CIRPASS
Digital Product Passport

D3.1
Benchmark of existing DPP-oriented reference architectures

January 2023 (M4)

Funded by
the European Union

Lead Beneficiary	**Politecnico di Milano**
Author(s)/Organisation(s)	**Marcello Colledani, Abdelrahman Abdalla**
Contact Email	**Marcello.colledani@polimi.it**
Contributor(s)	**Carolynn Bernier, Rigo Wenning, Boriana Rukanova, Mounir Kellil, Andreas Schneider, Kamila Anna Kocia, Jan Merckx, Maike Jansen, Eva Hill, Mario Malzacher, Kees Jacobs, Marvin Böll, Phil Archer, Eduard Wagner**
Work Package	**WP3**
Due Date:	**31st January 2023**
Actual Delivery Date	**15st February 2023**
Abstract:	**Deliverable D3.1 presents the outcomes of the benchmarking activity performed within WP3 of CIRPASS. The objective is to frame existing DPP-related initiatives and observe general macro-trends and existing gaps in view of the alignment with the ESPR Proposal goals. The deliverable is structured in three sections, focusing on (i) the presentation of the adopted classification methodology, (ii) the formalized presentation of a sub-set of existing DPP-related initiatives focusing on the IT architecture, (iii) the critical analysis of the entire set of mapped initiatives. Take-home messages and recommendations are summarized in the final section of D3.1 to be further considered within the future activities of CIRPASS.**

Document Revision History			
Date	**Version**	**Author/Contributor/Reviewer**	**Summary of Main Changes**
01/12/2022	V0.1 (draft)	Marcello Colledani	Structure of the Deliverable
31/12/2022	V1.0 (draft)	Marcello Colledani, Rigo Wenning, Abdelrahman Abdalla, Boriana Rukanova, DPP-initiative owners	Description of the methodology, DPP-initiative descriptions, Explanation of the mapping framework.
07/01/2023	V1.1 (draft)	Marcello Colledani, Abdelrahman Abdalla	First version, including section 1, 2, and 3.
13/01/2023	V1.2 (draft)	All WP3 partners	First set of reviews collected from the WP3 members.
20/01/2023	V1.3 (draft)	Marcello Colledani, Abdelrahman Abdalla, Carolynn Bernier	Complete version, including section 1, 2, 3, and 4.
24/01/2023	V1.4 (draft)	Marcello Colledani, Abdelrahman Abdalla	Complete version including all sections for review.
15/02/2023	1.0	Marcello Colledani, Abdelrahman Abdalla, Carolynn Bernier, Rigo Wenning	Final version addressing all comments originated in the internal review process.
04/03/2023	1.1	Marcello Colledani, Abdelrahman Abdalla, Carolynn Bernier	Final version addressing all minor requests for modification

			originated in the governing board approval review.
21/03/2023	1.2	Abdelrahman Abdalla, Carolynn Bernier	Minor typo corrections. Cutoff date added for Section 3.

Dissemination Level and Nature of the Deliverable		
PU	Public	**PU**
SEN	Sensitive, limited under the conditions of the Grant Agreement	**OPEN**
Nature	**R** = Report, **E** = Ethics or, **O** = Other	**R**

CIRPASS Consortium			
#	Participant Organisation Name	Short Name	Country
1	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	CEA	FR
2	SLR ENVIRONMENTAL CONSULTING(IRELAND)LIMITED	SLR Consulting	IE
3	FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV	Fraunhofer	DE
4	WUPPERTAL INSTITUT FUR KLIMA, UMWELT, ENERGIE GGMBH	WUPPERTALINSTIT	DE
5	STIFTELSEN CHALMERS INDUSTRITEKNIK	CIT	SE
6	VDE VERBAND DER ELEKTROTECHNIK ELEKTRONIK INFORMATIONSTECHNIK EV	VDE	DE
7	GLOBAL TEXTILE SCHEME GMBH	GTS	DE
8	+IMPAKT LUXEMBOURG SARL	+IMPAKT	LU
9	F6S NETWORK IRELAND LIMITED	F6S	IE
10	GEIE ERCIM	ERCIM	FR
11	E CIRCULAR APS	CEI Society ApS	DK
12	GS1 IN EUROPE	GS1 in Europe	BE
13	POLITECNICO DI MILANO	POLIMI	IT
14	CIRCULAR.FASHION UG (HAFTUNGSBESCHRANKT)	circularfashion	DE
15	DIGITALEUROPE AISBL*	DIGITALEUROPE	BE
16	KIC INNOENERGY SE	KIC SE	NL
17	TECHNISCHE UNIVERSITEIT DELFT	TU Delft	NL
18	TALLINNA TEHNIKAÜLIKOOL	TalTech	EE
19	VELTHA IVZW	VELTHA	BE
20	Energy Web Stiftung (Energy Web Foundation)	EWF	CH
21	BUNDESANSTALT FUER MATERIALFORSCHUNG UND -PRUEFUNG	BAM	DE
22	SyncForce BV	SyncForce	NL
23	ASOCIACION DE EMPRESAS TECNOLOGICAS ES INNOVALIA	INNOVALIA	ES
24	Textile Exchange	TextileExchange	US
25	Responsible Business Alliance	RBA	US
26	WORLDLINE FRANCE	WORLDLINE	FR
27	RISE RESEARCH INSTITUTES OF SWEDEN AB	RISE	SE
28	IPOINT-SYSTEMS GMBH	iPoint	DE
29	Global Electronics Council	GEC	US
30	Avery Dennison Atma GmbH	atma.io	AT
31	Global Battery Alliance	GBA	BE

Preparing the ground for the gradual piloting and deployment of the DPPs from 2023 onwards, focusing on developing a roadmap for prototypes in three value chains: electronics, batteries and textiles.

Grant Agreement: 101083432
Theme: DIGITAL-2021-TRUST-01
Start Date of Project: 01 October 2022
Duration: 18 months

Table of Contents

List of Tables

List of Figures

List of Abbreviations and Acronyms	
DPP	Digital Product Passport
ESPR	Ecodesign for Sustainable Product Regulation
GTIN	Global Trade Item Number
OEM	Original Equipment Manufacturer
PET	Privacy Enhancing Technologies

About CIRPASS

The European Commission has strong interest and ambition in relation to emerging technologies to support the 'twin', green and digital, transitions and specifically in the development of a **Digital Product Passport (DPP).** The DPP is defined by the European Commission as a structured collection of product related data with pre-defined scope and agreed data ownership and access rights conveyed through a unique identifier, and that is accessible via electronic means through a data carrier. The intended scope of the DPP is information related to sustainability, circularity, value retention for re-use, remanufacturing and recycling.

The aim of CIRPASS is to prepare the ground for a gradual deployment of DPPs, with an initial focus on the electronics, batteries and textile sectors. Spurred by the need to accelerate the transition to a more circular and sustainable economy, combined with new opportunities offered by a burgeoning data market, a large number of European and international initiatives have emerged recently. CIRPASS's methodology consists in uniting representatives from a large number of these early DPP pilots in order to build a balanced, open and transparent community dedicated to the design and roll-out of the upcoming European DPP.

To ensure a neutral and technology agnostic stance, CIRPASS relies heavily on the involvement of leading European Research and Technology organisations, supported by three standardization organisations, an experienced pool of circular economy and sustainability consultancies, several large European industrial associations, digital technologies and web experts, and digital solution providers. The CIRPASS consortium is made up of 31 partners in total.

By bringing together this community of expertise, the project will build consensus and momentum around the DPP concept and contribute to the development of common principles, prototypes and roadmaps to secure the interoperability of DPPs across value chains, sectors and market participants. Enhanced stakeholder dialogue will be achieved through extensive consultations addressing key DPP aspects such as ontologies, technical requirements and standardization needs.

1. Introduction and objectives

This deliverable reports the output of the activity carried out within T3.1 of WP3 in the CIRPASS project, in cooperation with the task force formed by members of T2.2, T3.1 and WP4. The objectives of the work performed in this task were twofold: (a) to **benchmark the IT technical features of digital product passport (DPP)-related initiatives**, either existing or under development, and (b) to **identify the most common features** in view of the future adoption of the DPP at industrial scale, in line with the concepts outlined in the "Proposal for Ecodesign for Sustainable Product Regulation (ESPR)"[1]. This analysis led to the identification of relevant macro-trends and specific recommendations that will form the basis to support subsequent activities of WP3.

The structure of this deliverable is organised as follows. In Section 1 the technical architecture benchmarking activity is positioned within the overall workplan of the CIRPASS project and the synergies with the main DPP concepts outlined in the ESPR Proposal are highlighted. Section 2 is dedicated to the detailed explanations of the adopted benchmarking methodology in view of ensuring the scientific validity of the approach and the repeatability of the mapping process. Section 3

[1] https://environment.ec.europa.eu/publications/proposal-ecodesign-sustainable-products-regulation_en

highlights the characteristics of selected DPP-related initiatives extracted from the database resulting from the application of the mapping approach. Section 4 is dedicated to an in-depth analysis of the entire set of mapped DPP-related initiatives, from the viewpoint of the supporting technical architecture details. Section 5 presents a critical analysis of the outcomes of the task activity, focusing on the lessons learnt. Additionally, this section provides a preliminary identification of existing gaps between the developed solutions and the ESPR Proposal needs. Section 6 wraps-up the main conclusions and maps possibilities for further exploitation of the outcomes outlined in this deliverable.

1.1 Positioning of D3.1 within the CIRPASS project

In this section, the positioning of the work carried out to prepare this deliverable is discussed with respect to the activity of the overall CIRPASS project. The workplan of the CIRPASS project is structured in 6 inter-linked work packages, representing three parallel work-streams carried out within WP2, WP3 and WP4, respectively focusing on DPP data-models (WP2), technical IT architecture of DPP solutions (WP3) and DPP-related standards (WP4), as shown in Figure 1. The work behind this deliverable D3.1 is part of WP3 and focuses on benchmarking existing technical IT architectures that have been developed or are under development to support the implementation of the DPP concept. Future activities within WP3 will further elaborate on the outcomes of this analysis with the objective to formalise the functional and non-functional requirements of a DPP architecture and to focus on suitable characteristics of the DPP technical blueprint, identification and dataspace integration solutions of future DPP-systems. The focus of D3.1 is on analysing and learning from the technical details of the solutions under development to further orient future developments towards the expectations and needs of the "Proposal for Ecodesign for Sustainable Product Regulations (ESPR)".

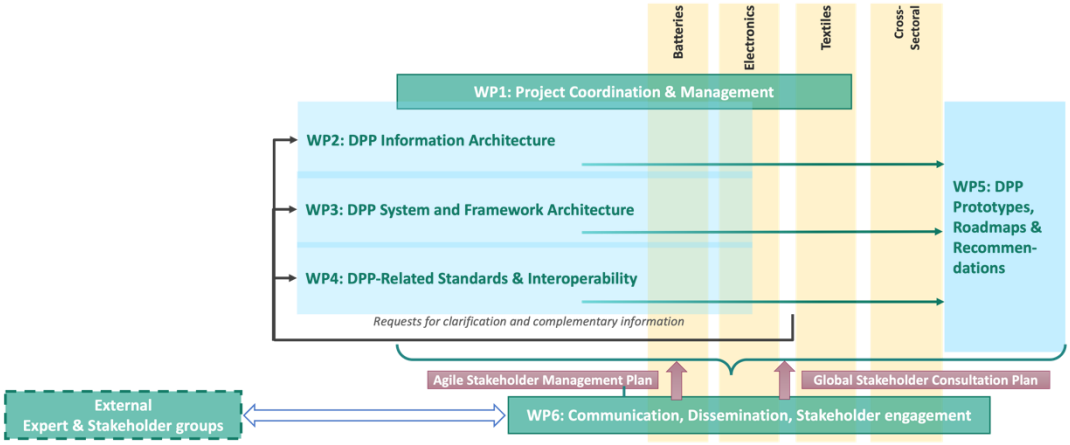


Figure 1 Workplan of the CIRPASS project.

From a technical IT perspective, the concept of a DPP can be characterised by the following 4 pillars, which are also visually represented in the graphical circular value –chain-oriented view depicted in Figure 2.

- A unique persistent ID for the product (including batch and/or serialisation as necessary) **(1)**
- A persistent data carrier (RFID, QR Code, digital watermark, Bluetooth tag, etc.) **(2)**
- A Digital connector between physical product and the digital place of information on the product (e.g., URL address) **(3)**
- An IT architecture for facilitating the data exchange **(4)** composed of:

- Standardised vocabulary;
- Standardised data exchange protocols and formats;
- Standardised stakeholder-dependent access mechanisms (read/edit rights);
- Distributed storage and management of information (in connection with EU dataspaces);
- A stakeholder-dependent interaction layer.

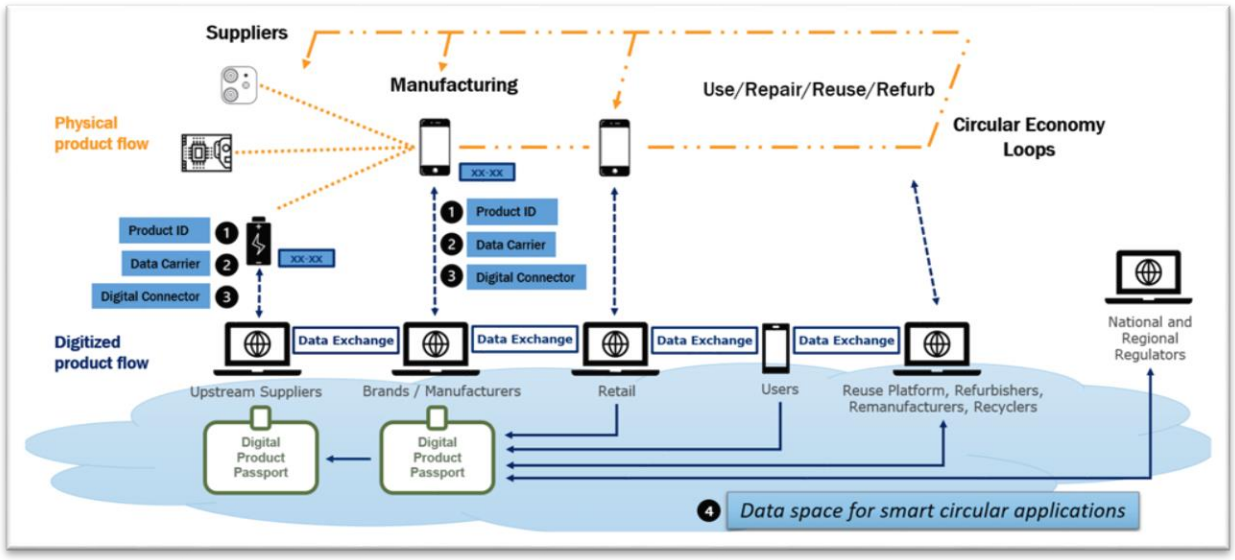


Figure 2 Reference schema of the DPP concept adopted in CIRPASS and positioning of the technical DPP pillars of relevance for WP3.

At the start of the CIRPASS project, several tasks were deemed critical as they would produce results providing necessary information for other interconnected and future tasks. In particular, three tasks were identified as parallel as each had the objective of benchmarking existing DPP-related initiatives[2], however, from different perspectives as per the respective work packages. The benchmarking of DPP-related initiatives focuses on information in WP2 (T2.2), technical architecture in WP3 (T3.1) and standards in WP4 (T4.1), with WP2 and WP3 scheduled to finalise deliverables in Month 3 (M3) of the project. As a consequence, collaboration among the three work packages was sought in order to ensure alignment and to minimise duplication of work. A dedicated cross-work package task force was set up to perform the initial identification and screening of the DPP-related initiatives. Key participants in this task force included the work package leaders of WP2, WP3, WP4, the task leader of T2.2, the sector leaders to benefit from their knowledge of the sector initiatives, as well as the project coordinator for overall cross-task coordination and technical experts from the respective work packages. The task force was formed immediately after the CIRPASS Kick-off meeting that took place on October 5th, 2022. Subsequently, the task force has held regular weekly meetings to discuss: (a) the approach for the identification of DPP-related initiatives to be analysed, (b) the development of a

[2] Already during the initial discussions at the Kick-off meeting and discussions with the taskforce it was identified that talking about DPP-pilots may be too restrictive, as pilots may raise expectations about some specific implementation and that may limit the identification of initiatives that are relevant for DPP but are in a more conceptual phase. Therefore, the broader term of DPP-related initiatives was introduced which allowed for more flexibility to make a broad identification of developments that are identified by partners or the external network as relevant or informative for DPP.

categorisation framework for the data collection of the DPP-related initiatives, (c) the data collection tool development, (d) the progress on data collection, and (e) approaches for data analysis and presentation. Next to these cross-work package task force meetings, additional coordination meetings within the three work packages also took place to further progress on activities as agreed in the DPP-related initiatives task force meetings. The screening of DPP-related initiatives was therefore a joint effort between different work packages teams. Deliverable D3.1 summarises the main results of this benchmarking activity with a specific focus on the technical IT solutions.

1.2 Synergies with the ESPR Proposal objectives

In this section, the alignment of the objectives of the D3.1 benchmarking activity with the ESPR Proposal target goals is discussed to share with the readers a broader view of the entire DPP context of reference.

The ESPR Proposal's objectives are to reduce the negative life cycle impacts of products and improve the functioning of the internal market. It also contributes to EU industrial policy objectives to foster sustainable production, promote supply and demand for sustainable products, and ensure a level playing field for products sold on the internal market. The ESPR Proposal lays down a framework for setting ecodesign requirements, based on product sustainability and circularity, for a broad range of products, creating digital product passports and prohibiting the destruction of unsold consumer products. Under the scope of the ESPR Proposal, only a few sectors are exempt (e.g. food, feed, medicinal products, etc.).

The ESPR Proposal takes into consideration other regulations to ensure consistency with other existing policy provisions and Union policies (e.g., the European Green Deal, Industrial Strategy for Europe, Circular Economy Action Plan, EU strategy for sustainable and circular textiles, Green Claims, Corporate Sustainable Due Diligence, Market Surveillance Regulation, Union legislation on waste, chemical and food safety). The ESPR Proposal also provides information on delegated act developments, regulation exemption rules, obligations of actors along the supply and value chains, regulation enforcement and compliance, policy and standard harmonisation among state members and with national policies, and small and midsized enterprise (SME) implications.

The product passport concept (purpose, data included, system) is presented on item (26) to (39) (page 25-27 of the Proposal). The ESPR Proposal *"also includes the creation of a digital product passport to electronically register, process and share product-related information amongst supply chain businesses, authorities and consumers. This is expected to increase transparency, both for supply chain businesses and for the general public, and increase efficiencies in terms of information transfer. In particular, it is likely to help facilitate and streamline the monitoring and enforcement of the regulation carried out by EU and Member State authorities. It is also likely to provide a market-intelligence tool that may be used for revising and refining obligations in the future."* (pg.9)

While the details of the DPP for specific product groups will be defined in specific delegated acts, the ESPR Proposal contains information on technical aspects of the DPP that will apply to all product groups for which delegated acts will be developed. The DPP shall offer free access to data to actors along the entire value chain based on their respective access rights set out in the applicable delegated act. This information must be based on open standards and interoperable formats and be machine readable, searchable and structured. To balance accessibility and IP protection, DPP will allow differentiated access depending on the type of information and typology of stakeholders. It is

expected that actors may introduce or update information in the DPP, including, where needed, the creation of a new DPP. This, as well as the period for which the DPP shall remain available, will be defined in the delegated acts.

While DPP implementation is expected to be supported by and produce positive impact on SMEs, the cost may be relatively heavier. As a result, ESPR proposes a number of measures to help SMEs mitigate risks and costs related to DPP implementation. In particular, to support SME's in filling the digital divide gap, the authors of this summary expect that *DPP-as-a-Service* operators (intermediaries) will offer low-cost DPP data storage and access facilities. According to Art 10. they will not be allowed to sell, re-use or process data beyond what is necessary.

A DPP will be specific to the item, batch or product model, depending on the complexity of the value chain, and the size, nature and impacts of the product considered. A DPP can be assigned to intermediate goods or materials. When applicable, the DPP should be easily accessible by scanning a data carrier, such as a watermark or a QR code. The data carrier should be on the product itself to ensure the information remains accessible throughout its life cycle. However, the ESPR Proposal also states that the data carrier shall be physically present on the product, its packaging, or on documentation accompanying the product. To ensure interoperability, the types of permitted data carriers, the data carrier, the unique product identifier, and unique operator and facility identifiers will be standardised to guarantee compatibility with external components such as scanning devices.

The Commission will set up and maintain a product passport registry to, at minimum, store a record of all data carriers and unique identifiers linked to products placed on the market or put in service. This registry will be interconnected with the EU Customs Single Window Certificates Exchange. However, the DPP itself should be based on a decentralised data system set up and maintained by economic actors. The DPP shall additionally require standards for data access rights management, data storage and processing, data authentication, reliability, integrity, security and privacy.

The benchmarking analysis in this deliverable highlights the most common technical trends adopted by DPP-oriented initiatives that have been developed, or are under development, in different sectors, with the objective to investigate gaps and orient future developments in line with the expectations of the ESPR Proposal.

2. Methodology and procedures

The methodology and procedures adopted within the activities of T3.1, in cooperation with the cross-WP task-force are explained in this section. To further clarify, the first part of the activity has been conducted in synergy with the other WPs in the task force, while the phase of analysis and benchmarking has been conducted by introducing WP-dependent criteria and mechanisms.

