, as verification methods typically provide cryptographic public keys for verification.

A.6.1. DID Document properties

Property	Required?	Value constraints
id	yes	A string that conforms to the rules of the DID Syntax.

Property	Required?	Value constraints
alsoKnownAs	no	A set of strings that conform to the rules of RFC3986 for URIs.
controller	no	A string or a set of strings that conform to the rules of the DID Syntax.
verificationMethod	no	A set of Verification Method maps that conform to the rules in Verification Method properties, such as cryptographic public keys, which can be used to authenticate or authorize interactions with the DID subject or associated parties.
authentication	no	expression of the relationship between the DID subject and a verification method for this relation. An example of a verification relationship is authentication with a verification method cryptographic public keys.
assertionMethod	no	
keyAgreement	no	
capabilityInvocation	no	
capabilityDelegation	no	
service	no	A set of Service Endpoint maps that conform to the rules in Service properties.

A.7. Verification Method

A set of parameters that can be used together with a process to independently verify a proof. For example, a cryptographic public key can be used to verify a digital signature; in this context, it verifies that the signer possessed the associated cryptographic private key.

"Verification" and "proof" in this definition are intended to apply broadly. For example, a cryptographic public key might be used during the Diffie-Hellman key exchange to negotiate a shared symmetric encryption key (keyAgreement). This guarantees the integrity of the key agreement process. It is thus another type of verification method, even though descriptions of the process might not use the words "verification" or "proof."

A.8. Properties

Property	Required?	Value constraints
id	yes	A string that conforms to the rules of the DID URL Syntax.

Property	Required?	Value constraints
controller	yes	A string that conforms to the rules of the DID Syntax.
type	yes	A string.
publicKeyJwk	no	A map representing a JSON Web Key that conforms to [RFC7517]. See definition of publicKeyJwk for additional constraints.
publicKeyMultibase	no	A string that conforms to a [MULTIBASE] encoded public key.

When a controller property (see [13]) is present in a DID document, its value expresses one or more DIDs. Any verification methods contained in the DID documents for those DIDs should be accepted as authoritative, such that proofs that satisfy that verification methods are to be considered equivalent to proofs provided by the DID subject.

The DID controller has its own DID, distinct from the DPP/DMP identifier. It implies that we use verification methods and relationships.

A.9. DID Service endpoints

Means of communicating or interacting with the DID subject or associated entities via one or more service endpoints. Examples include discovery services, agent services, social networking services, file storage services, and verifiable credential repository services. To summarize, a service is a service endpoint network address, such as an HTTP URL, at which services operate on behalf of a DID subject.

A.9.1. Endpoint Properties

Property	Required?	Value constraints
id	yes	A string that conforms to the rules of [RFC3986] for URIs.
type	yes	A string or a set of strings.
serviceEndpoint	yes	A string that conforms to the rules of [RFC3986] for URIs, a map, or a set composed of a one or more strings that conform to the rules of [RFC3986] for URIs and/or maps.

A.10. DID References

The DID standard does not foresee a direct property to reference another DID document.

The “alsoKnownAs” property should lead to a set of URIs as stated by the W3C Standard [17], therefore it might be used to build a relationship between DID. This functionality can also be realized using the service section, either via direct usage or indirect as part of the result of a custom service (e.g. DPP).

Option1:

Utilize the optional DID property “alsoKnownAs” to refer to the same subjectID (i.e. MaterialID) from another EOP, who creates it’s own DID. That implies we must have DID methods, that support DID Documents (basically all methods beyond DID:key). Those references in DID documents would be publicly visible, as the DID should be publicly resolvable and a resolver returns the same DID document regardless of who is asking.

Option2:

Services in the DID document could be for example a presentation service for credentials (that are identified by a DID) such as a DPP or DMP. Services presenting DMP/DPP credentials can be seen as protected resource, thus requiring authorization of the requestor (think of Oauth2) in order to get access to confidential parts of the DMP. Sensitive information would then only be presented (or selectively disclosed) to authorized requestors.

References to DIDs from other EOPs or the other DMPs of the same EOP would then be part of the Credential payload and could also be fields relevant to selective disclosure.

A.11. DID resolution / DID resolver

The process that takes as its input a DID and a set of resolution options and returns a DID document in a conforming representation plus additional metadata. This process relies on the "Read" operation of the applicable DID method. The inputs and outputs of this process are defined by the W3C as follows [13]

- resolve: the resolve function accept the DID and resolution options as input and return the DID Document as key-value pairs (a map) in a representation that conforms to the VC data model and is serialized with on of the media-types application/did+json; application/did+cbor or application/did+ld+json
- resolveRepresentation: the resolvePresentation function has the same input as the resolve function, accepting a DID and resolution options, but the return value is a byte stream of the DID Document formatted in the corresponding representation.

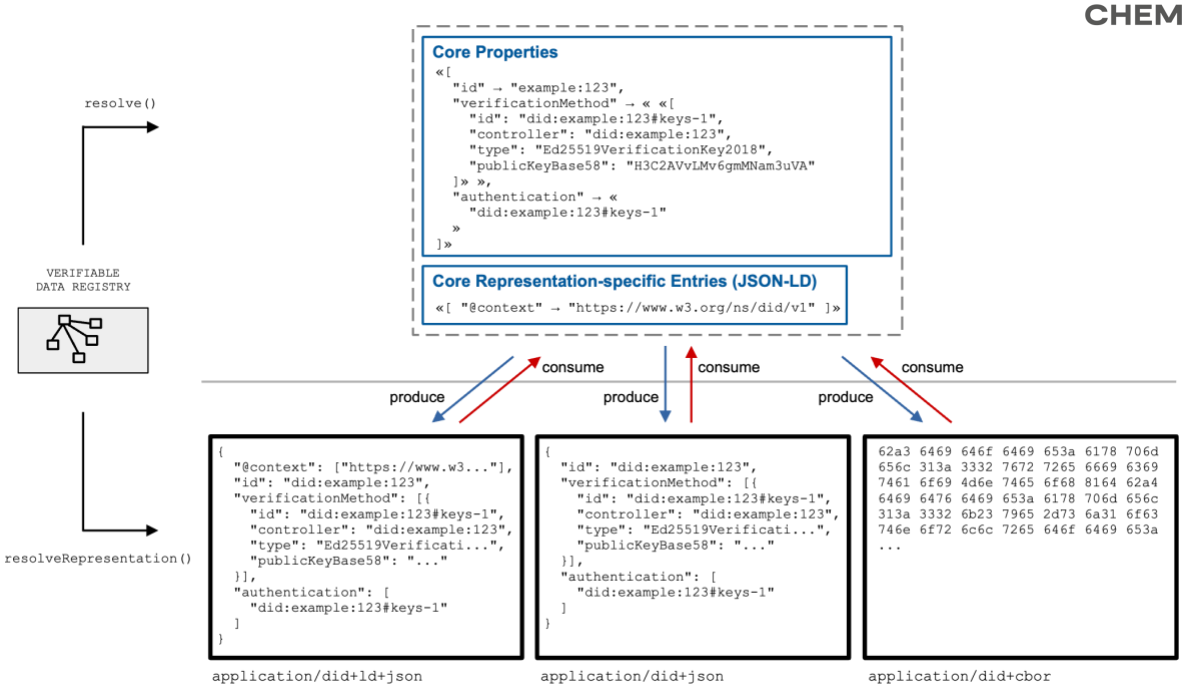

Figure A3 DID resolution

The resolution of a DID is performed by the resolver, which is a software and/or hardware component. The resolver accepts the DID as input and produces a conforming DID document as output. An example is the universal resolver [17] [18]

A.12. Representation

A concrete serialization of a DID document in this specification is called a representation. A representation is created by serializing the data model through a process called production. A representation is transformed into the data model through a process called consumption. The production and consumption processes enable the conversion of information from one representation to another. This specification defines representations for JSON and JSON-LD, and developers can use any other representation, such as XML or YAML, that can express the data model. The following sections define the general rules for production and consumption, as well as the JSON and JSON-LD representations.