The left-hand side of Figure 3 provides a high-level overview of the process. More specifically, in a first phase the task force worked on the development of a DPP-initiative characterization framework focusing on several classification axes (Step A) and implemented that framework in the form of an excel tool and an online questionnaire (Step B) in order to support the data gathering step. The task force also worked on the identification of DPP-relevant initiatives (Step C) and on the collection of inputs on DPP-related initiatives analysis via the tools to establish the CIRPASS knowledge base of DPP-related initiatives (Step D) to support a more in-depth WP-dependent analysis.

The CIRPASS knowledge base of DPP-related initiatives was then made available for use to different work packages, where depending on the specific objectives of each respective work package, a further customised selection of DPP-related initiatives took place (Step E), based on work package dependent criteria. This then led to the customised analysis (Step F) and deliverable writing (Step G) for the specific work package.

In this section, we focus only on the steps carried out by the DPP-related initiatives task force (i.e. steps A, B, C, and D). Steps E, F, and G will be covered in the Sections 3 to 5 of this deliverable.

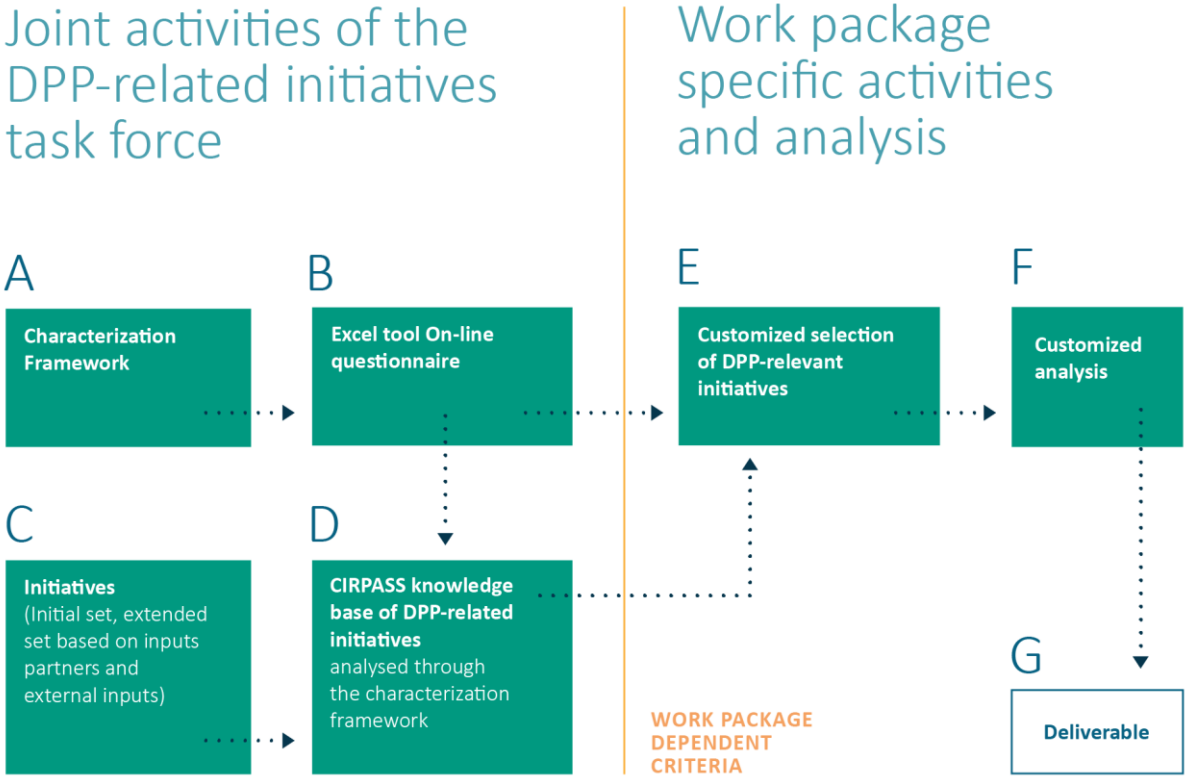


Figure 3 DPP-related initiatives activities carried by the task force and the individual work packages

In the future, other work packages will also make use of the CIRPASS DPP-related initiatives knowledge base for their activities.

2.1 The overall benchmarking methodology

For the data collection related to DPP-related initiatives, a categorization framework needed to be developed to identify dimensions and categories along which to organize the data collection about the initiatives in a uniform way. The categorization framework was developed in a number of steps. First, some preliminary preparation before the CIRPASS Kick-off meeting was performed by WP2 in consultation with key stakeholders from T2.2, where an initial idea about how the categorization framework could be organized. This was then developed and presented during the CIRPASS Kick-off-meeting. The high-level framework (see Figure 4) consisted of several dimensions as follows: (1) Actors; (2) Technical design; (3) Data; (4) Initiative characterization, and (5) Standards.

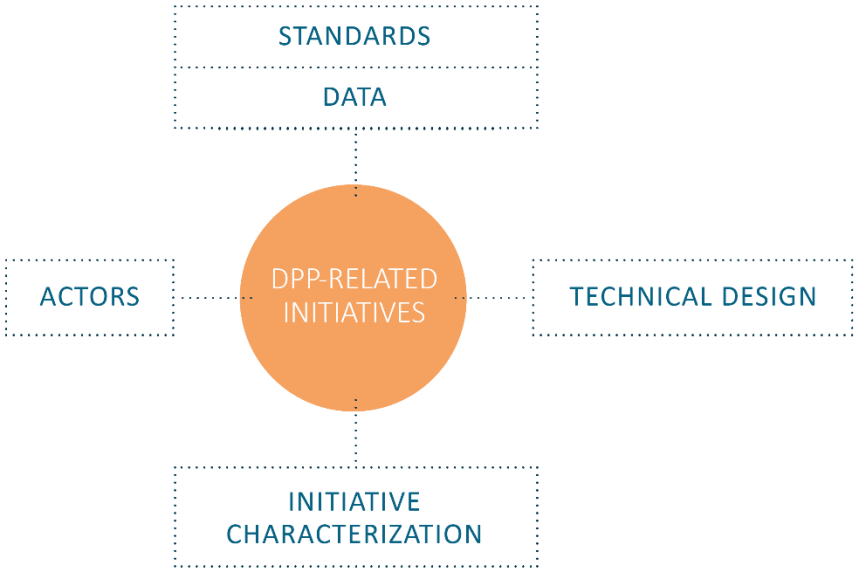


Figure 4 Initial high-level dimensions of the categorization framework as discussed during the CIRPASS Kick-off meeting

Following the CIRPASS Kick-off meeting on October 5th, 2022, the further development of the categorization framework was initiated by the DPP-related initiatives task force to further define and fine-tune the categories and the dimensions. In addition, WP2 and WP3 had internal discussions to fine-tune the categories relevant to the respective work packages. During these discussions it was decided that the standards dimension would not be part of the joint data collection of screening of initiatives, as WP4 focuses on standards, while WP2 and WP3 on initiatives. Nevertheless, WP4 was actively involved in the DPP taskforce, collaborated on the framework development, and followed the developments, to ensure that the standards work is aligned with the work related to the DPP-related initiatives screening. WP4 also added some of the initiatives that were looking into standardisation and provided input in order to ensure that the identified categories in the categorization framework for the pilots were in line with what is stated in the standards. This was necessary to perform a gap analysis on standards, but also to highlight if additional initiatives/Expert Groups/ etc. were needed to work on missing standards.

As a result of this iterative process, the DPP-related initiatives classification framework was developed early November, 2022.

2.2 DPP-related initiatives data gathering procedure

The screening of DPP-related initiatives was meant to provide a quick scan of initiatives as part of tasks T2.2 and T3.1, to produce results in the first three months of the project, and to feed these results into other related tasks. Once the work on the initiatives started, based on discussions in the DPP initiatives task force, and based on feedback received from external stakeholders, it became clear that collecting data about DPP-related initiatives was an important task and that it was necessary to build and maintain a knowledge base on that topic not only in the first months of the project but also throughout the project duration. Similarly, it was important to set-up a process to enable populating this knowledge base not only with pilots to which CIRPASS partners or their immediate network had access to, but to allow for an open process where external parties interested in sharing information about their initiatives would be welcome to do so.

Figure 5 illustrates the process of DPP-related initiative inclusion in the knowledge base of CIRPASS. This knowledge base has been used in a tailored way by the related tasks in CIRPASS work packages, depending on their specific objectives and needs. These related tasks have then collected more detailed information on relevant initiatives selected from this knowledge base to meet the needs of their specific task.

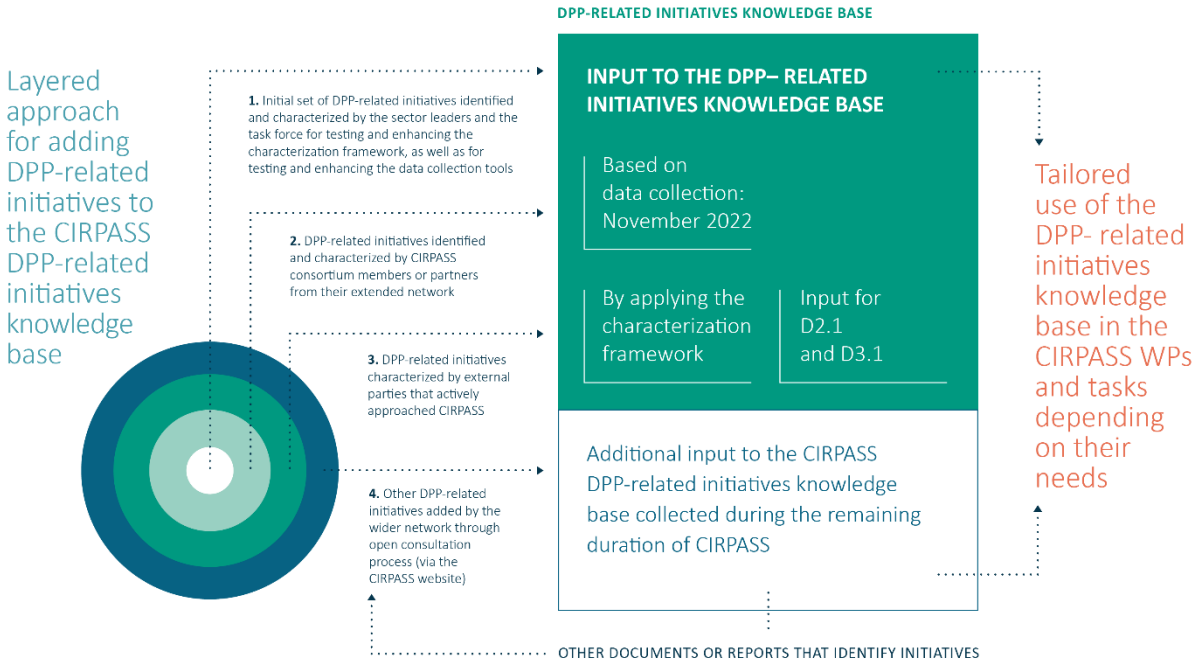


Figure 5 Approach followed for the DPP-related initiatives screening

As illustrated in Figure 5, the approach followed for the inclusion of initiatives in the CIRPASS DPP-related initiatives knowledge base was layered, starting from: (1) a limited set of initiatives the task force had access to and which were used to develop the data collection framework and tools and to perform initial initiatives analyses. Subsequently moving to (2) the data collection process was opened to the CIRPASS partners who were invited to contribute additional initiatives they were able to bring in via their own network, and (3) data collected from external parties that actively approached the CIRPASS consortium and volunteered to contribute information about their initiative. These processes resulted in the initial knowledge base which is used by WP2 and WP3 for the deliverables D2.1 and D3.1. However, the data collection process for further expanding the CIRPASS DPP-related initiatives knowledge base will continue after these formal deliverables are submitted. This continuation will ensure that new information about DPP-related initiatives is recorded when such information becomes available. This process will be enabled via (4) open consultations using an online questionnaire that will be made available for public access on the CIRPASS website. This knowledge base will be a valuable resource for other work packages and tasks as the project progresses. Additionally, in Figure 5 we also explicitly acknowledge that there are documents and reports from other projects which identify DPP-related initiatives. Such reports may contain lists of DPP-related initiatives collected for other purposes but may still contain valuable information to further feed the CIRPASS knowledge base. Encouragement to provide additional information via the open online consultation process will come from either CIRPASS members actively reaching out to initiatives and encouraging them to fill-in the online questionnaire or via the CIRPASS dissemination process, whereby more parties become aware of the CIRPASS project and choose to proactively approach CIRPASS with further contributions to the CIRPASS DPP knowledge base.

Figure 6 provides further insights about the preliminary phases adopted in steps (1) and (2) for identifying an initial set of DPP-related initiatives. For further details on the task-force activities and the adopted procedures for identification and data gathering on DPP-related initiatives please refer to D2.1 of CIRPASS.

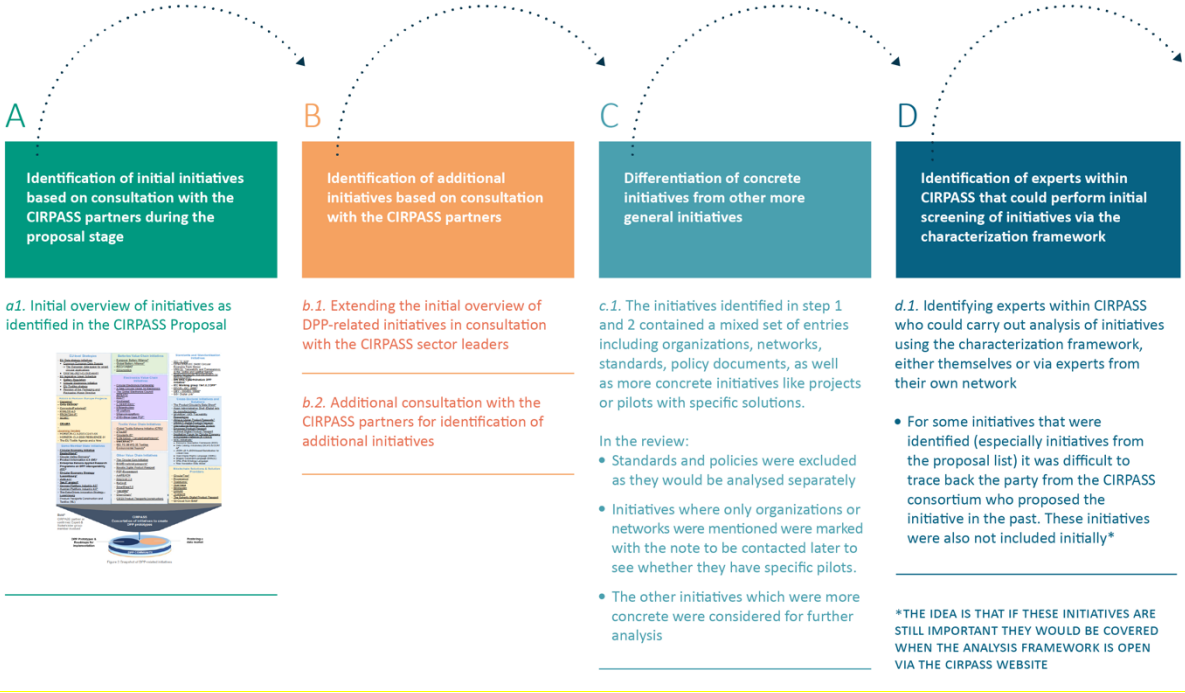


Figure 6 Way of working for identifying DPP-related initiatives within the reach of the CIRPASS network

2.3 Description of the classification framework: "Technical Design" section

In this section, the overall mapping framework synthetically presented in Section 2.1 at the basis of the adopted benchmarking methodology has been further detailed for the section concerning the "Technical Design" of the DPP-related initiatives. The rationale behind this reference classification framework, developed within WP3, is to further gather information on the solutions adopted by the existing DPP-related initiatives with respect to the four fundamental pillars characterizing the technical IT perspective of the DPP, briefly introduced in Section 1.1 of this deliverable. The whole reference classification framework, that enabled the analysis performed in the next sections, is reported in Table 1. An in-depth presentation of the individual classification pillars in proposed in the next sub-sections.

Table 1: Mapping of the DPP-related initiative

Reference classification framework for mapping DPP-related initiatives Technical Design section							
Product ID	**Type**	Instance			Category		
	Granularity	Model		Batch	Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized		Proprietary	Data ports	Others	
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling			Enforcement			Others
IT architecture: Data mgmt features	**Evidence**	Blockchain			Verifiable Credentials		Others
	Convenience	Wallet			Data Ports		Others
	Data protection	PETs			Anonymization		Others
	Traceability	Tagging (QR, NFC, RFID)					Others

2.3.1 Product identification (ID)

In today's globalised world, production chains are distributed internationally. Once produced, retail also has complex structures to bring the tangible goods to consumers. Just to give an example, unique identifiers integrated in machine-readable data carriers, like barcodes, are in wide use since 1974 to identify goods and help logistics to trace products until they are finally checked out by the consumer.[3,4] In the classification framework, a deliberate choice was made not to ask for a specific technology, but to gather responses on the characteristics of those identifiers.

Many industries have their own identification scheme and, typically, the product identifier itself can carry a lot of semantics that make assertions about the product. Some systems, like OEM numbers in the automotive industry, have a granularity that only goes down to the model level. For various production-related reasons, other systems have special numbers for the goods produced within one batch. And finally, the identification can go down to the actual instantiation of a certain model to identify an actually produced single item of that model. Some systems have the flexibility to simultaneously identify a hierarchical granularity, for example identifying the model, the batch and the instance (and more) with one number. The questionnaire was designed to identify some semantics to avoid later contradictions with the DPP. As the semantics of those identifiers will most probably be additionally reproduced in the DPP, the question of how identifiers expressed semantics was not explored.

Today, a product is often wrapped and a Barcode, QR-code, Bluetooth tag or RFID tag is put onto the packaging or otherwise attached to the good. In other industries, identifiers are etched onto the product. Sometimes, goods carry multiple numbers. For example, OEM identifiers are used for spare parts in automotive industry. Thus, a certain spare part, produced by a supplier and delivered to several OEM's or car manufacturers can now carry more than one OEM Number plus a serial number (on the part) from the supplier who produced it.

Identification schemes based on product identification simplify talking ***about*** a given product with a given level of granularity, which in turn simplifies reasoning about the product. The benchmarking effort was done to discover the level of granularity of identifiers used in current DPP-related initiatives. From a circular economy viewpoint, the information needed may vary depending on whether a good can be reused and/or repaired or not. If so, the identification needs to be on the single item level in order to enable the recording of information about eventual repairs and changed parts. To only determine the composition of materials and certain other properties, an identification on the level of product model, variant, batch or lot is probably sufficient. It was therefore of high interest for the evaluation how many initiatives approach identification based on product categories, whether they work with instances of goods or if their approach can accommodate several levels of granularity. This question was organized in a hierarchical way to only ask for the granularity of categories if categories were used. Due to the importance of the question, it was asked twice, using different words to target different developer communities. Thus 'Type = Instance' is equivalent to 'Granularity = Single Item'.

[3] For example, the ISO/IEC standards 15459 and 154183 are used to identify goods and to trace them within retail chains. An example solution based on these standards is the Global Trade Identification Number (GTIN).

[4] Another approach to product identification is based on the international standards of IEC 61406-series which uniquely identify products using a unique identification URL. In addition, the 61406 standards may, but do not necessarily, encode globally unique identifiers as defined by ISO/IEC 15459. However, there is no consensus as to whether an IEC 61406-series identifier identifies a product or an entry in a database about the product.

2.3.2 Product Data Carrier

The notion of product data carrier refers both to the way the product ID is put on or attached to the product and secondly, to means for making this ID machine readable to enable automatic identification. For open and interoperable systems, standardised data carriers and agreed data carrier encoding syntaxes are necessary.

Given the above centralisation of the information model around the Product ID, it becomes clear that the relationship between the good and its informational representation is of the utmost importance. And if this relationship is pertained by the identifier given to a certain product or category of products, it is also clear that once the tangible good does not carry its Product ID anymore, the link between a given product and informational representation is lost. In this case, a recycling effort will, for example, have to use optical characteristics and background information to detect a given category of products. But this information will get lost easily again. Today we can observe that the higher the value of the goods, the more persistent the identifiers. A T-shirt has an identifier that can be detached once it is sold and leaves retail. A car has a persistent identifier called Vehicle Identification Number (VIN), and this VIN is attached to the car in ways that make it very difficult to remove it.

Current data carriers used in retail have some shortcomings. Product IDs are typically printed on the wrapping or on care labels that are often discarded or removed after sale, destroying the relation between the actual good and its Product ID. Attempts to solve this problem are already underway and there are now various ways to attach a Product ID to a good. For example, live implementations of this have existed for 10 years using RFID technology. More recently, embedded solutions consisting of printing QR codes directly on garments are being proposed.[5] It is therefore very interesting how initiatives are trying to tackle this issue and which type of carrier they have chosen to carry the Product ID.

But some identifiers may not be machine readable. An OEM number printed on a piece of metal that itself is riveted onto the good is not trivially machine readable while it is easy to make an RFID call into an unsorted hive of things to discover what is in that hive, provided that all things in the hive carry an RFID tag. Machine readability by means commonly available to consumers, e.g. smartphones, is also an important issue.

It is crucial to know if the data carrier should be used for sorting during and after the use phase or not. Indeed, most data carriers used today are not robust enough to still be functional after a prolonged use phase (QR, RFID etc.). Another important aspect to consider is that the data carriers should be easily read to enable lean and potentially even automated sorting processes. However, several data carriers and solutions have been developed in recent years who are able to sustain the use phase and support efficient sorting processes. However, the question of data carrier persistence was not explicitly addressed in the analysis.

The decision to use certain data carriers will depend highly on the economics of the business case, but can also imposed by legislation (ex. pharmaceuticals) or imposed by the market (e.g., retailer mandates). The delegated acts will play an important role here.

[5] Examples: https://www.decathlon-united.media/media/decathlon-united-rfid-en & https://embelex.averydennison.com/p/2

2.3.3 Digital Connector, ID Issuing and Data Storage

As there are many ways to link (i.e., resolve) a product or product category to the information about that product or category, the question related to the digital connector resolver was "Does the ID link directly to information on the web or is there an intermediate resolver?"

Next, the comparison framework targets the issuing of product ID's and the centralised or decentralised nature of this mechanism. Under the concept of "ID minting", the evaluation wanted to determine who controls the creation of the identifiers that will build the product ID.

The issuing of the product ID can be centralised or decentralised. Centralisation is understood as the control over the creation of IDs by one actor rather than the independent creation of IDs by every actor in the system. In the course of the evaluation, we realised that every shade of grey was present. Centralized systems, like GS1 GTINs are, in reality, very decentralised. The reason is that GS1 delegates large parts of the numbering scheme to commercial entities participating in the system. But GS1 still controls the numbering as those participants are obliged to observe certain conditions and constraints that come with the delegation. Other IDs, like DIDs are, by design, totally decentralised as anybody can open their own page with identifiers. But questions of interoperability remain as the cryptographic methods for the verification of the ID are not yet fully standardised. Europe-wide traceability schemes such as the Tobacco Products Directive, have a two-level centralized approach. The authorities in the European member states issue product ID's, within a framework that was defined by the European authorities. Like for citizen IDs, product IDs also play a central role in the commercial "sovereignty" of commercial actors. Hence the importance of the debate surrounding centralisation or decentralisation.

While the topic of the issuing of product ID's is also a question of system coherence which might justify centralisation, the location of data storage is less a question of interoperability and more a question of sovereignty, data security and liability.[6] Indeed, data storage will play a big role in the business models attached to the creation of a DPP. The physical control over a central storage platform of all digital product passport information would provide huge commercial leverage. In the future, the legal environment of such a system as well as the economic networking effects will create enormous economic gravity around such a system. And this gravity can be used in monetization and other exploitation techniques. Additionally, a huge central system is a very lucrative target for hackers and needs enormous investments into IT security. This is known to affect the usability. However, a central system historically had and continues to have many advantages such as: its IT architecture is simple, it always has a perfect overview of its state, and it can be easily controlled by authorities. However, centralized systems are less scalable and can thus become chaotic and complex when an increasing number of applications and features are added. Additionally, centralized systems pose severe concerns with respect to competition law, as they are more susceptible to cyberattacks and industrial espionage i.e., tracking the requests allows to draw conclusions on produced specimen or types.

It was therefore interesting to see which projects opted for centralisation and who followed the more difficult path of decentralisation and resilience.

[6] Ilias Iakovidis, "Digital Product Passport- first ideas on HOW"
https://webgate.ec.europa.eu/TMSWebRestrict/resources/js/app/index.html#/library/detail/82455

2.3.4 The IT Architecture

The purpose of a DPP is to contribute to the building of a circular economy. The vision of CIRPASS is to make the right information at the right time at the right location available to the right stakeholder in order to increase the circularity of goods significantly. This in turn requires that an architecture must be as inclusive as possible in order to facilitate the inter-connection of legacy data systems. Information must be easy to access, transport and be used in a high variety of situations. The DPP initiatives analysis framework focused on decisive aspects in this respect.

Data is normally transported using a transmission protocol that carries payload information. One of the most widespread protocols used is Transport Layer Security version 1.3 according to RFC 8446 that underlies most data exchanges on the web. This is a standardised protocol. However, many projects also use a proprietary exchange protocol to convey information about the good's properties. It was important to evaluate to what extent current initiatives are already using standardised protocols. This was the objective of the "openness level" question.

As discussed previously, the DPP data could potentially be stored in a centralised cloud service. If this were the case, normally this cloud service will make an API (Application Programming Interface) accessible to participants of its service allowing those participants to upload and download information, but also undertake data processing within this cloud service. However, an API may be standardised, but it may also be proprietary. In the latter case, the API is controlled by the entity controlling the cloud service and can change anytime, even to exclude certain participants. The advantage of using an API is that it allows the central cloud service to set policies, to control data processing and to execute tasks. However, in order to mix one's own information with third party information, the organization uploading and merging its own data into the data from the cloud structure will need to fully trust that cloud structure, which is not always the case. A way around this dilemma is to integrate the usage constraints with the data (as data annotations) as exemplified by the Special Project[7] e.g., for data protection issues. In this case, instead of accessing a cloud service via an API, data is exchanged but contains usage limitations. Compliance with the usage limitations is then a question of the contractual relations between parties exchanging data. Hence the question about "data packaging" which refers to whether a given system uses an API or is rather centred around the exchange of data outside of a cloud infrastructure. However, this is distinct from the question of whether an architecture is centralised or distributed. Federations of services, which are hybrid architectures, can use API's to request information on a given service but not actually exchange the entire data package.

Product information is often very valuable. Sometimes, information on tangible goods and their composition can reveal trade secrets. The question of who can access that information and to what extent becomes crucial in commercial exchanges and trust relations. For example, a recycling system facing the high variety of the European single market will also need a sophisticated system to control access to potentially very sensitive information. Advanced research in the last decade has shown that the use of roles and attributes in access control helps to create such sophisticated systems and allows to reflect the societal variety. Hence the question about "Access control level" used by existing initiatives to understand how far they have already advanced in this area. The first question distinguished between simple access control and advanced access control to find out how many systems are only using simple access control policies, e.g. to let people access all information once

[7] https://specialprivacy.ercim.eu/

they have a username and a password. The second question concentrates on the different known advanced access control systems. They can be overlapping. One way to handle advanced access control is that a user has a number of attributes. Only if the appropriate attribute can be shown to the system, access to the information will be given. Those can be credentials and other attributes. The role-based access control defines roles of people or entities in a system. The person or system wanting to access information has to provide proof that they have that role in the system. This is semantically more sophisticated and difficult, but is closer to the normal human organization of work and workflows. The benchmarking allows to find out whether the initiatives under development address difficult access situation and if they do so, how those are addressed.

However, access control alone is not sufficient. Once a player has received access, they may not use the data as intended. This is normally considered in framework contracts between players. Dataspaces with fixed rules are an option here, but if a system is supposed to support actors coming together without needing long negotiations between lawyers, these rules must be machine readable which is not always the case. The concept of data use limitation comes initially from the Digital Rights Management area. Within this, we can distinguish two streams: (1) the rights labelling and (2) the rights management enforcement. Rights labelling expresses permissions, constraints and obligations attached to the processing of the data related to a certain product ID. Labelling is crucial for actors to understand what they can do with the data. The rights enforcement comes rather from the media industry and plays a minor role in general data processing. Here, the system only lets people process data in certain ways and tries to secure those limitations with cryptographic means. It was, nevertheless, worthwhile asking whether DPP-related projects are investing in cryptographic processing limitations. It is expected that the rights labelling approach will be significantly more important in survey results as it provides the necessary hooks for algorithms to process data in compliant ways automatically. This is crucial in high volume systems such as the DPP.

As data management and usage are critical, it is worthwhile asking what data management and protection features are implemented by the surveyed initiatives. How is evidence secured relative to the provided information to allow for later accounting and equity? Are there additional features that make the use of such a system more convenient? Do DPP-related initiatives take into account data protection and what tooling do they provide to sanitize or protect data?

2.4 Tools for collecting data from DPP-related initiatives

The tools used for collecting data from DPP-related initiatives are described extensively in CIRPASS report “D2.1 Mapping of legal and voluntary requirements and Screening of emerging DPP-related pilots”. These consist in an excel tool and an online questionnaire tool, both implementing the classification framework.

In addition to the use of these two tools, using the answers provided, Word formatted tables were prepared and sent individually for **verification** and **completeness** to the owners of the initiatives. This step allowed to gather clarifications and further improve the quality of the results gathered. These results are provided in section 3.1 below.

3. Examples of a subset of relevant DPP-oriented reference architectures

In this section, an extended view of a subset of mapped DPP-initiatives is provided. These initiatives were selected from the list of responses to the online questionnaire tool because they fulfilled the following objective WP-dependent criterion (Step E), of relevance for WP3:

> WP3 dependent criterion: provide extended view of DPP-related initiatives that provided at least one entry in the *IT Architecture* area of the classification framework.

As a consequence, all the initiatives that did not fulfil this criterion were considered in the detailed analysis of the mapped initiatives reported in Section 4 but were not dedicated a specific highlight in section 3.1. In the following paragraph, we provide detailed highlights of the 32 initiatives fulfilling the WP-dependent criterion, and whose response to our online questionnaire was received before December 13, 2022.

3.1 List of the DPP-related initiatives

For each of the mapped DPP-related initiatives fulfilling the WP-dependent criterion, a specific Word table template was created and distributed to the contact person of the specific initiative in order to gather additional information on the objective, scope, sector(s) of application and technical implementation features of the initiative. The descriptive text received was not edited except when exceeding the character limit. Comments provided by the authors were included in footnotes if the comment clarified an "others" element. The list of the 32 ongoing initiatives at European level fulfilling the WP-dependent criterion is reported in Table 2.

Table 2 List of focus initiatives

ID	Initiative short name	ID	Initiative short name
1	atma.io	17	itmatters
2	BP	18	Peppol
3	Wordline B-TraaS	19	QI-Digital
4	CircThread	20	RCS BP
5	circular.fashion	21	RR
6	CYCLANCE	22	Worldline TCS
7	DDCC	23	TextileGenesis
8	DIBICHAIN	24	Tings
9	DigiPrime	25	Tokenized Distributed Ledger
10	DNV	26	Toxnot
11	EasyBat	27	Worldline TPD
12	EON	28	TRACE
13	EPEAT Ecolabrl	29	TRICK
14	eReuseDPP RR	30	TrusTrace
15	FEDeRATED	31	Vine
16	GTS	32	ZVEI DPP4.0

3.1.1 atma.io

atma.io						
End to end traceability platform.						
Mapping with respect to the reference framework						
Product ID	**Type**	Instance		Category		
	Granularity	Model	Batch	Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes		No		
	Resolver	Yes		No		
Digital connector	**ID minting**	Centralized		Decentralized		
	Data storage location	Centralized		Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others	
	Data packaging	Data transfer		API		
IT architecture: Access control	**Level**	Simple		Advanced		
	If advanced	Attribute based		Role based		
IT architecture: Data use	Labeling	Enforcement		Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others		
	Convenience	Wallet	Data Ports	Others		
	Data protection	PETs	Anonymization	Others		
	Traceability	Tagging (QR, NFC, RFID)		Others		
Unique technical aspects						
atma.io is built on a state-of-the-art microservices based architecture that follows domain-driven-design principles. This architecture and design split the overall functionalities into loosely coupled services that can be developed, operated, and scaled independently. We are following a polyglot approach for the individual microservices which means that we are employing different technologies that are best suited for the specific domain of the individual services (both, from a persistence layer and programming language perspective). For highly scalable inter-service communication, we utilise asynchronous messaging technologies and a variety of design patterns						

to enable both horizontal and vertical scalability. atma.io provides REST-ful APIs for data exchange with external systems and applications. Our standard APIs are GS1 EPCIS compatible to facilitate an easy data exchange with other systems. In addition, we have a standardised way to integrate with Blockchain and Distributed Ledger. Our platform features state-of-the art data security and is designed from ground up to be highly interoperable, and optionally offers a fully redundant set-up.

Maturity level and application sectors

The solution is used by 6 of the 20 biggest fashion brands and traces ca. 23 billion unique items. There are other sectors that utilise our solutions, i.e. food, pharmaceuticals, beauty, packaging, logistics and automotive. We are continuously enhancing our services, enabled by quantitative feedback from the process implementation, piloting and scaling up existing solutions. The atma.io platform provides a range of configuration options, ranging from enabling specific features and modules over use-case specific configurations down to data schemas. We implemented role-based access control for authorisation. User accounts can be created with different access rights and privileges. For both the product-level and the item-level, atma.io uses a flexible schema, allowing additional fields to be captured and managed. atma.io is designed and built for processing data at very large scale and throughput. For example, our Serialization API in the standard configuration provides the ability to process 300 requests per second with a payload size of up to 1000 identifiers per request. We enable consumers to interact with products directly via targeted, contextual and personalized experiences (resolver).

3.1.2 BP

Battery Pass (BP)

The Battery Pass Project is developing cross-industry content and technical guidelines for a digital battery passport according to EU Battery Regulation requirements and to demonstrate them in a pilot project.

Mapping with respect to the reference framework

Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer			API		

IT architecture: Access control	**Level**	Simple		Advanced
	If advanced	Attribute based		Role based
IT architecture: Data use	Labelling	Enforcement		Others
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others
	Convenience	Wallet	Data Ports	Others
	Data protection	PETs	Anonymization	Others
	Traceability	Tagging (QR)		Others

Unique technical aspects

We consider the following technical aspects GAIA-X, NGSI-LD, SSI, comprehensive modular Standard Stack considering value chain, data processing and governance.

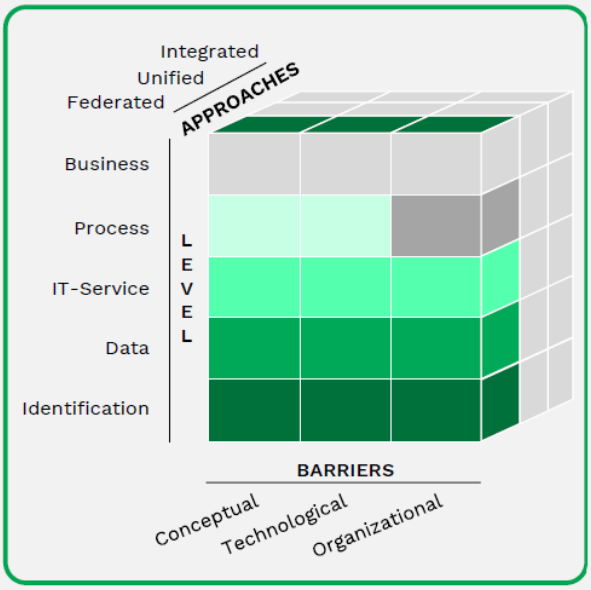
Maturity level and application sectors

Initially, the Battery Pass Project is scoping the automotive industry. But as discussed with stakeholders, most of the standard stack elements could be used for other products and sectors (e.g. GAIA-X specifications). The modularity of the standard stack architecture enables the exchange of sector specific aspects by not changing the entire architecture. As we are aiming to use existing standards for applying most adopted and mature standards.

Enterprise Interoperability Framework (ISO 11354)[1]

Level:

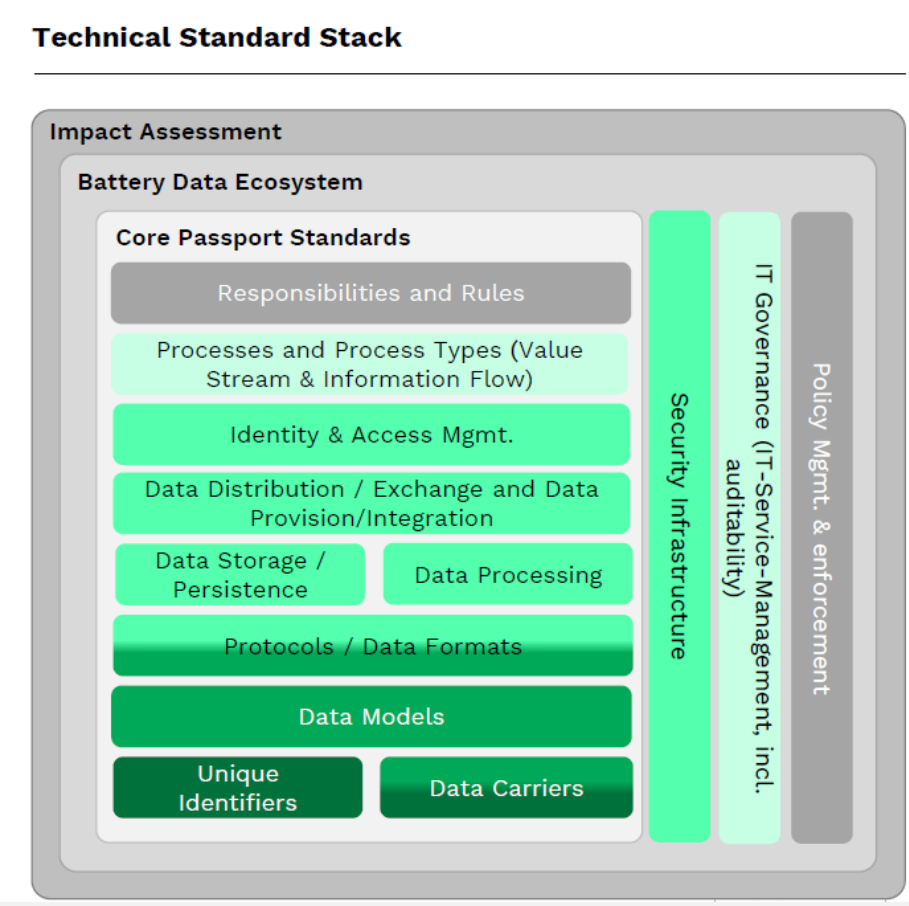
- Business: harmonisation at the level of organization (i.e., methods of work, legislations, culture, ...)
- Process: how to connect internal processes of two companies to create a common one
- IT-Service: Identifying and composing independently designed and developed IT-Services
- Data: interoperability of data to find and share information (i.e., different data models) from heterogeneous bases
- Identification: Unique identification of products, organisations and people along the value chain



Barriers:

- Conceptual barriers: syntactic and semantic differences of information to be exchanged
- Technological barriers: incompatibility of IT to present, store, exchange, process and communicate data
- Organisational barriers: They relate to the definition of responsibility (who is responsible for what?) and authority (who is authorised to do what?)

1) Source: https://www.researchgate.net/publication/220921500_Enterprise_Interoperability_Framework



3.1.3 Worldline B-Traas

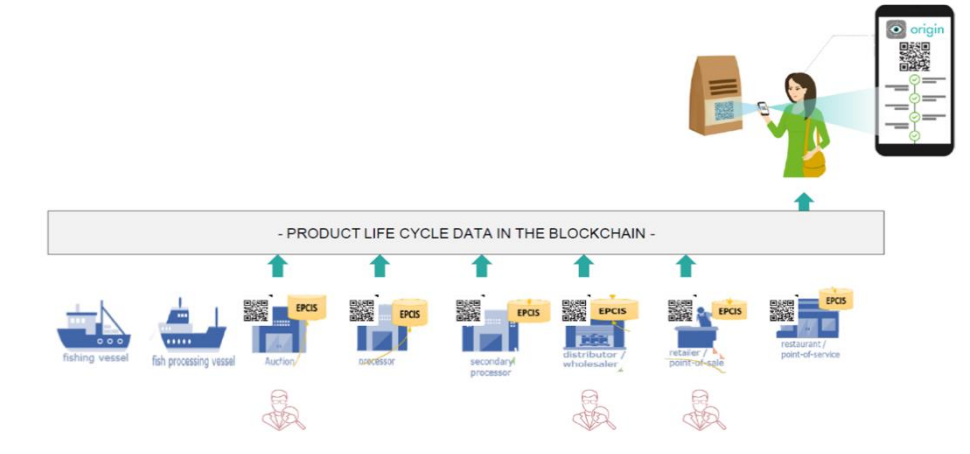
Blockchain Trace (B-TraaS)
B-TraaS for Blockchain Traceability as a Service is an open product to allow creation, management and operability of specific traceability chain related to a product value cycle where multiple actors would be involved. As an example, the solution could be used to trace the supply chain of Tuna fish from fishermen up to end consumer who acquire transformed tuna product in a shop. At each stage of the product life cycle, each actor will input information related to his operation to the traceability chain.

Mapping with respect to the reference framework								
Product ID	**Type**	Instance				Category		
	Granularity	Model		Batch		Prod. order		Single item
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other	
	Machine readable data carrier	Yes				No		
	Resolver	Yes				No		

Digital connector	**ID minting**		Centralized		Decentralized
	Data storage location		Centralized		Decentralized
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others
	Data packaging		Data transfer		API
IT architecture: Access control	**Level**		Simple		Advanced
	If advanced		Attribute based		Role based
IT architecture: Data use	Labelling		Enforcement		Others
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials		Others
	Convenience	Wallet	Data Ports		Others
	Data protection	PETs	Anonymization		Others
	Traceability	Tagging (QR, NFC, RFID)			Others

Unique technical aspects

B-TraaS has been designed in a way that enables the quick and easy creation of a traceability chain based on blockchain technology. Through a web interface, an economic operator would be able in a few clicks to define his traceability chain, input product characteristics to be traced, involve relevant stakeholders and finally generate their own private Blockchain. Through mobile apps or connecting production machines via standardised API, all actors involved would be able to exchange data via their own traceability blockchain.