A.13. Requirements on Identifier

The DID Use Cases Document [19] by Kim Hamilton-Duffy, Ryan Grant, and Adrian Gropper defines 4 characteristics an identifier has to meet:

- decentralised: there should be no central issuing agency;
- persistent: the identifier should be inherently persistent, not requiring the continued operation of an underling organization;
- cryptographically verifiable: it should be possible to prove control of the identifier cryptographically.
- resolvable: it should be possible to discover metadata about the identifier.

A.14. Material-ID resolve DID Subject

Catena-X is using an UUID as identifier for the DPP, in comparison the unique identifier of the DPP for Chem-X is the DID of the entity, which will be generated from a combination of the company identifier, the subject (identifier of the entity, e.g. GTIN, Material-ID) and a salt. This combination will be hashed and can be used for a cryptographic key generation.

A custom resolver accepts the material identifier (material number in combination with a company identifier), GTIN, or another serial number and derives the DID from it. The resolver would allow authenticated resolving of the DID document, already verifying the granted access level of the requester.

The yellow-pages function of the resolver needs to be part of the platform provider.

A.15. Accessibility

The accessibility of the DID Document is defined by the DID method, based on Chapter 8 of the DID Standard [20] DID Definition Document. Next to the definition of the requirement on a DID method syntax, although the specification of the requirements of the DID method operations are part of this chapter.

A DID method must specify how the authentication happens and how CRUD operations are protected. The resolution of a DID Document is a read access and can be already restricted based on the definition of the method.

The specification of DID:web is published as an unofficial draft version at W3C and leaves the implementation of authorization and authentication mechanism and procedures to the implementer.

This would allow an authenticated and authorized resolution of a DID Document in addition to authenticated and authorized access to services like a DPP.

The DID standard allows public and private resolution as well as access to sections of a public DID document.

A.16. Verifiable Credentials

VC is a W3C standard, available in Version 2 [16]. The Chem-X Verification Workstream explains Verifiable Credentials in its Report.

B Comparison of ID Schemas

	Web-enabled structure path / query string	Identification link	decentralized identifier	product & group identification	Digital Object Identifier (DOI)
example	**path:** https://example.com/01/09524000059109/22/2A/10/ABC123/21/12345XYZ?11=251121 **query:** https://www.example.com/?.25P=QCELMI12345&.S=654321	**path (item only)**: https://www.example.com/freetext **query (model, batch, item)**: https://www.example.com/?.S=freetext&.10B=freetext	**DID**: did:web:example.com:model4TR **URL**: https://resolver.io/did:web:example.com:model4TR/?service=item-dpp **universal-resolver**: https://dev.uniresolver.io/#did:web:identity.foundation	Data carrier like **RFID** in combination with: - EDC Tag - GS1 Digital Link Data carrier like **2D code** in combination with: - Data Identifier encoding - Issue Agency Code	https://doi.org/10.1000/N44APB7E
Global Uniqueness	Yes, ensured by ISO / IEC 15459 in combination with the prohibitence of reusing / reassignment of identifiers	Yes, ensured by ISO / IEC 61406 in combination with the prohibitence of reusing / reassignment of identifiers	Yes, ensured by the W3C Decentralized Identidiers Standard v1.0 in combination with the prohibitence of reusing / reassignment of identifiers	Yes, ensured by ISO / IEC 15459 in combination with the prohibitence of reusing / reassignment of identifiers	Yes, ensured by ISO / IEC 15459 and 26324 in combination with the prohibitence of reusing / reassignment of identifiers. The issuing agency needs to check the uniqueness of the Id and the metadata used for the registration
Persistence	Supported by the lifecycle management rules based on ISO / IEC 15459	Supported by the lifecycle management rules based on EN IEC 61406	Persisitence is guaranteed by the mixture of decentralized structure and processes, the control of the DID owner and the definition of the DID Standard	Supported by the lifecycle management rules based on ISO / IEC 15459	In responsibility of the issuing agency, ensured by the provisioning od descriptive metadata