Maturity level and application sectors

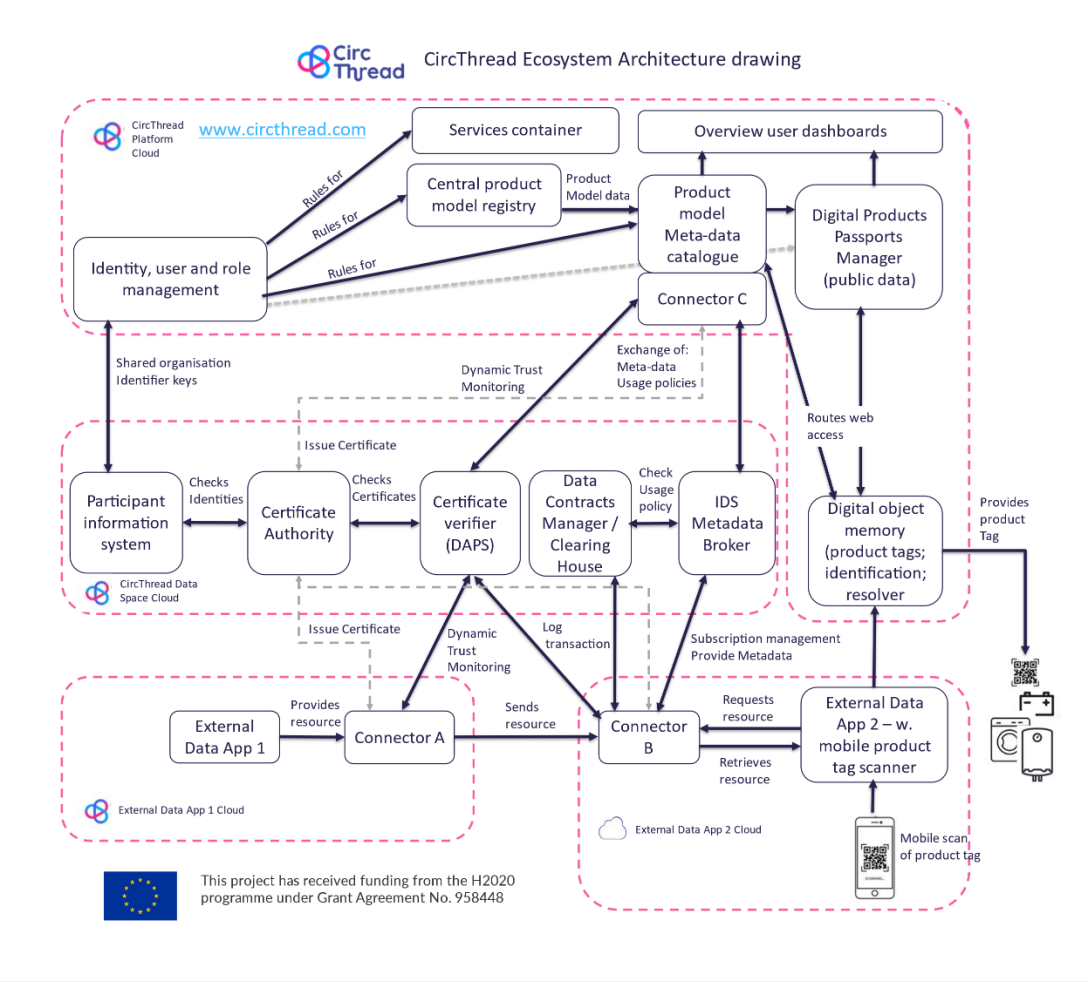
The solution has been used in its first version under the brand “Origin” from bureau Veritas. https://www.bureauveritas.fr/besoin/origin-la-solution-blockchain

3.1.4 CircThread

CircThread
CircThread is a H2020 EU-funded project (2021 – 2025) with the objective to unlock access to product data for circular economy purposes. The main target is to facilitate information flow exchanges across the extended product life cycle from the product as manufactured to retailers, consumers, repairers, collectors, pre-treatment operators and recyclers, as a Circular Digital Thread using Digital Product Passports. The information can vary from data consisting of product characteristics, product components, their materials and chemicals data, and related circularity, environmental, social, and economic information. This data will be captured, linked, and shared on a cloud-based, collaborative ecosystem with a software platform and a linked circular data space with a core set of open-source modules, to allow all actors throughout the product life cycle to share the necessary information. To ensure that more materials and products stay in the economic loop, benefitting the sustainability of the economy and the environment and reducing carbon emissions.

Mapping with respect to the reference framework							
Product ID	**Type**	Instance		Category			
	Granularity	Model	Batch	Prod. order	Single item		
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes		No			
	Resolver	Yes		No			
Digital connector	**ID minting**	Centralized		Decentralized			
	Data storage location	Centralized		Decentralized			
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others		
	Data packaging	Data transfer		API			
IT architecture: Access control	**Level**	Simple		Advanced			
	If advanced	Attribute based		Role based			
IT architecture: Data use	Labelling	Enforcement		Others			
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others			
	Convenience	Wallet	Data Ports	Others			
	Data protection	PETs	Anonymization	Others			
	Traceability	Tagging (QR, NFC, RFID)		Others			

Unique technical aspects
The CircThread Ecosystem will enable the following: • The registration and validation of organisations and their users based on their roles across the life cycle of products. • The central registration of product models, which form the basis of a model in a company's line of devices or appliances. • The generation of Digital Product Passports for individual products under a product model. Based on a linkage between the product model, the product serial number that allows individual identification of a product, a QR code for the digital-physical linkage with resolver to the digital product information. • The generation of product meta-data catalogues at the product model level to enable a registry of potentially available information for exchange at decentralized databases from the data provider. • The exchange of documents referenced in a product meta-data catalogue based on the International Data Spaces reference model and associated IT infrastructure. • The decentralized linking of software services to the data space, also referred to as external data apps, which can connect to the information exchange system, so as to process product information.
Maturity level and application sectors
Pilots: batteries; boilers; solar photovoltaic glass; washing machines; dishwashers. Services: 14 product life cycle information exchange and management services at TRL 4 to 5 at start of the project. Platform: first prototype under development Dataspace: first prototype under development using IDSA test-bed & Fraunhofer connector.



CircThread IT architecture diagram: www.circthread.com

T5.1 report – CircThread architecture overview and schematics: https://circthread.com/download/deliverable-5-1-architecture-overview-and-schematics/

3.1.5 circular.fashion

circular.fashion
circular.fashion is a sustainable change agency creating software and system innovation for a circular economy in fashion and textiles. Their DPP initiative, the circularity.ID® is a digital platform containing product transparency information, along with essential material data, to enable a holistic circular system. The objectives are to provide data to facilitate circular business models such as resale, rental and recycling at end-of-life and meanwhile increasing transparency of sustainability efforts and empowering customers. The system is built on the circularity.ID® Open Data Standard which has been developed to power circular practices and ensure longevity and recyclability, taking into account insights and requirements for making a product circular from material to design, use and sorting. Data stored in the system can be reached using circularity.ID® data carriers that are attached to the garments and contain a URL for consumers and a machine-readable identifier.
Mapping with respect to the reference framework

Product ID	**Type**	Instance		Category		
	Granularity	Model	Batch	Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes		No		
	Resolver	Yes		No		
Digital connector	**ID minting**	Centralized		Decentralized[8]		
	Data storage location	Centralized		Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others	
	Data packaging	Data transfer		API		
IT architecture: Access control	**Level**	Simple		Advanced		
	If advanced	Attribute based		Role based		
IT architecture: Data use	Labelling	Enforcement		Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others		
	Convenience	Wallet	Data Ports	Others		
	Data protection	PETs	Anonymization	Others		
	Traceability	Tagging (QR, NFC, RFID)		Others		

Unique technical aspects

- Interface for augmented sorting stations.
- Data carriers selected based on on-site tests with sorting facilities.
- circularity.ID Open Data Standard based on extensive research with recyclers, sorters, re-commerce/retailers, repair organisations and producers.
- Data standard is used or intended to be used from five other platforms.
- It allows machine-readable data exchange via API between different systems and stakeholders.
- Platform is built to work with various product identifiers such as GTIN and organisation/location identifiers such as OAR, GLN.

Maturity level and application sectors

[8] The issuing of IDs can be decentralized or centralized, based on user preference.

The circularity.ID system has been in use with several fashion brands since 2019. The circularity.ID Open Data Standard has been constantly further developed. In 2023 version 4.0 will be launched. Currently, the standard and the circularity.ID system is built for apparel. It could be easily expanded to cover other similar product types. Several textile sorting companies are already equipped with sorting stations to work with the data from a circularity.ID. The sorting stations can be easily expanded to other product passports once they are standardised.

https://circular.fashion/en/

https://circularity.id

https://circularity.id/open-data-standard.html

3.1.6 Cyclance

CYCLANCE							
Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model		Batch	Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer			API		
	Level	Simple			Advanced		

IT architecture: Access control	**If advanced**	Attribute based	Role based	
IT architecture: Data use	Labelling	Enforcement	Others	
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others
	Convenience	Wallet	Data Ports	Others
	Data protection	PETs	Anonymization	Others
	Traceability	Tagging (QR, NFC, RFID)	Others	

Unique technical aspects

The EECC DPP's uses GS1 Standards (EPCIS with EECC's EPCIS "EPCAT", Digital Link, Resolver,…)

Maturity level and application sectors

Application Sectors:

Fresh Food, Textile, Plastic Packaging, Electronics Industry, and Battery

- Packaging: DPPs are ready for Packaging at R-Cycle where we won the sustainability award https://packagingeurope.com/news/winners-of-the-sustainability-awards-2022-announced/8680.article, we use all relevant plastic producing parameters focusing on Recyclability.
- Battery: DPP demonstrator is ready using producing events for producing battery anodes within a Fraunhofer Initiative, focusing on CO2 and water footprint.
- Textile: DPP will be demonstrable with the consent of C&A with original 100Mio+ events
- Food: DPP adoption out of METROs PIER (ProTrace Inhouse EPCIS Repository powered by EPCAT), running for 7 years.
- Electro/Industry: DPP adoption demonstrator with real data for Schaeffler is ready.

3.1.7 DDCC

Digital Data Chain Consortium (DDCC)

The Digital Data Chain is a technology stack consisting of three solutions: (1) identification of objects based on IEC 61406-x – Identification Link, (2) digital manufacturer information, conform to VDI Guideline 2770 (to become IEC standard in 2023) and (3) information exchange platforms for the provisioning of object data and information along the supply chain and over the whole object lifecycle.

Mapping with respect to the reference framework

Product ID	**Type**	Instance			Category		
	Granularity	Model		Batch	Prod. order		Single item
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other

	Machine readable data carrier	Yes		No	
	Resolver	Yes		No	
Digital connector	**ID minting**	Centralized		Decentralized	
	Data storage location	Centralized		Decentralized	
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others
	Data packaging	Data transfer		API	
IT architecture: Access control	**Level**	Simple		Advanced	
	If advanced	Attribute based		Role based	
IT architecture: Data use	Labelling	Enforcement		Others	
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others	
	Convenience	Wallet	Data Ports	Others	
	Data protection	PETs	Anonymization	Others	
	Traceability	Tagging (QR, NFC, RFID)		Others	

Unique technical aspects

(1) The Digital Data Chain offers a full-fledged technology stack with comprehensive solutions for identification, intelligent product documentation (manuals, drawings, spare part lists, certificates) and platform solutions for the provisioning of the documentation and information between manufacturer, owner/operator and service provider. This solution has been developed by the industry for the industry. Compared to other solutions from the B2C sector, that only cover basic requirements like ID and basic technical attributes, the Digital Data Chain covers all requirements of the producing industries, especially authority or legal/statutory documentation requirements.

(2) To preserve and ensure the competitiveness of European manufacturers the technical solutions used for the DPP must be 100% cost free and open source. Otherwise, the European manufacturer will have to pay more for imported intermediate and preliminary products compared to non-European competitors and therefore loose competitiveness. If payable technologies were chosen for the DPP this would cause significant economic damages for European manufacturers. Compared to other solutions like EPCIS/Oliot the AutoID solution and the intelligent documentation solution of the DDC are 100% cost free. There is no protected IP, hidden costs or paid prerequisites to use the solutions of the DDC.

Maturity level and application sectors

The Digital Data Chain started as B2B solution for production hardware used in the chemical industry. It spread quickly to all sectors that use the same hardware for production such as pharmaceuticals, food & beverage, water & wastewater, infrastructure, oil & gas and power generation. Other industries like aeronautics, automotive and machinery are starting PoCs for

implementation. The Digital Data Chain is already implemented by global players like Siemens, BASF, Bayer, etc. but also SMEs. In total the DDC technology stack is implemented or under implementation at 500+ companies worldwide. The estimated worldwide market volume of goods provided with DDC technologies till 2030 is 10+ billion EUR.

- SAMSON Product Video: https://www.youtube.com/watch?v=YVDFUrAzvRY
- LESER Product Video: https://www.youtube.com/watch?v=jZk6XZSJlCg
- EMERSON Product Video: https://videos.emerson.com/detail/video/6232376213001/find-spare-parts-using-qr-codes
- DDC Consortium official website: https://www.digitaldatachain.com
- Press release concerning the collaboration between DDC Consortium and Industrial Digital Twin Association (IDTA) regarding the Digital Twin: https://digitaldatachain.com/portal/news

DDC at the ACHEMA 2022, the world leading fair for production hardware in the chemical and pharmaceutical industry. Exhibition of 20+ DDC conform products on the DDC fair stand from different manufacturers. In total 100+ manufacturers showed their DDC conform products on their company fair stands on the ACHEMA 2022.

3.1.8 DIBICHAIN

DIBICHAIN							
DIBICHAIN aims to map material and product life cycles using distributed ledger technology (DLT) to enhance circular economy.							
Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		

IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others
	Convenience	Wallet	Data Ports	Others
	Data protection	PETs	Anonymization	Others
	Traceability	Tagging (QR, NFC, RFID)	Others	

Unique technical aspects
Considers the concerns of companies exposing their full identity on the ledger.

Maturity level and application sectors
Maturity level: prototype level; Link: https://dibichain.com/ https://www.blockchainresearchlab.org/wp-content/uploads/2020/05/BRL-Working-Paper-No-18-DibiChain.pdf https://github.com/chainstep/dibichain-demo

3.1.9 DigiPrime

DigiPrime
Focuses on enabling cross-sectorial applications of circular products by (1) federated platform architecture (2) circularity-oriented services and (3) value-chain integration services.

Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others		
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		

IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others
	Convenience	Wallet	Data Ports	Others
	Data protection	PETs	Anonymization	Others
	Traceability	Tagging (QR, NFC, RFID)		Others

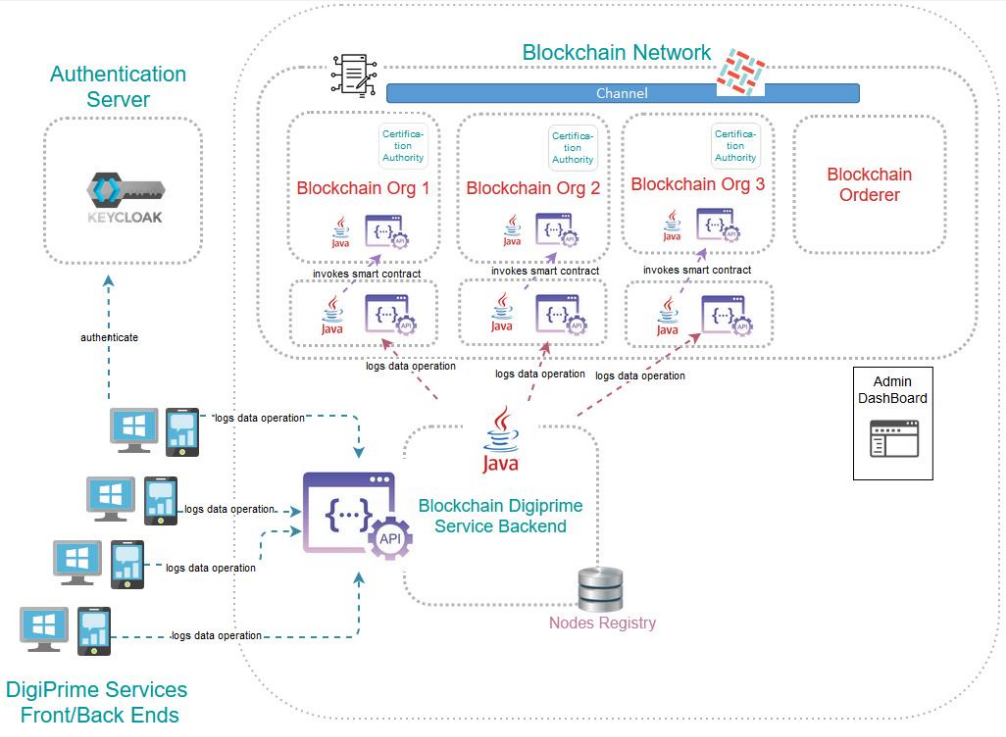
Unique technical aspects

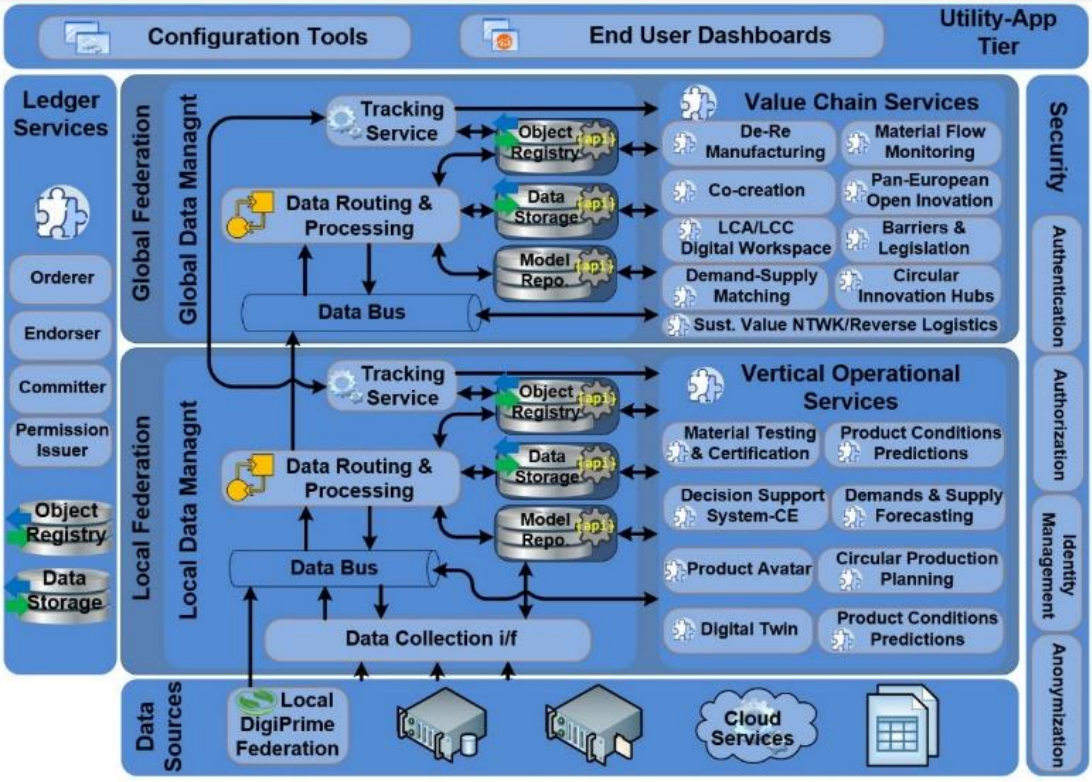
DigiPrime is a decentralized federated platform with general purpose data structures to allow maximum customizability and pluggability of services to allow processing and sharing of data across value-chains. Platform infrastructure acts as a container for business services and circular entities shared across the services that agreed to share the entities. Topics like the product management and the certification of a product are made by services, dedicated to a sector (like battery, automotive, etc.) or cross-sectorial. Some of services implement typical DPP features like product data provenance, traceability and anti-tampering proofs. Traceability of data inside the platform is implemented by using a blockchain technology and smart contracts. Key strength of the platform is the easy extensibility, allowing many kinds of services made by very different technologies to be installed in the platform and integrated with the platform polymorphic database.

Maturity level and application sectors

The platform infrastructure and the services have been validated in a live environment, by satisfying a set of use cases defined for the DigiPrime platform. Maturity is TRL8 for the infrastructure and the core platform services. DigiPrime Services maturity ranges from TRL5 to TRL9: integration of new services is ongoing, so to extend the existing functionalities to all the sectors. The main sectors of application are Battery, Automotive, Solar Power, Textile, Composites and Techno-Polymers.

https://www.digiprime.eu/





3.1.10 DNV

DNV Digital Product Passport							
DPP infrastructure based on proven industrial supply chain data collection solution with integrated data validation							
Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model		Batch	Prod. order		Single item
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports		Others
	Data packaging	Data transfer			API		
	Level	Simple			Advanced		

IT architecture: Access control	**If advanced**	Attribute based		Role based
IT architecture: Data use	Labelling	Enforcement		Others
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others
	Convenience	Wallet	Data Ports	Others
	Data protection	PETs	Anonymization	Others
	Traceability	Tagging (QR, NFC, RFID)		Others

Unique technical aspects

The key feature of the DNV product passport is twofold:

- First, DNV's decades of experience in the certification and assurance domain allows to define the data stack for the establishment of a green claim to be fully in line with specifications of scheme owners or regulators. This knowledge is crucial at the outset of the establishment of a DPP program to make it coherent and compliant. Part of this is also, a definition of where and how to source data from either existing legacy systems or to ingest data manually or semi-automatically with a robust verification mechanism to avoid accidental or intentional data tampering/misrepresentation.
- Second is the use of proven traceability, serialisation technology that enables all key features as foreseen by the EU DPP (e.g. proof of provenance, unique/batch/product line identification, full track and trace, attachment of additional datasets to product/batch/etc. – such as social/environmental audit data etc.

Maturity level and application sectors

The DNV DPP is based on industrially proven serialisation and traceability technology, currently in use in several large-scale deployments across various industries (e.g. food, apparel/textiles, industrial products)

DNV's knowledge and expertise for claim and process verification and assurance spans decades and 100k plus customers

3.1.11 EasyBat

EasyBat

To date, lifecycle asset management for batteries has been cumbersome at best. Before EasyBat, tracking battery assets was essentially non-existent. Currently, in Belgium, the registration of customer-owned assets, such as a home battery, requires a lot of information and burdensome paperwork collection.

EasyBat aims to greatly simplify that process. The solution focuses on the entire battery lifecycle by creating a digital passport which third-parties such as the manufacturer, installer, and/or DSO can verify. Such a DER Passport provides a shared state of the asset and its history to any pre-approved energy market participants. Original equipment manufacturers (OEMs), distributors, installers, and accredited inspection and certification organisations issue and verify every relevant asset transaction throughout a battery's lifecycle.

EasyBat heavily leverages the open-source EW-DOS technology stack, including EW Switchboard, a new interface for managing decentralised, self-sovereign identities, as well as their associated assets, roles, and permissions.

Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain		Verifiable Credentials		Others	
	Convenience	Wallet		Data Ports		Others	
	Data protection	PETs		Anonymization		Others	
	Traceability	Tagging (QR, NFC, RFID)			Others		

Unique technical aspects

EasyBat project is an asset lifecycle management project leveraging the use of Decentralised Identifiers (https://www.w3.org/TR/did-core/). Under this project, each battery has a unique DID and several stages in the life of a battery are recorded in the battery's DID serving as a digital passport.

Organisations themselves also have a role; these include:

- Governing Body: this could be a single or group of organisations. e.g. bebat. A single or group of organisation will have a Decentralized Identifier (DID).
- Asset: it is an eligible asset mentioned by governing body. e.g. battery, inverter, PV, EVSE, car. Each asset has a Decentralized Identifier.

- OEM: this could be an asset manufacturing company, producing finished products like Batteries. Each OEM will have a Decentralized Identifier(DID).
- Asset Installer: it is a certified professional or an organisation allowed to install assets (only qualified).
- Asset Verifier: a designated individual from an organisation to verify correctness of asset installation.
- Asset Owner/User: an individual or organisation owning or leasing the asset.

DLT technology is also used. More specifically, ERC 1056 and ERC 1155 standards have been utilized for this project.

- ERC 1056 can convert any externally owned Ethereum account to DID and support management of delegation and serviceEndPoints. It considers all valid Ethereum addresses as valid DID. A DID can have manages its own delegation and attributes. The implementation of ERC 1056 allows to maintain a registry of DIDs.
- ERC 1155 is a multi-standard token standard that include any combination of fungible, non-fungible tokens, or other configurations. The ERC 1155 approach can be extended to use a single ERC 1056 instance to create and manage proxy identities. This allows to:
    - update the owner of a DID without changing the DID uniform resource name (URN)
    - add/update metadata URI to the Proxy Identity (without the need of using serviceEndpoints)
    - add/remove recovery agents
    - add/remove delegates

Attributes per battery recorded in the digital passport include:

- Manufacturer: manufacturer of the battery [string]
- Model: model of the battery [string]
- Capacity: capacity of battery in kWh [float]
- Serial Number: serial number of the battery [string]
- Chemical Type: chemical type of the battery [string]
- Weight: weight of the battery in kg [float]

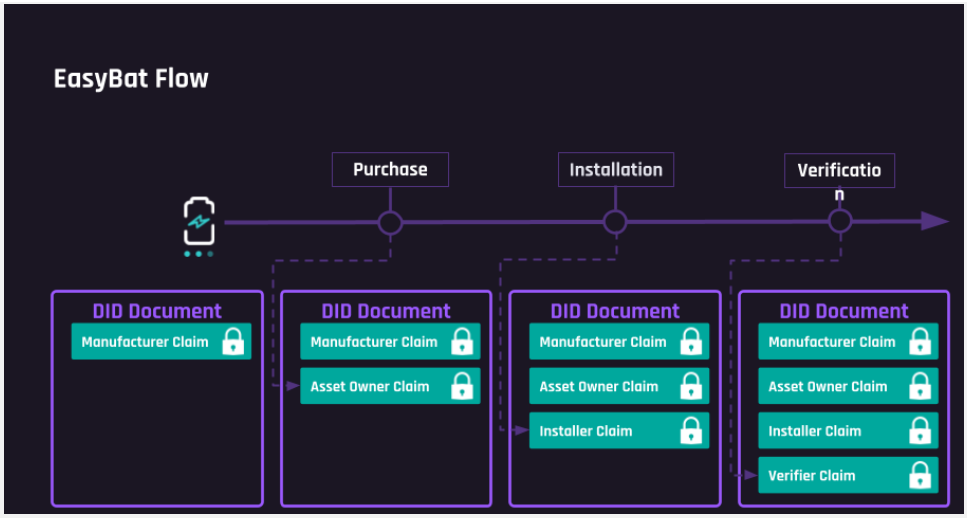
QR Code specification:

- Universally Unique Identifier (UUID) generated 128 bit QR code.

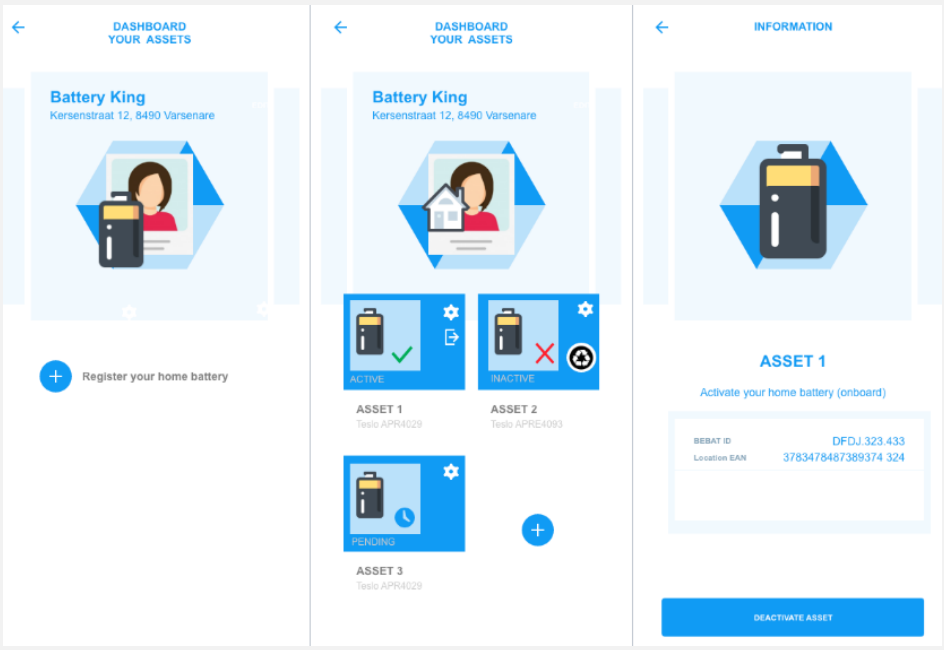
Maturity level and application sectors

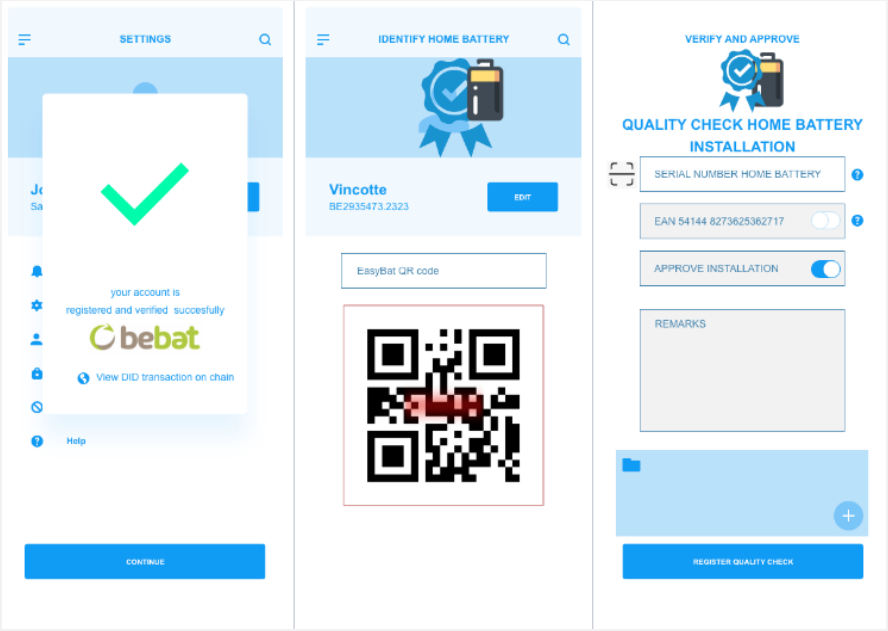
The EasyBat project is a Minimum Viable Product (MVP) that only focuses on the battery sector. A first beta release has been successfully tested and upcoming iterations are planned (still work in progress).

EasyBat DID flow:



Pictures of EasyBat wireframes:





Useful links:

https://easybat-dev.energyweb.org/
https://github.com/energywebfoundation
https://medium.com/energy-web-insights/bebat-launches-easybat-an-open-source-decentralized-solution-for-battery-lifecycle-management-281f2ace61e9
https://pers.fluvius.be/bebat-en-fluvius-lanceren-easybat-om-levensloop-batterijen-beter-op-te-volgen-via-blockchain.

3.1.12 EON

EON							
EON is retail's leading product digitisation platform. We connect physical products with a Digital ID to make them more traceable, interactive, and valuable.							
Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others		
	Data packaging	Data transfer			API		

IT architecture: Access control	**Level**	Simple		Advanced
	If advanced	Attribute based		Role based
IT architecture: Data use	Labeling	Enforcement		Others
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others
	Convenience	Wallet	Data Ports	Others
	Data protection	PETs	Anonymization	Others
	Traceability	Tagging (QR, NFC, RFID)		Others

Unique technical aspects

The Product Cloud is an extensible data-centric application that allows brands to frictionlessly ingest product and event data from disparate sources, transform, harmonise, and resolve the data to support interoperability. This data management and orchestration layer allows brands to track, report and analyse on all aspects of a products lifecycle. EON's Data Ingestion/Pipeline tool offers a low-code/no-code intuitive self-service UI and underlying services to orchestrate data movement along with offering data mapping, transformations and processing reporting. Specifically designed to handle complexity automatically.

- Supports ingesting data from diverse and multiple sources.
- Supports all major data stores and file formats
- Supports industry data standards just as EPCIS, Circular Data Protocol, etc along with brand defined data standards.
- Quickly analyse product data to determine compliance state based on brand defined policy scopes
- Data governance, performance, scalability, and security built-in.

Digital Link Resolver - Programmatic redirects with a robust rules engine. Certificate of Ownership - AI based rules engine along with optical character recognition and blockchain agnostic. Multi-layered brand protection approach which combines overt, covert, and digital authentication techniques. Exploration, Intelligence & Insights Lab. Traceability Manager. Customer Experience Studio. EON Exchange.

Maturity level and application sectors

EON powers product digitisation (Digital ID) for the largest global brands and retailers — with partners and clients like H&M, Chloe, Target, Mulberry, Kathmandu, Giorgio Armani, Brunello Cucinelli, Coach, Victoria Secrets and many more. We are an enterprise ready SaaS platform, with experience deploying Digital Product Passports across complex global organisations, and in many geographies. Our platform specialises in data sharing and data exchange between brands and resale and recycle partners, with some of the largest players in the world like Vestiaire Collective and Waste Management connecting in through the EON product digitisation platform.

References:

- Forbes: This Technology Will Have a Profound Effect on the Fashion Industry
- Vogue Business: Digital IDs — a game changer for fashion
- Vogue Business: Chloe moves ahead on commitment to give all products Digital ID
- EU Commission invites EON — learning from frontrunners, Digital Product Passports
- EON pioneers Circular Data Protocol with H&M, GS1, EU and more — foundation for Digital Product Passport legislation
- Business of Fashion: What Digital IDs can do for Fashion with Natasha Franck x Natalie Massenet
- Forbes: Could fashion's digital tag, EON, help fashion become circular?
- Forbes: Carbon Labels, Digital Passports And Traceability Tags – Clothing Labels' New Normal

3.1.13 EPEAT Ecolabel

EPEAT Ecolabel

EPEAT is a global Type 1 Ecolabel for electronic products, including ICT products and photovoltaic modules. It is used by purchasers world-wide to identify sustainable electronic products. EPEAT consists of 3 elements:

1) Lifecycle-based performance criteria for the product, supply chain and company in 4 areas – carbon/greenhouse gas reduction, circularity, chemicals of concern and corporate supply chain due diligence (social) performance;
2) 3rd party conformance assurance system; and
3) Public, searchable product registry (www.epeat.net) that identifies products awarded the EPEAT ecolabel.

Mapping with respect to the reference framework

Product ID	**Type**	Instance			Category		
	Granularity	Model		Batch	Prod. order		Single item
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized		Proprietary	Data ports		Others
	Data packaging	Data transfer			API		
IT architecture:	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		

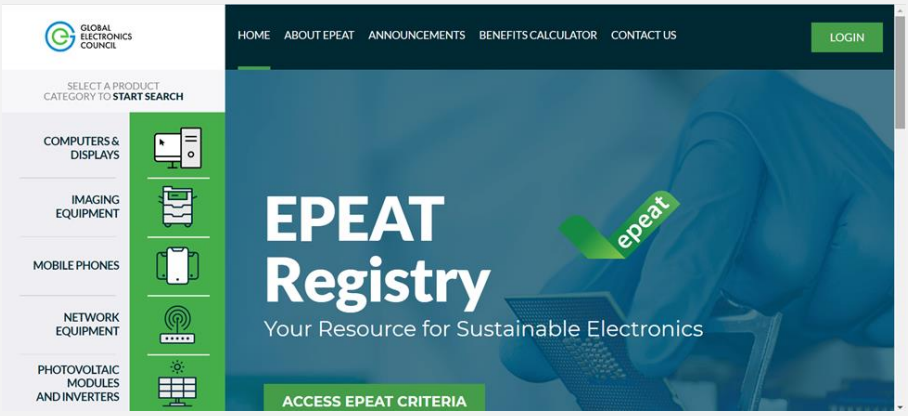
Access control				
IT architecture: Data use	Labelling	Enforcement	Others	
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others
	Convenience	Wallet	Data Ports	Others
	Data protection	PETs	Anonymization	Others
	Traceability	Tagging (QR, NFC, RFID)		Others

Maturity level and application sectors

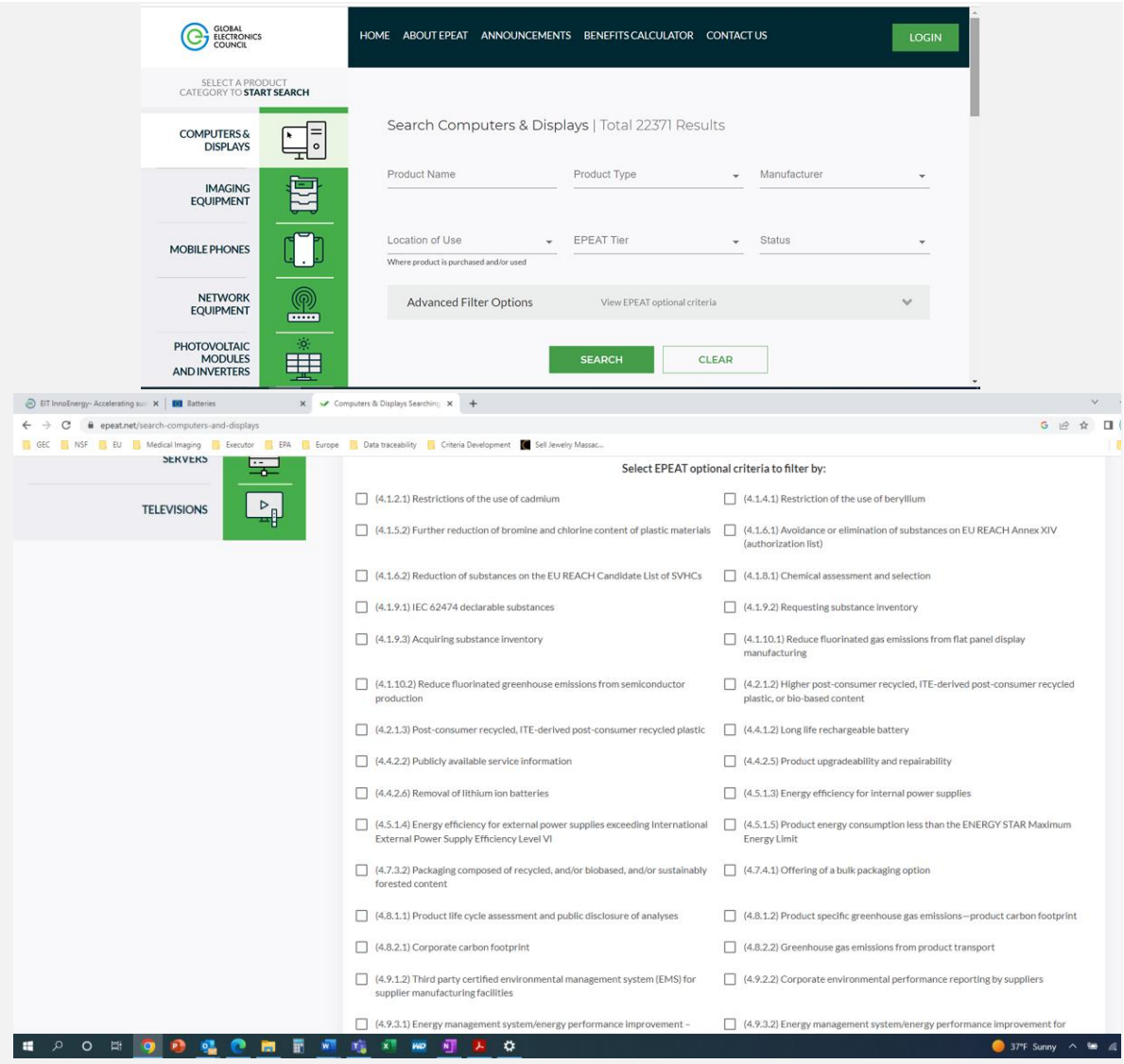
Electronics sector; applicable to finished products including computers, displays, imaging equipment, mobile phones, televisions, servers, network equipment & photovoltaic modules. EPEAT (www.epeat.net) was launched in 2006. Currently (Nov 2022), over 60 global and regional electronics brands participate and over 4000 unique products carry the EPEAT ecolabel. EPEAT has minimum criteria that must be met to be awarded EPEAT (bronze), products attain higher levels of recognition for meeting more aspirational, optional criteria (silver and gold).

The EPEAT platform has a "back end" that is accessible by password only. Manufacturers enter data for performance criteria. Independent Conformance Assurance Bodies (CABs) and EPEAT Program verify data entry and review evidence submitted by manufacturers. The public-facing registry allows users to identify products (by model) that meet EPEAT and download data in Excel format. EPEAT also provides API data feeds using unique product identifiers.

EPEAT provides a public searchable Registry at www.epeat.net. Products are organized by category as shown on left.



Registry can be searched by product name, type, manufacturer, country of use, and EPEAT Tier.



3.1.14 eReuseDPP

eReuseDPP/Usody							
A DPP architecture and pilot for the circular management of ICT devices in use.							
Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		

IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others
	Data packaging		Data transfer	API	
IT architecture: Access control	**Level**		Simple	Advanced	
	If advanced		Attribute based	Role based	
IT architecture: Data use	Labelling		Enforcement	Others	
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others	
	Convenience	Wallet	Data Ports	Others	
	Data protection	PETs	Anonymization	Others	
	Traceability	Tagging (QR, NFC, RFID)		Others	

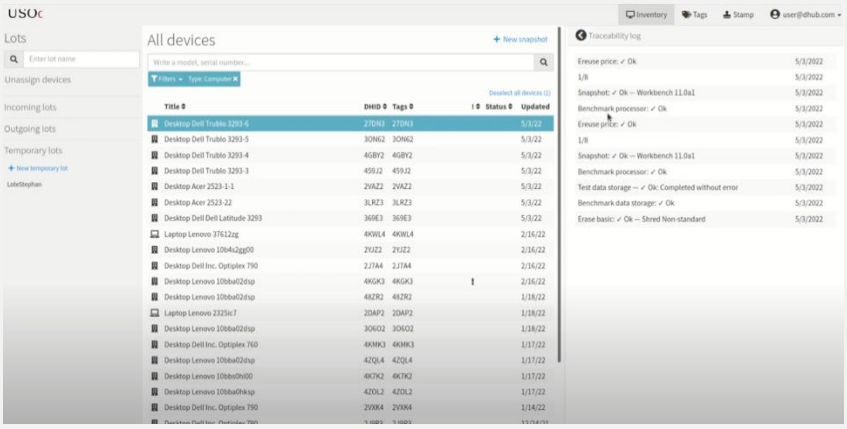
Unique technical aspects

The eReuseDPP system manages an inventory of digital device product details combined with a ledger of device lifecycle events. The ledger is recorded in a verifiable registry, equivalent to the function of a notary public, that offers transparency and accountability about the detailed data. The verifiable registry relies on an append-only distributed ledger, which can apply agreed on rules about procedures when a condition is met (smart contracts, inexorability). We have integrated it into DeviceHub, an open-source device inventory system that acts as a client and intermediary on behalf of human device owners that can record supporting digital details and content and generate and deliver digital product passports (JSON and HTML formats currently). The product and part details are retrieved using an open-source hardware inspection software that creates secure documents (snapshots).