	Web-enabled structure path / query string	Identification link	decentralized identifier	product & group identification	Digital Object Identifier (DOI)
Syntax	Syntax is defined by: - ISO / IEC 15459, Web usage by: - IETF RFC 3986 - ISO / IEC 18975	Syntax is defined by: - ISO / IEC 15459, Web usage by: - IETF RFC 3986 - ISO / IEC 61406	Syntax is defined by DID Standard: - identifier prefix is "did" followed by the method (e.g. "web","eth", ...), and the method spcific ID, ech block is separated by a ":" as delimitter Web usage by: - IETF RFC 3986	Syntax is defined by: - ISO / IEC 15434, - ISO / IEC 15459, - ISO / IEC 15961 - ISO / IEC 15962 - ISO / IEC 17360 - ISO / IEC 18000 Web usage is not avaiable	Syntax is defined by: - ISO 26324 Web usage by: - IETF RFC 3986
Granularity	Supports identification on - Model - Batch - Item level	query based identification link supports identification on - Model - Batch - Item level, path based identifcation link on the other hands supports identifiaction on Item level only	Supports identification on - Model - Batch - Item level	Supports identification on - Model - Batch - Item level	Supports identification on - Model - Batch - Item level
Interoperability	Can be used with web technologies and existing supply chain equipment	Can be used with web technologies and existing supply chain equipment	Can be used with web technologies and existing supply chain equipment	Can be used with web technologies and existing supply chain equipment	Can be used with web technologies and existing supply chain equipment

	Web-enabled structure path / query string	Identification link	decentralized identifier	product & group identification	Digital Object Identifier (DOI)
Openness	Can be used with web technologies and existing supply chain equipment	Can be used with web technologies and existing supply chain equipment	Can be used with web technologies and existing supply chain equipment	Can be used with web technologies and existing supply chain equipment	Can be used with web technologies and existing supply chain equipment
Type of Issuing	Issuing Agency	self issuing	self issuing	Issuing Agency	Issuing Agency
domain dependent	no	yes	valid for DID:WEB	no	yes
link to other schema	Web enabled, structured path and Web enabled query string is at the same also an “Identification Link”				example is a valid "Identifiaction Link"
license	GS1: provision fee + annual fee depending on annual turnover ~650€ to ~33K€	depends, open source or properity license model possible	open source	depends, open source or properity license model possible	Annual fee + fees based on the number of used links. ~9k€ / anno
use case	cross sector	cross sector	cross sector	cross sector	mainly used in science and referencing publication
remark	A GTIN is an Item Identifier, it is identifying a brown bottle 500ml, but it is not a serialized item (an unique single bottle) Chem-X on the other hand, defines item as a serialized item.	A DPP identifier should not be based on speakable scheme, so it should not distinguished on identifier scheme level between Model, batch and Item. Target on the identification link is an identification of a batch, product or item based on the specific id. Using a uuid to identify a model, batch, or item DPP will fuifill this requirement		Focus on physical object, DMP / DPP can not be fetched based on delivery note for example	typically used for publications / scientific work

	Web-enabled structure path / query string	Identification link	decentralized identifier	product & group identification	Digital Object Identifier (DOI)
meets regulatory	yes, part of JTC-24	yes, part of JTC-24	yes, part of JTC-24	yes, part of JTC-24	yes, part of JTC-24
use existing technology	yes	yes	yes	yes	yes
ownership / controll	GS1 / economic operator	economic operator	economic operator	GS1 / economic operator	DOI
non speaking Id	TRUE	TRUE	TRUE	TRUE	TRUE
protected access					
public access	TRUE	TRUE	TRUE	TRUE	TRUE
Metadata of EDC	FALSE	FALSE	TRUE, as part of the DID Document	FALSE	FALSE
resolver					
availablity in supply chain	the major player are using GTIN already, but it cannot be guaranteed for SME	no major usage in chemical industry	no major usage in chemical industry	RFID not common, 2D code more often used, mainly barcode in place	not used in chemical industry for objects
implementation complexity	medium	medium	medium	medium	medium
EDC compatibel	no	yes	yes	no	no