Verifiable proofs and decentralised identifiers follow the W3C DID model. The verifiable registry is DLT agnostic and mapped into two backends: a permissioned Ethereum, and IOTA DLT.

Maturity level and application sectors

TRL 7 - System prototype demonstration in operational environment. The prototype manages about 20 thousand ICT devices, and generates simple DPPs for these products as they change hardware configuration during lifespan due to repair, refurbishment, usage, while recording proofs in a verifiable registry linking changes to documents (snapshots), timestamps and summaries.



3.1.15 FEDeRATED

CEF FEDeRATED Action (FEDeRATED)

FEDeRATED was an EU CEF project for digital co-operation in logistics which consists of 15 partners located in 6 EU Member States (Luxemburg, Italy, Finland, Netherlands, Spain, Sweden). However, the project is open to observer organizations that would like to contribute and join efforts to realize sustainable data sharing. The German Ministry of Transport and Digital infrastructure participates as an observer in the FEDeRATED projects. Within the context of testing data sharing opportunities on their feasibility business and public authorities are invited to participate in a multitude of national and cross-bordering pilots and living labs.

- Demonstrate how the federative platform as proposed by the EU Digital Transport and Logistics Forum (DTLF) can work.
- Identify the conditions (barriers and opportunities/benefits) that allow different stakeholders to make use of federated data sharing platforms.
- Facilitate seamless and cross bordering multimodal freight transport, cross bordering harmonized data interoperability, and data sharing between relevant actors.
- Enable paperless transport in all transport modes via concrete actions and large-scale collaboration.
- Support eGovernment, including a one-stop shop and only once reporting functionalities, and a corridor management information system approach.
- Develop a reference architecture for a sustainable data sharing environment.

Find more information at: http://www.federatedplatforms.eu/

Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain		Verifiable Credentials		Others	
	Convenience	Wallet		Data Ports		Others	
	Data protection	PETs		Anonymization		Others	
	Traceability	Tagging (QR, NFC, RFID)			Others		

Unique technical aspects

The vision is to go from a monolithic data sharing platform perspective towards a federated network of platforms. Enabling all supply chain operators to connect, operating their own IT systems or platforms. In contrast to the traditional platforms which only access data that is within the database of their system, the federated platform aims to leverage on decentralized architectures in order to access any data anywhere in the world. Moreover, the adoption of semantic web technologies for linked data (RDF) enables a better representation of data and powerful querying capabilities.

Maturity level and application sectors

The maturity level is akin to the TRL 6-7 level. This means that FEDeRATED is applied and developed in several prototypes and different sectors, but has no market ready product to offer.

The main purpose is the development of the foundations for a secure, open, and neutral data sharing infrastructure provision through practical Living Labs. The 15 FEDeRATED partners are executing 23 Living Labs/Pilots until the end of 2023. Living Labs are required to cover several modes of transport putting focus upon multi-modal concerns and events within (including a

section of) a transport corridor. The Living Labs address the value of enhanced transparency, data sharing with a focus beyond a single organization, and encourage data sharing and collaboration among multiple parties along the transport chain.

3.1.16 GTS

Global Textile Scheme (GTS)							
Developed by a cross sectoral industry initiative of material suppliers, brands, retailers and IT companies (ERP). The develop a unique end-to-end data exchange standard for textile value chains with "Mapping function" (current data worlds can remain the same).							
Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain		Verifiable Credentials		Others	
	Convenience	Wallet		Data Ports		Others	
	Data protection	PETs		Anonymization		Others	
	Traceability	Tagging (QR, NFC, RFID)				Others	
Unique technical aspects							
USP: Pulling data concept, like an online bank statement. Covering data from fiber to circularity. Technical implications: (1) catalogue with clear semantics and; (2) encoding each of the data in the							

catalogue for multilingual features. Today the system is based on article – colour – size (Stock Keeping Unit = GTIN) but could be extended to article – colour – size – production order - lot.

Per user only onetime translation/mapping process per product class, therefore reduced interface complexities.

Maturity level and application sectors
Maturity level: Complete for today's needs.

3.1.17 itMatters

ItMatters							
Cradle to Grave unique A&F ID traceability solution.							
Product ID	**Type**	Instance			Category		
	Granularity	Model		Batch	Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	NFC
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized		Proprietary	Data ports	Others	
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling		Enforcement		Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain		Verifiable Credentials		Others	
	Convenience	Wallet		Data Ports		Others	
	Data protection	PETs		Anonymization		Others	
	Traceability	Tagging (QR, NFC, RFID, GS1)			Others		
Unique technical aspects							

Itmatters digital cloud S.A.A.S Platform provides the following information to brands & manufacturers, End Customers and government administrations, as suggested by the chart below.

Knowing that adjustments or new regulations, would be permanently updated to comply with any local or governmental regulations.

ITMATTERS TECHNICAL SOLUTION:

A patented solution based on invisible molecular taggants with unique codes made of rare earths oxides, with both luminescent and coding capabilities. Unforgeable and not replicable, food contact approved. Taggants can be integrated directly into any materials (Cotton, any natural or synthetic fibres, polymers, papers, cardboard, metal…), printed on the surface with invisible inks, sprayed on some items or embedded into secure labels/documents.

3 different levels of identification, depending on the customer use cases:

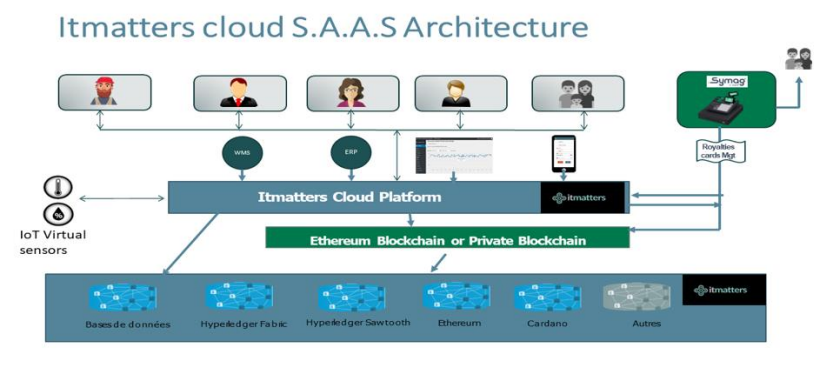
- Taggant detection under UVB light;
- Unique Optical signature recognition.
- with “PocketLab” technology.

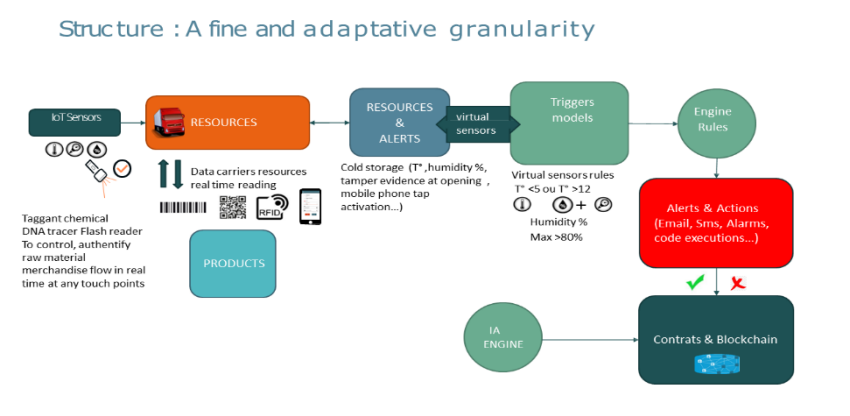
Real rime reading ID & recording in itmatters cloud platform including alerts. No need to hold inventory to perform laboratory test analysis! And in case necessary, lab analysis to detect the unique molecular composition, with a legal proof value.

A range of long lasting soft washable tag UHF or BI techno (UHF & NFC) embedded in any garments or apparels to fit any product which support our recycling automatised processing of raw material component composition sort out.

Please see all technical features related to Garments and shoes smart tag: https://1drv.ms/x/s!AuG5tIk70Dt7g84TL6Ho1YTgllvCFw?e=42rkPU

Any data carrier (UHF,RFID,NFC,GS1 digital Link,QR Code, Datamatrix, bluetooh, Lorawan, Sigfox..) connect with itmatters cloud platform. Itmatters platform have got Blockchain Ethereum and a private Blockchain, an AI tool, an impact calculator tool under the EU PEF method (product environmental footprint). A powerful architecture based on products and resources agnostic with any ERP, WMS or POS software.





Maturity level and application sectors

Itmatters is able to deploy our Cradle to Grave solution at full scale. Itmatters by Olnica Taggant chemical DNA Tracer is a patented technology already endorsed in various industries and offer a strong answer to the textile industry (cotton, wool, cashmere frauds) but also for any kind of raw material which is a powerful answer in the A&F and luxury sector.

We have all the tags ready including the washable 3 cm soft UHF tag and the 7 cm bi techno UHF& NFC tag to support large production over 1 billion (see the access link above).

We have a cloud platform build on two engines an IoT engine which records in real time any data carrier information from Cradle to Grave and a predictive engine (AI) device set: to alert, to anticipate and to take action regarding merchandise flow traceability. Finally, with our customised mobile phone application to keep each brand graphical universal, interacting with customers providing accurate information on each product, such as product authenticity, manufacturing location, % of recycled raw material used and anything to comply with the DPP CIRPASS Consortium.

Itmatters cloud platform is scalable upon the number of tags and companies integrated. It is hosted by world class datacentre companies with the highest level of PET's (cyber security, GDPR and California protection act - compliant).

Itmatters is Ellen Mc Arthur.Org , Textile Exchange.Org - Fédération française de l'économie circulaire, FFG membre. Our application sectors are the A&F retail, luxury houses, food industries but itmatters is suitable for any industry looking for a full traceability solution. Itmatters is today collaborating with key major A&F and luxury retailers.

3.1.18 Peppol

Peppol

Peppol is a global network based on open standards, where you can connect once and reach everybody in the network. The format is based on ISO standards and any kind of product related information can be exchanged using the Peppol network. Suppliers and manufacturers are already using this network to provide this kind of data. It is a mature organization with well-established governance (Peppol Interoperability Framework) including legal agreements, governance, and compliance measures, operating in more than 40 countries all over the world.

OpenPeppol, a non-profit international association established under Belgian law, was founded in 2012 as a follow-up to the PEPPOL Large Scale Pilot project (LSP) launched in 2008 and funded by the European Commission. The goal of the PEPPOL LSP was to enable frictionless trade between public and private bodies by developing Business Interoperability Specifications and standardising the exchange of business documents on an open and secure network.

Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain		Verifiable Credentials		Others	
	Convenience	Wallet		Data Ports		Others	
	Data protection	PETs		Anonymization		Others	
	Traceability	Tagging (QR, NFC, RFID)			Others		

Unique technical aspects

Peppol enables buyers and suppliers to exchange business documents and processes by using the Peppol network in compliance with the Peppol Interoperability Framework. Peppol provides a ready-to-use, scalable, both domestic and cross border, four-corner model, utilising a market of private sector service providers that are connected to sending and receiving organisations.

The Peppol Interoperability Framework provides the specifications and the governance for the exchange of data over the Peppol eDelivery network. Peppol is based on standards from OASIS and CEN and can enable traceability based on specific business requirements.

The Peppol network connects the platforms of service providers, but it is not a platform in itself. The Peppol network is created by hundreds of Peppol-certified Service Providers around the world. They securely distribute message content (business documents or any product information agreed) between buyers and suppliers, based on an open, four-corner model.

Maturity level and application sectors

Although originally conceived as a European project, Peppol is increasingly being used around the world, therefore the market scope is international with high penetration. The interoperability framework is just as relevant for trade between private businesses (B2B) as it is for trade between public and private sector bodies (B2G). The Peppol network can be used for any type of information as long as it is defined in a standardized way and agreed by the partners exchanging it. Peppol has information models and technical formats for product information used for product catalogues and ordering used in the supply chain exchange. Because Peppol is being used for business process interoperability such as product information exchange, eCatalogues, eOrdering, etc., it is being used in any type of organization (public or private). The Peppol initiative is cross-sector, as Peppol is the main network for exchanging data regarding electronic catalogues, electronic invoices and other supply chain documents in all sectors of the economy.

Useful link: https://peppol.org

3.1.19 QI-Digital

QI-Digital

QI-Digital is an initiative to improve the efficiency and effectiveness of Germany's quality infrastructure through digitalization. The initiative is a collaboration between the Federal institute for materials research and testing (BAM) and other main Germany's QI actors with support from the Federal Ministry of Economic Affairs and Climate Action (BMWK). The main components of the QI-Digital are a federated platform for secure and traceable data exchange between QI actors and digital assets such as digital product passports, smart standards, and digital certificates. By leveraging digital technologies and a corresponding legal framework, QI-Digital enables the rapid development and deployment of new QI processes and procedures. The resulting processes and procedures are transferable to different use cases, as demonstrated by the examples of additive manufacturing and H2 gas stations explored by BAM.

Mapping with respect to the reference framework

Product ID	**Type**	Instance			Category		
	Granularity	Model		Batch	Prod. order		Single item
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
	ID minting	Centralized			Decentralized		

Digital connector	**Data storage location**		Centralized		Decentralized	
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others	
	Data packaging		Data transfer		API	
IT architecture: Access control	**Level**		Simple		Advanced	
	If advanced		Attribute based		Role based	
IT architecture: Data use	Labelling		Enforcement		Others	
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others		
	Convenience	Wallet	Data Ports	Others		
	Data protection	PETs	Anonymization	Others		
	Traceability	Tagging (QR, NFC, RFID)		Others		

Unique technical aspects

A digital product passport based on assets administrative shells which is compatible with other QI digital assets such as Smart Standards and digital certificates.

QI-Digital offers a unique approach to embed the DPP in the complete chain of quality infrastructure. Hence it is an important element make the DPP as the starting point to transform the EU single market into the age of digitization – in in other words “EU single market 4.0”.

Maturity level and application sectors

Maturity is in the concept level and user stories collections and requirement analysis.
https://www.qi-digital.de/

3.1.20 RCS BP

RCS BP

RCS Battery Passport has clear data governance over a chain of custody system to issue the battery passport combining multiple threads of data from multiple data points. RCS BP incorporates different global users (public, regulator, commercial), to understand battery’s ESG footprint/origin, tracing solution for passport material, recycled content and GHG emissions.

Mapping with respect to the reference framework

Product ID	**Type**	Instance		Category			
	Granularity	Model	Batch	Prod. order	Single item		
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other

	Machine readable data carrier	Yes		No	
	Resolver	Yes		No	
Digital connector	**ID minting**	Centralized		Decentralized	
	Data storage location	Centralized		Decentralized	
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others
	Data packaging	Data transfer		API	
IT architecture: Access control	**Level**	Simple		Advanced	
	If advanced	Attribute based		Role based	
IT architecture: Data use	Labelling	Enforcement		Others	
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others	
	Convenience	Wallet	Data Ports	Others	
	Data protection	PETs	Anonymization	Others	
	Traceability	Tagging (QR, NFC, RFID)		Others	

Unique technical aspects

As the project is in the stage of proof of concept at the moment, the tech solution at the moment is prototype end-user website based on ReactJS and optimised towards mobile devices. In parallel we are working on backend and database architecture design, depending on learnings and validations of our assumptions based on user feedback, after interactions with created hands-on prototype. As we are considering integration with RCS VINE possible tech stack could be based on Elixir with PostgreSQL DB, hosted in the Cloud (AWS or other providers), but as the track and trace part may require using distributed ledger some of the blockchain technologies are also in consideration.

Maturity level and application sectors

Prototype website for user hands-on experience with UX optimized for mobile devices, initial high-level system design and possible architecture scenarios (advanced product sprint, just before MVP development stage).

PoC, Considering different options

3.1.21 RR

Reserve Resources (RR)						
SaaS from where textile recyclers can collaborate with fashion brands and textiles waste suppliers (manufacturers, post-consumer sorters) to access the waste in large aggregated volumes and by their required spec (fibre composition, fabric type, colour, right preparation, quality check), including help with best set up of the necessary supply chains. Brands and public sector can get market insight, aggregated data and trace verification of textile waste flows from source to recycling, do planning and matchmaking or policy development.						
Mapping with respect to the reference framework						
Product ID	**Type**	Instance			Category	
	Granularity	Model	Batch		Prod. order	Single item
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No	
	Resolver	Yes			No	
Digital connector	**ID minting**	Centralized			Decentralized	
	Data storage location	Centralized			Decentralized	
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others
	Data packaging	Data transfer			API	
IT architecture: Access control	**Level**	Simple			Advanced	
	If advanced	Attribute based			Role based	
IT architecture: Data use	Labelling	Enforcement			Others	
IT architecture: Data mgmt features	**Evidence**	Blockchain		Verifiable Credentials	Others	
	Convenience	Wallet		Data Ports	Others	
	Data protection	PETs		Anonymization	Others	
	Traceability	Tagging (QR, NFC, RFID)			Others	
Unique technical aspects						
Traceability of textile materials is unique: when materials are passed from one party to another, we register batches, but through inhouse processes we allow mixing of batches and apply a mass-balance approach. We don't do any trace product by product, but material category by category (e.g. 100% cotton knit scraps). We also enable trace of brand share of the waste throughout the supply chain with the same approach.						

Maturity level and application sectors
Our SaaS offers a service for 4 stakeholders: brand, recycler, waste supplier (e.g. garment factory, a hotel or a post-consumer sorter) and waste handler (any type of preprocessor in between supplier and recycler). The product is fully operational and covers the majority of key features needed for brands and garment factories (industrial waste) for the basic processes. We are currently ~50% level with features for recyclers and handlers, and we are just starting to include post-consumer collectors.

3.1.22 Worldline TCS

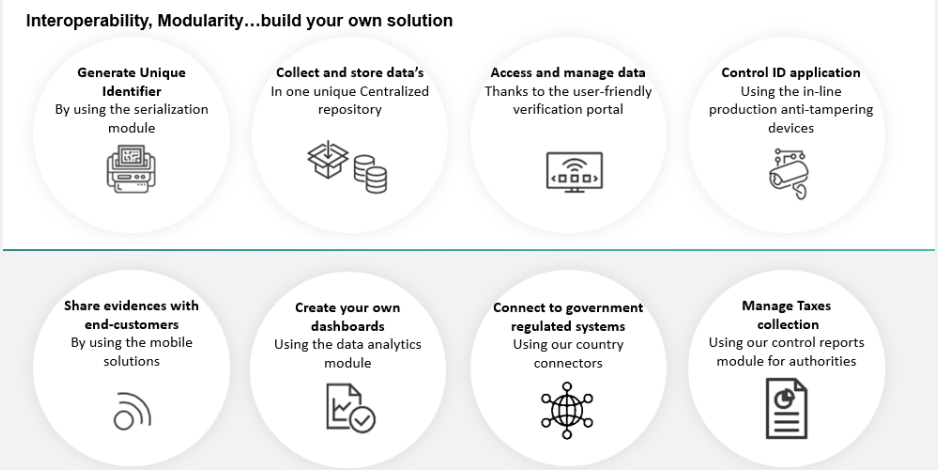
Tax Control Suite (TCS)
Worldline excised stamp and track and trace solution, so called product name Tax Control Suite: • Is a digital tool for control and monitoring of all excised goods, manufactured or imported into a market, territory or country (near real time visibility with our mobile app); • Destined to fight illicit trade with less admin burden; • Increases the revenue for the authority's administration due to the tax collection monitoring; • Fully compliant with existing international and/or local regulation; • State-of-the-Art: customisable, interoperable with existing IT systems and leading edge technologies; • Supporting digitisation and international recognition.

Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model		Batch	Prod. order		Single item
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized		Proprietary	Data ports		Others
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		

IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others
	Convenience	Wallet	Data Ports	Others
	Data protection	PETs	Anonymization	Others
	Traceability	Tagging (QR, NFC, RFID)		Others

Unique technical aspects

Worldline Tax control suite is a modulable solution to be composed with components that would suit with local authority's needs.



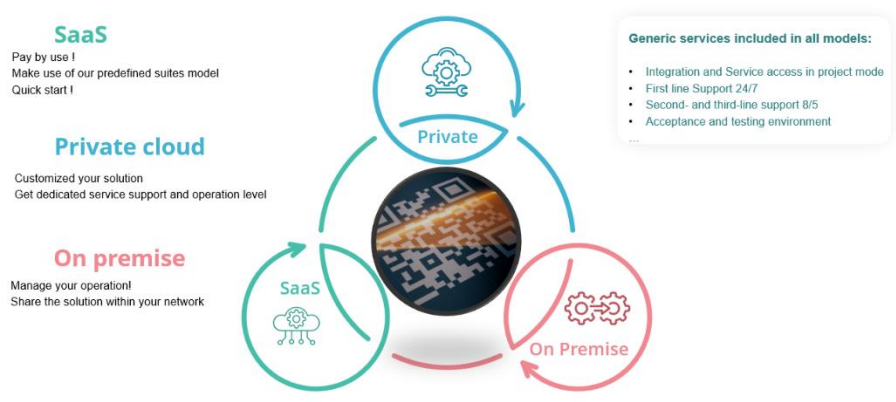
The core components are:

- Portal to register the economic operators (including registration of related master data such as information around their facilities, their machines, etc.).
- Portal to enable the order or generation of Unique Identifier to be applied on product to be traced.
- Event repository to control and store the product tracking related events sent by the manufacturers along the product life cycle. The events may cover production processes as well as logistic operations.
- Machine to machine integration thanks to API managing the operations directly from the system of the manufacturers.
- Additional modules could be:
- Statistics and reporting module to provide to the authority a full market or industry related report.
- Mobile application to provide easy access to evidence or control tools.

In addition to the Worldline Tax Control suite which is a fully digital solution, Worldline has strong partnership with the best specialists to provide additional features that would enhance the verification and control of traceability notions:

- Anti-tampering hardware devices to control unique code application on production lines:
- Physical tax stamps design lay-out, printing and supply facilities and;
- New security features technologies.

Worldline may propose a flexible delivery model of the Tax Control Suite. From acting as a global and dedicated service provider to a simple solution provider operated on local premise.



Maturity level and application sectors

Solution used to control tobacco industry in different versions.

- Digital Tax Verification in Switzerland;
- Unique Identifier generation and economic operator registrations in Denmark, Lithuania, Greece, Cyprus, The Netherlands;
- Tax control and import management in Ecuador.

Link: WL Traceability for Authorities - YouTube.

3.1.23 TextileGenesis

Textile Genesis

Textile Genesis is a Blockchain-based platform for the traceability of the origin of fibres for the fashion and textile ecosystem. It includes all 5-6 tiers of the supplier ecosystem, using Fibercoins to trace sustainable textile products from fibre-origin to retail. Fibres such as wood-based.

Mapping with respect to the reference framework

Product ID	**Type**	Instance			Category		
	Granularity	Model		Batch	Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		

Digital connector	**ID minting**	Centralized	Decentralized		
	Data storage location	Centralized	Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others
	Data packaging	Data transfer	API		
IT architecture: Access control	**Level**	Simple	Advanced		
	If advanced	Attribute based	Role based		
IT architecture: Data use	Labelling	Enforcement	Others		
I doIT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others	
	Convenience	Wallet	Data Ports	Others	
	Data protection	PETs	Anonymization	Others	
	Traceability	Tagging (QR, NFC, RFID)	Others		

Unique technical aspects

Blockchain-based architecture, highly scalable, using so-called Fibercoins to warrant against double spending. Not only companies that want to produce with sustainable fibres but also third-party auditing bodies have access to verify ESG credentials of supplier's production sites. Thus, the platform offers a chain of custody for raw materials/fibres (and farm level) from the source throughout the entire value chain. Including fibre forensic audit results. Data is real-time data from different stakeholders.

The platform uses bots for automated business and certificate validations (source: https://textileexchange.org/app/uploads/2021/05/Webinar-Textile-Exchange-and-TextileGenesis-Collaboration-September-2-2020.pdf)

Maturity level and application sectors

Cross-industry platform with a high maturity level, more than 1500 suppliers that create sustainable products have joined Textile Genesis and more than 50 brands in the textile/fashion industry use Textile Genesis to be sure about the origins of the fibres they use. In this way they can show they are using sustainable fibres in their production chain.

Useful links:

https://textilegenesis.com/

https://textileexchange.org/app/uploads/2021/05/Webinar-Textile-Exchange-and-TextileGenesis-Collaboration-September-2-2020.pdf

3.1.24 Tings

Tings

Responsible operator and consumer focused product lifecycle support system. Durable goods and apparel. DPP ready.

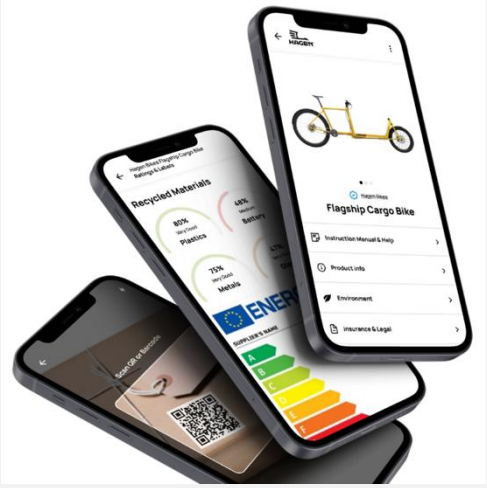
Mapping with respect to the reference framework							
Product ID	**Type**	Instance		Category			
	Granularity	Model	Batch	Prod. order	Single item		
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes		No			
	Resolver	Yes		No			
Digital connector	**ID minting**	Centralized		Decentralized			
	Data storage location	Centralized		Decentralized			
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others		
	Data packaging	Data transfer		API			
IT architecture: Access control	**Level**	Simple		Advanced			
	If advanced	Attribute based		Role based			
IT architecture: Data use	Labelling	Enforcement		Others			
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others			
	Convenience	Wallet	Data Ports	Others			
	Data protection	PETs	Anonymization	Others			
	Traceability	Tagging (QR, NFC, RFID)		Others			

Unique technical aspects

Support for different taxonomies by using mapping capability.

Maturity level and application sectors

Closed MVP with users. Cross-sector. Designed to fit with DPP data and data system if similar to ESPR and CIRPASS proposal described DPP will be decided. Before DPP enforcement offers responsible operators to make as much product data digitally available as possible for consumers to use products more responsibly, extend product consumption period, support products taken to upcycle and recycle. Currently uses based on guesswork DPP data set. System supports more data and functionality from responsible operators to consumers than predicted for DPP.



3.1.25 Tokenized Distributed Ledger

Circularise/Tokenized distributed ledger							
Circularise is the leading software platform that provides end-to-end traceability and secure data exchange for industrial supply chains.							
Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain		Verifiable Credentials		Others	
	Convenience	Wallet		Data Ports		Others	
	Data protection	PETs		Anonymization		Others	

	Traceability	Tagging (QR)	Others

Unique technical aspects

The patent-pending Smart Questioning makes it possible for all companies to cooperate in a trusted information exchange. In the system, companies are anonymous, remain the only owner of the data and can stop communicating it any time. They decide how much information is shared and with whom and are able to validate the answers to any question without sharing the original data. Circularise's technology allows for companies to communicate about the data of their products and for anyone to scan the QR-Code on the product in order to see the product information or ask a Smart Question to the decentralised store of the full bill of material spread over the local databases of all suppliers reaching back to the mining stage. The anonymity and control of the amount of data shared at any moment is the only way to get all companies to cooperate and thereby overcome the issues with centralised databases that are rejected due to the risk to confidential business data.

Maturity level and application sectors

Circularise technologies allow communication on data instead of simply the data. In supply chains we often deal with data that needs to remain a secret. All normal encryption methods can be decrypted over time. We use an implementation of zero-knowledge proof (ZKP), a technology we call "Smart Questioning "that allows stakeholders to ask critical questions (e.g. "Does this plastic part contain material "x"?") to a guarded dataset of private information (e.g. the bill of materials). Practically speaking, the user sees the reference on Blockchain (hash) and by asking questions to this hash, the question is sent to every locally stored dataset of every supply chain stage. Practically speaking, it is the "interrogation" of the entirety of the supply chain of a product by asking a list of specific questions to a QR-Code or hash. As the private information is audited, so is the output.

www.circularise.com

3.1.26 Toxnot

Toxnot

Toxnot (a 3E company) is a software company with a mission to improve health and sustainability across the global supply chain by streamlining the chemical transparency process. Toxnot provides an efficient system for manufacturers to import chemicals data, provide insight into their hazard profiles, report on the results and create safer products. Organisations use Toxnot to automate transparency reporting and compliance, easily collect hazard information, and reduce risks across their global supply chain. Toxnot scales from small businesses to Fortune 500 enterprises.

www.toxnot.com

Mapping with respect to the reference framework

Product ID	**Type**	Instance			Category		
	Granularity	Model		Batch	Prod. order		Single item
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other

	Machine readable data carrier	Yes			No
	Resolver	Yes			No
Digital connector	**ID minting**	Centralized			Decentralized
	Data storage location	Centralized			Decentralized
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others
	Data packaging	Data transfer			API
IT architecture: Access control	**Level**	Simple			Advanced
	If advanced	Attribute based			Role based
IT architecture: Data use	Labelling	Enforcement			Others
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials		Others
	Convenience	Wallet	Data Ports		Others
	Data protection	PETs	Anonymization		Others
	Traceability	Tagging (QR, NFC, RFID)			Others

Unique technical aspects

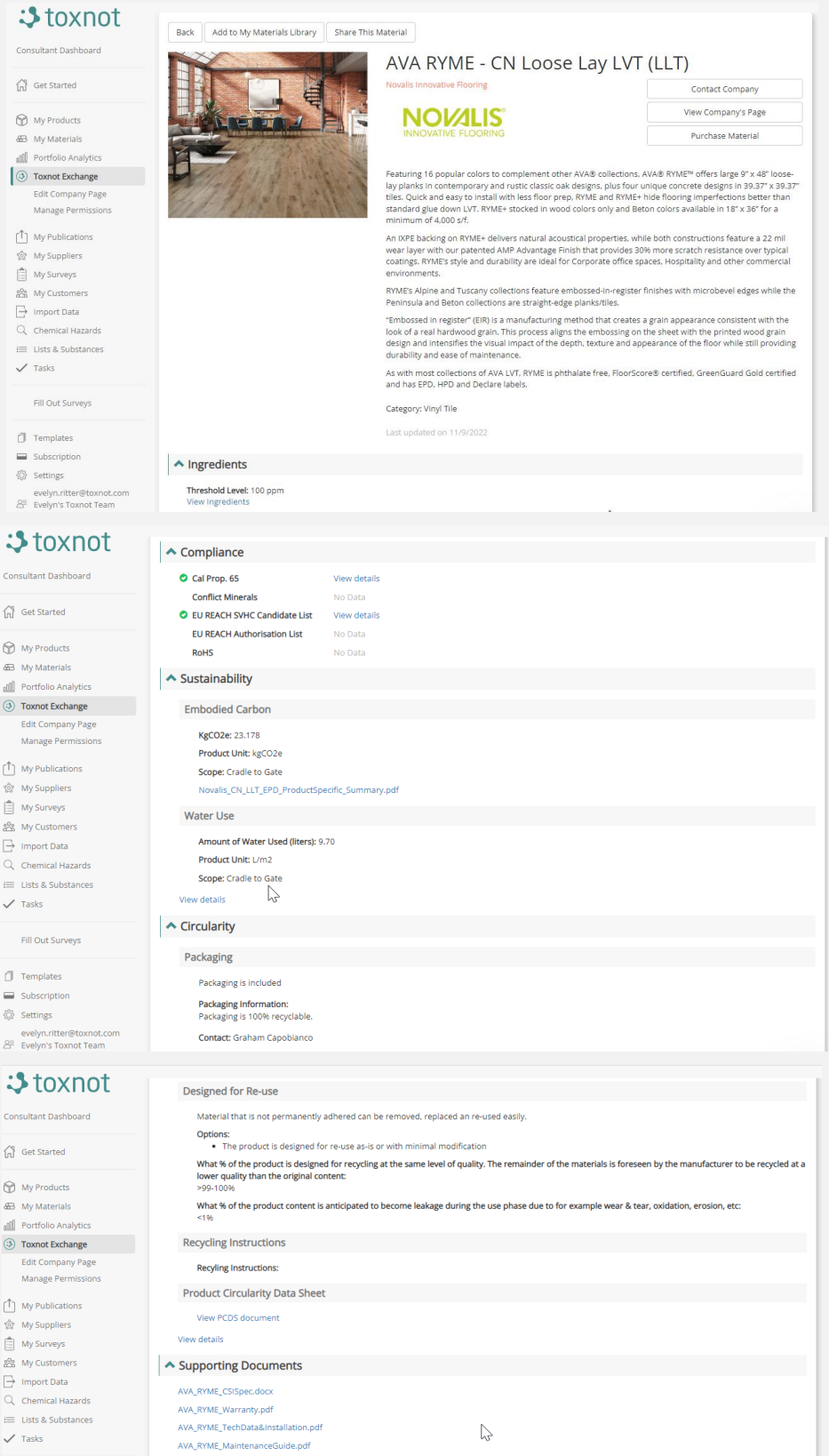
The Toxnot Product Passport system is specifically designed to meet emerging product passport requirements, enable supplier data exchange today, and be easily expanded as guidelines evolve. Our proprietary data protections allow suppliers to mark chemicals as proprietary but users to still screen those proprietary chemicals against regulations such as EU REACH or PFAS regulations. Simplified infrastructure allows for clear ownership and low cost. Suppliers can create a Toxnot Digital Product Passport for free and can automatically create an EU REACH, EU RoHS, CA Prop 65, and Product Circularity Data Sheet as part of the free account. All data fields are aligned with industry-standard initiatives & needs and are updated as terms and usage change.

Maturity level and application sectors

The Toxnot Product Passports are live in the system and already used by X of companies. Companies can enter full chemical ingredient disclosure, compliance data, sustainability data such as embodied carbon and water use, circularity information, recycled content, end-of-life options and more. We have companies from a wide variety of sectors using the system, including industrials, building products, chemical manufacturers, packaging, electronics and more. Passports can be published as public, restricted, or private, based on each company's desire. Some notable product passport publishers include: Covestro, Novalis, Steelcase, Kohler, AEP Span, Windmöller GmbH, and more.

Follow this link to an example passport:

https://toxnot.com/Exchange/Database/Detail/d3531fe3-9750-49b9-a546-fe19f7c5d90f



3.1.27 Worldline TPD

TPD Repositories

Worldline is deeply involved in the Track and Trace activities linked to the European Regulation for tobacco manufacturers and importers and for local and European authorities.

The European Regulation (TPD and Implementing Acts) helps European authorities to fight against tobacco illicit trade by tracking all tobacco products in the European territory.

Worldline provide one stop shop solutions to EU economic operators and EU member states allowing them to comply with the regulation , for example the primary repository for importers and manufacturers of tobacco products. When necessary, Worldline also provides to its customers other ancillary services such as private repositories and connectivity modules to further secure the compliance with the regulation.

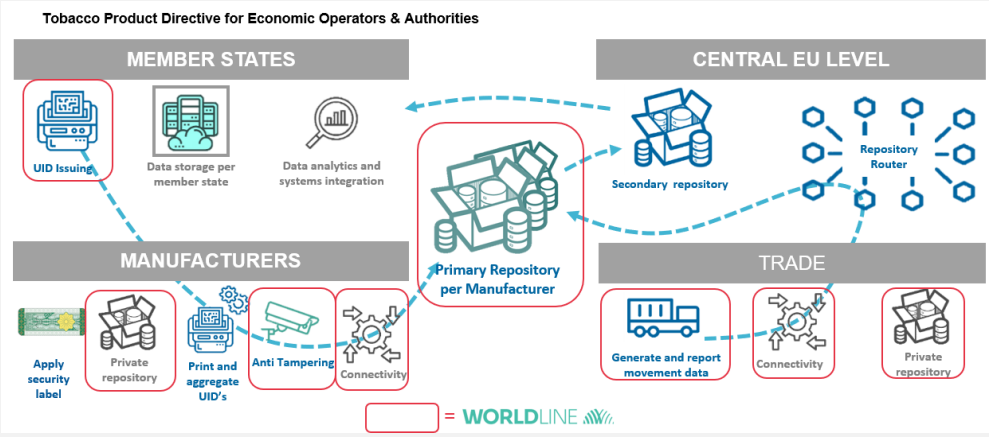
Mapping with respect to the reference framework

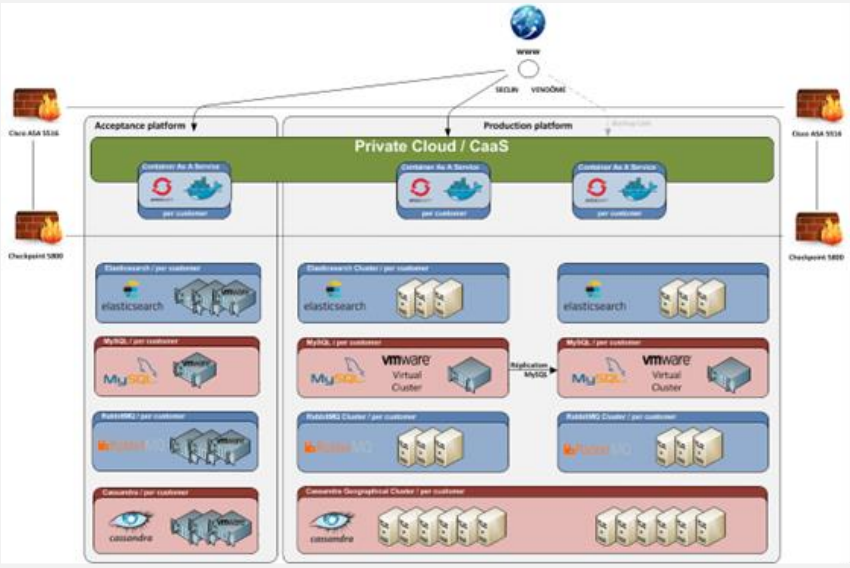
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain		Verifiable Credentials		Others	
	Convenience	Wallet		Data Ports		Others	
	Data protection	PETs		Anonymization		Others	
	Traceability	Tagging (QR, NFC, RFID)			Others		

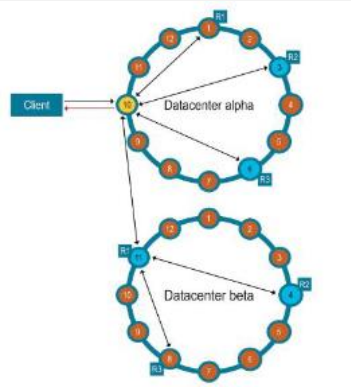
Unique technical aspects

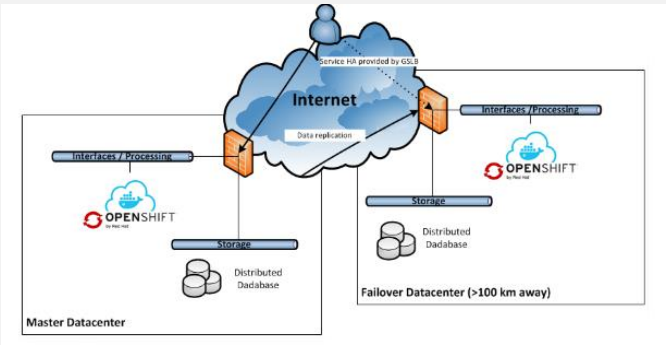
In order to ensure business continuity and no loss of data as per EU regulation, Worldline implemented on their private cloud infrastructure a fully redundant platforms architecture using

different data-centres (active and passive). This architecture allows an instant platform switch in case of major disaster. All used technologies are fully redundant at several levels (Openshift and CaaS management, MySQL management, Elastic stack and RabbitMQ, Cassandra storage, WebDAV and Webscale).









Maturity level and application sectors

Worldline is operating 6 regulated primary repositories and 5 manufacturer centralised Track and Trace systems since 2019 to support to EU tobacco product directive implementing regulation.

This is representing the management of:

- 25 billion unique products traced a year;

- 100 billion of product related tracking events a year and;
- 30 Terabytes of data processed and stored a year.

3.1.28 TRACE

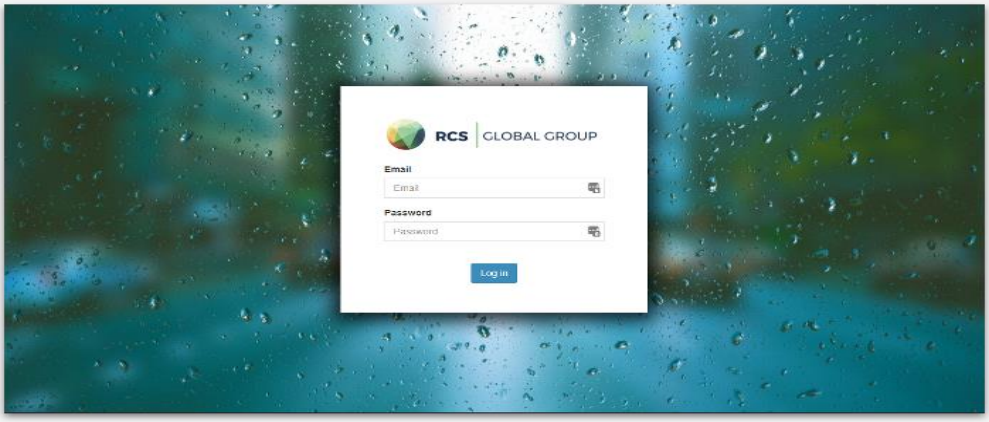
TRACE							
TRACE is a web-based platform functioning as an established approach to collect ASM traceability data to ensure chain of custody documentation, transparency on contamination risks and provide traceability reports and export documentation to our clients							
Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	**Batch**		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			**No**		
	Resolver	Yes			No		
Digital connector	**ID minting**	**Centralized**			Decentralized		
	Data storage location	**Centralized**			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	**Others**		
	Data packaging	**Data transfer**			API		
IT architecture: Access control	**Level**	**Simple**			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	**Others**			
	Convenience	Wallet	Data Ports	**Others**			
	Data protection	PETs	Anonymization	**Others**			
	Traceability	**Tagging (QR, NFC, RFID)**		Others			
Unique technical aspects							
The tech solution is in production since 2019, TRACE 2.0 will adopt a miro-service architecture to ensure agility, improved traceability, easier debugging and maintenance. This will be based on a							

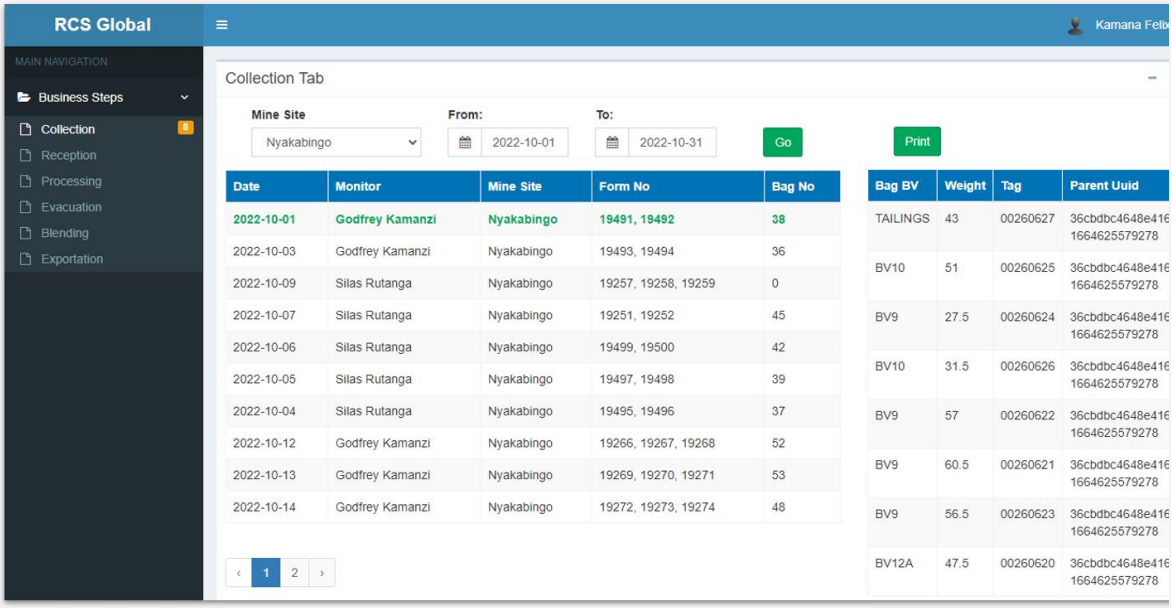
cloud formation infrastructure on AWS to enhance security, quality, maintainability, and data integration. Possible tech stack could be based on Elixir with PostgreSQL DB.

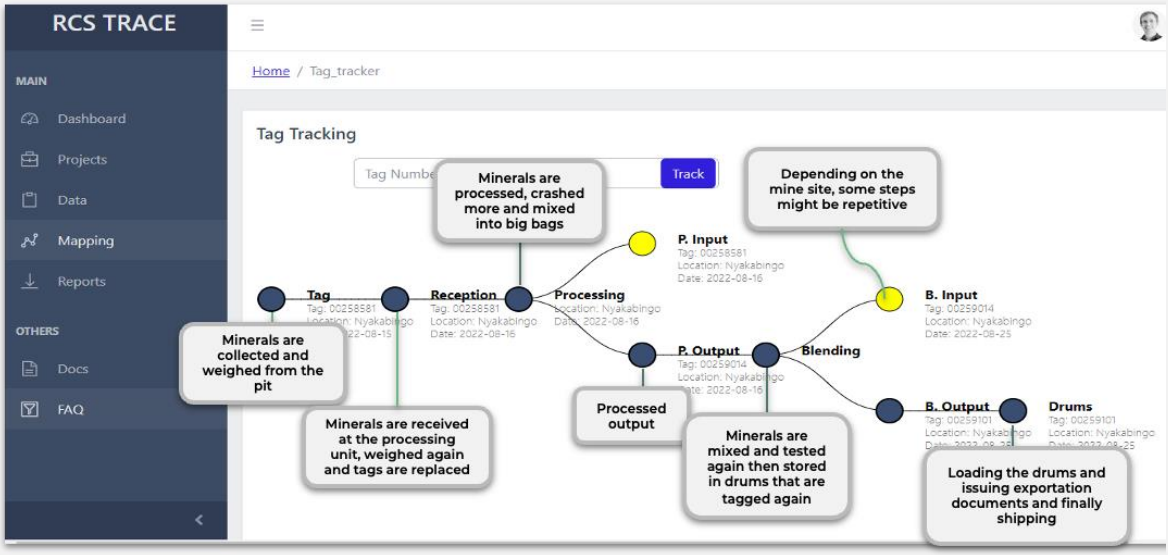
Maturity level and application sectors

TRACE version 1.0 was launched in 2019, current work is on TRACE 2.0. TRACE is used by RCS clients to trace monitored ASM material from pit/ tunnel to export, with potential expansion to extend traceability to cover the entire value chain.

Note: the dataset used for demonstration is a dummy one







3.1.29 TRICK

TRICK
Product data TRaceability Information management by BloCKchains interoperability and open circular service marketplace. TRICK Project arises from the need from the Textile and clothing industry to be more transparent and traceable, easing the transition from linear to circular. The TRICK project consists of providing a complete, reliable, SME-affordable and standardised platform to support the adoption, tracing and demonstration of sustainable and circular approaches, secured by Blockchain enabling the enterprises to collect product-secured data. TRICK's main goal is to provide affordable and standardised enablers to move SMEs closer to a circular economy. The achievement of this objective will come through the creation of a platform

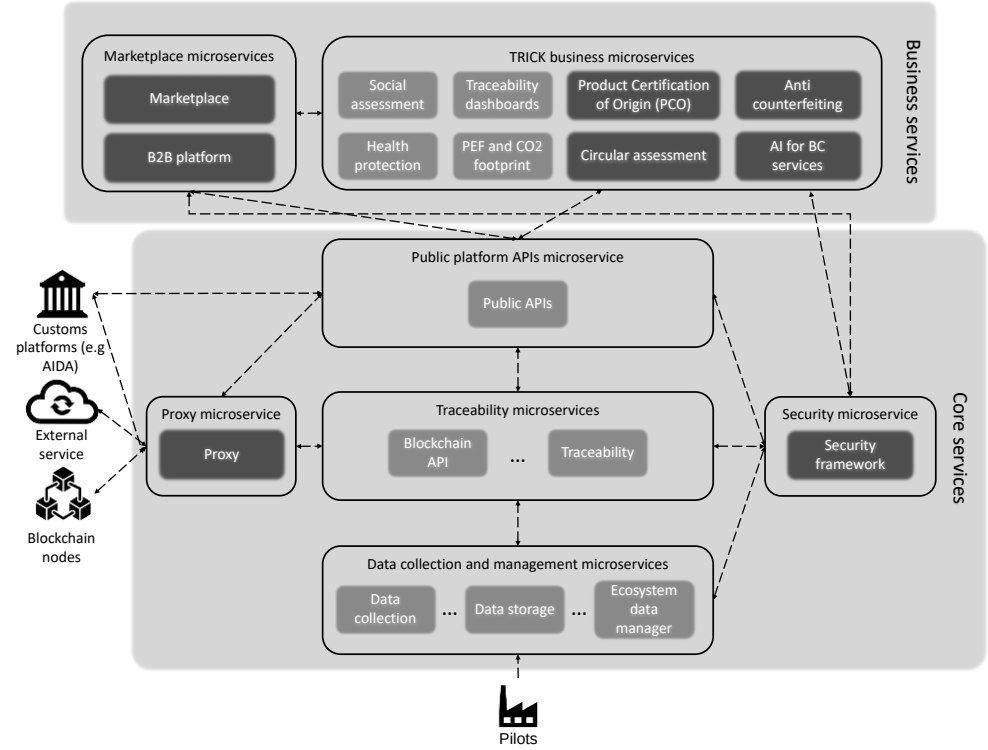
for the management of circular product information based on data collection and secured by Blockchain. The TRICK platform will perform the collection and data management of secure product data all along the supply chain together with a set of six services available in an open B2B marketplace.

Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order		Single item
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports		Others
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		
IT architecture: Data use	Labelling	Enforcement			Others		
IT architecture: Data mgmt features	**Evidence**	Blockchain		Verifiable Credentials			Others
	Convenience	Wallet		Data Ports			Others
	Data protection	PETs		Anonymization			Others
	Traceability	Tagging (QR, NFC, RFID)			Others		

Unique technical aspects

Typically, the modern IT platform architectures are based on several services, i.e... data storage, database, core services to perform specific functionality. The micro-service approach, proposed in TRICK, uses loosely coupled, collaborating services to enable rapid development and deployment and adoption of simple communication protocols, synchronous or asynchronous. The figure depicts TRICK microservice architecture where data coming from end users is collected and managed by a set of microservices (e.g. data collection, data storage and ecosystem data manager). Traceability micro-services are responsible for managing data stored in the blockchain and to implement the traceability functionality. The basic functionalities, provided by core services are exposed by public platform APIs micro-service. This service is the touch point among the core services, the marketplace, the business services and B2B platform. The business services offered

by TRICK platform are: social assessment, health protection, traceability dashboards, PEF and CO2 footprint, Product Certification of Origin (PCO), circular assessment, anti-counterfeiting, AI for BC services. In the proposed approach, each business service is a microservice. By following the same approach, marketplace microservices contain this application and B2B platform. The goal of B2B platform is to offer access directly to TRICK public APIs to build external application based on TRICK services.



Maturity level and application sectors

Considering the technical aspects of the TRICK platform traceability and PCO as core of the TRICK solution are on a good maturity level. The smart contracts have already been implemented to be used on the Blockchains both public and private.

The TRICK platform is addressed specifically for the textile sector which end users are represented on the project consortium covering the whole textile value chain for both technical and fashion textiles. The solution will be validated by the textile industrial users on two pilots and a replication for the food sector, as well represented on the project.

Link: https://www.trick-project.eu/

3.1.30 TrusTrace

TrusTrace

Supply chain transparency and product traceability SaaS platform for global fashion and retail brands.

TrusTrace is a leader in fashion supply chain traceability. Our SaaS technology empowers brands and suppliers around the world to standardize how supply chain and material traceability data is captured, digitized and shared. With all trusted supply chain traceability data stored on a single

platform, brands get the right evidence in the right place to back-up product claims and meet regulatory compliance. Trustrace is based in Stockholm, Sweden, with offices in India (Coimbatore), France and the US. We currently have a 100+ strong team and solid experience in delivering large scale traceability programs.

Mapping with respect to the reference framework							
Product ID	**Type**	Instance		Category			
	Granularity	Model	Batch	Prod. order	Single item		
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes		No			
	Resolver	Yes		No			
Digital connector	**ID minting**	Centralized		Decentralized			
	Data storage location	Centralized		Decentralized			
IT architecture: Data transport	**Openness level**	Standardized	Proprietary	Data ports	Others		
	Data packaging	Data transfer		API			
IT architecture: Access control	**Level**	Simple		Advanced			
	If advanced	Attribute based		Role based			
IT architecture: Data use	Labelling	Enforcement		Others			
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others			
	Convenience	Wallet	Data Ports	Others			
	Data protection	PETs	Anonymization	Others			
	Traceability	Tagging (QR, NFC, RFID)		Others			

Unique technical aspects

Trustrace is SAAS platform which is built for scale. And configurable for multiple use cases. We have ultra large fashion brands recording millions of transactions per month. Platform includes Extraction Framework(OCR) over 80% accuracy Entity Customization (Extending any entity without code). Data warehouse for analytics (Includes Power BI). Integrations with Rest API and Excel. Event triggers (webhooks for brands).

TrusTrace's technology stack and automation is ISO 27001 certified which means it meets rigorous information and data protection standards with its information security practices to keep user data secure.

Maturity level and application sectors

Trustrace was founded in 2016 and is currently a trusted traceability solution provider for more than 45 Brands. TrusTraces core customer are global enterprise scale fashion and retail brands such as Adidas, OTB and Fast Retailing. Trustrace operates worldwide with most customers in Europe and the US.

Trustrace already has a small version of the Digital Product Passport i.e.:

https://m.trustrace.com/product/Residus/en/CYRIL-DRESS/product-journey

TrusTrace is leading the textile group for the development of the DPP in Sweden under the Trace4Value project, where we are also testing RFID technology as well as looking into the use of resolvers: https://trace4value.se/

Trustrace has recently launched the Traceability Playbook as an industry initiative:

https://trustrace.com/traceability-playbook-fashion-supply-chains

3.1.31 Vine

VINE							
Vine is a Cloud based Platform for Supply chain visualisation, ESG & DD performance management, audit programme overview and supply chains risk mitigation							
Mapping with respect to the reference framework							
Product ID	**Type**	Instance			Category		
	Granularity	Model	Batch		Prod. order	Single item	
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes			No		
	Resolver	Yes			No		
Digital connector	**ID minting**	Centralized			Decentralized		
	Data storage location	Centralized			Decentralized		
IT architecture: Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer			API		
IT architecture: Access control	**Level**	Simple			Advanced		
	If advanced	Attribute based			Role based		

IT architecture: Data use	Labelling	Enforcement	Others	
IT architecture: Data mgmt features	**Evidence**	Blockchain	Verifiable Credentials	Others
	Convenience	Wallet	Data Ports	Others
	Data protection	PETs	Anonymization	Others
	Traceability	Tagging (QR, NFC, RFID)	Others	

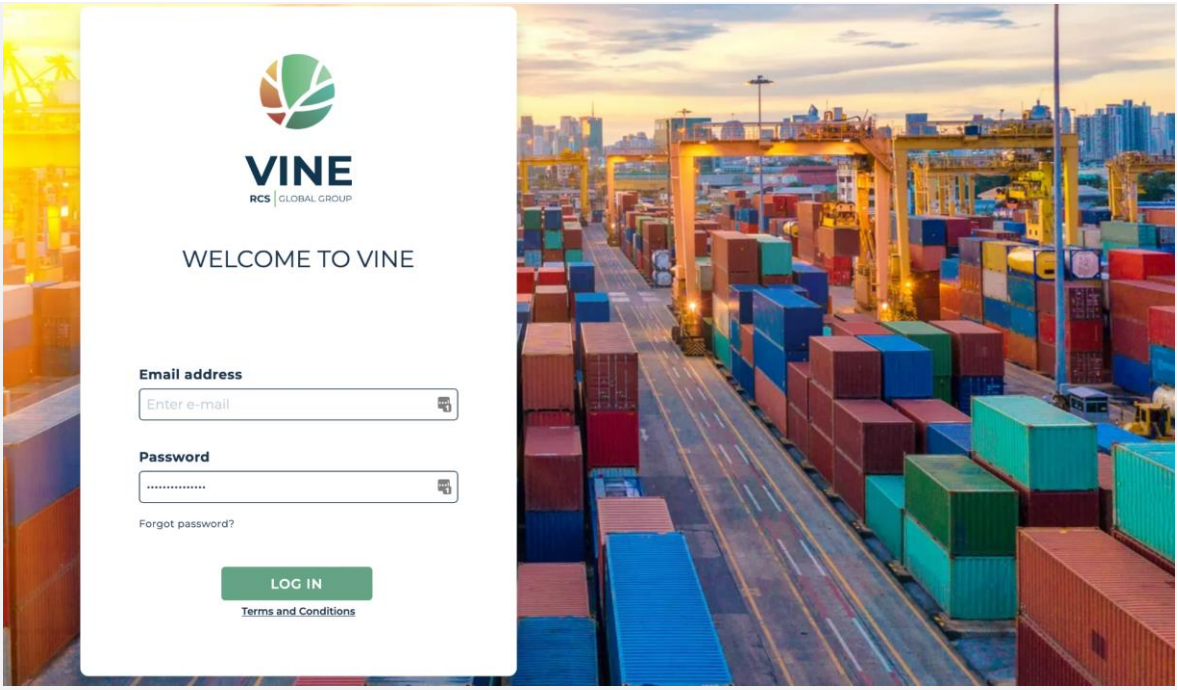
Unique technical aspects

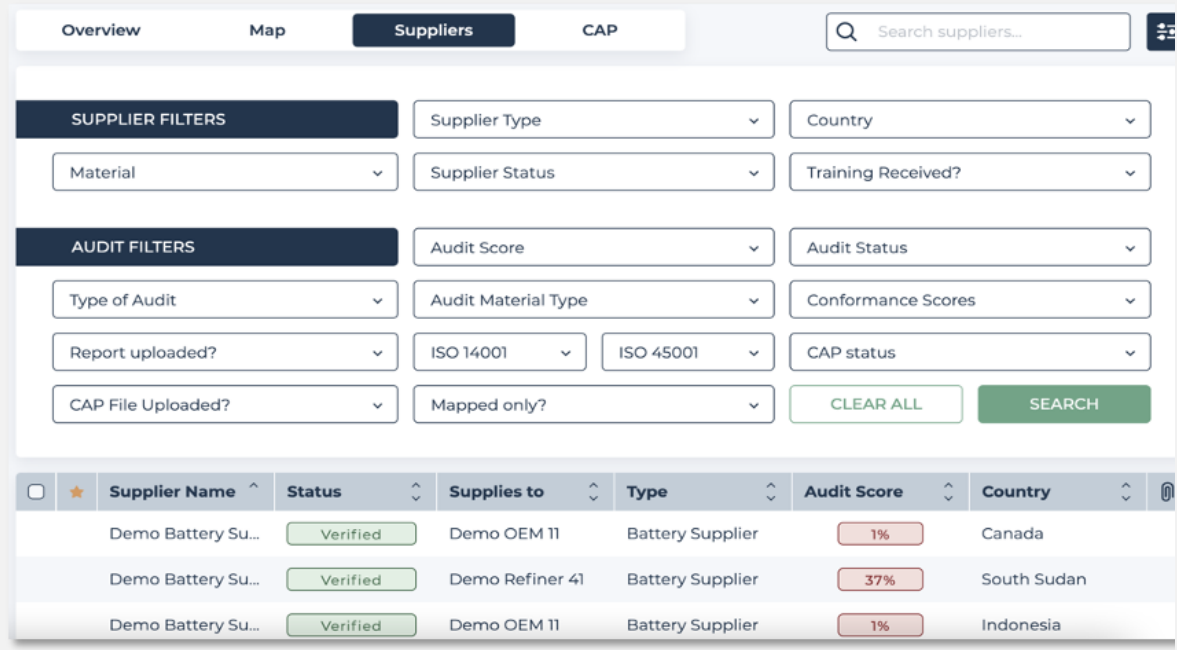
At the moment Vine is a cloud platform hosted on Heroku, using Elixir with Phoenix framework and LiveView as core for the backend and also Javascript (AlpineJS) and GraphQL, all connected to PostgreSQL DBs. As the system is constantly scaling and expanding some of the elements of tech stack and architecture could be updated in Q1-2 to provide better performance and security for more mature products and allow future scaling. Part of Vine is customised fork of Balkan library that was optimised towards supply chain mapping and could be regarded as a unique technical solution.

Maturity level and application sectors

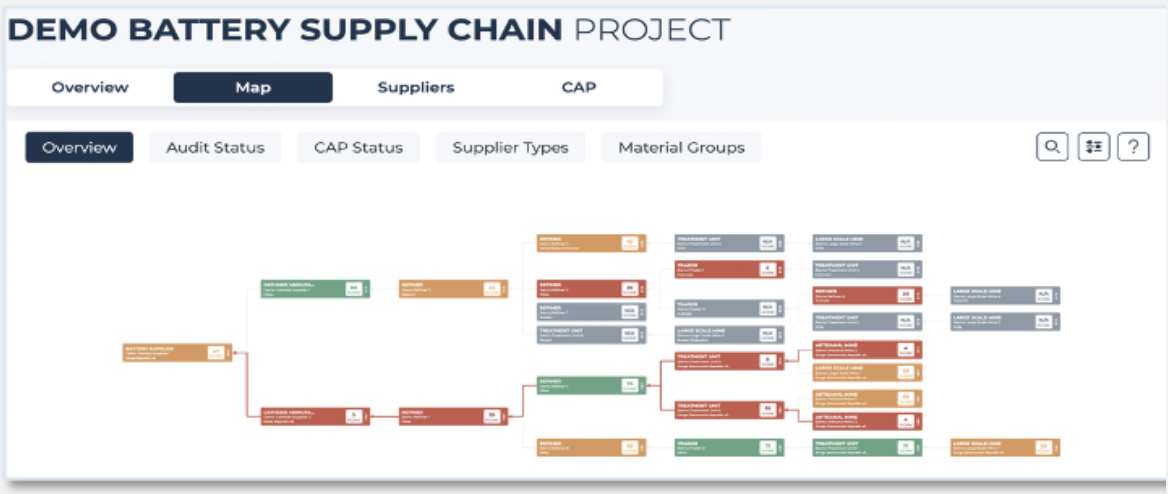
VINE version 1.0 was launched in early 2022, current work is on version 1.5 as well as VINE Battery Passport extension. VINE is a platform used by various value-chain stakeholders' functioning in the mining, manufacturing, and automotive sectors. It offers clients a wide range of services including multi-tier supply chain visualisation, ESG & Due Diligence performance management, and audit programme overview.

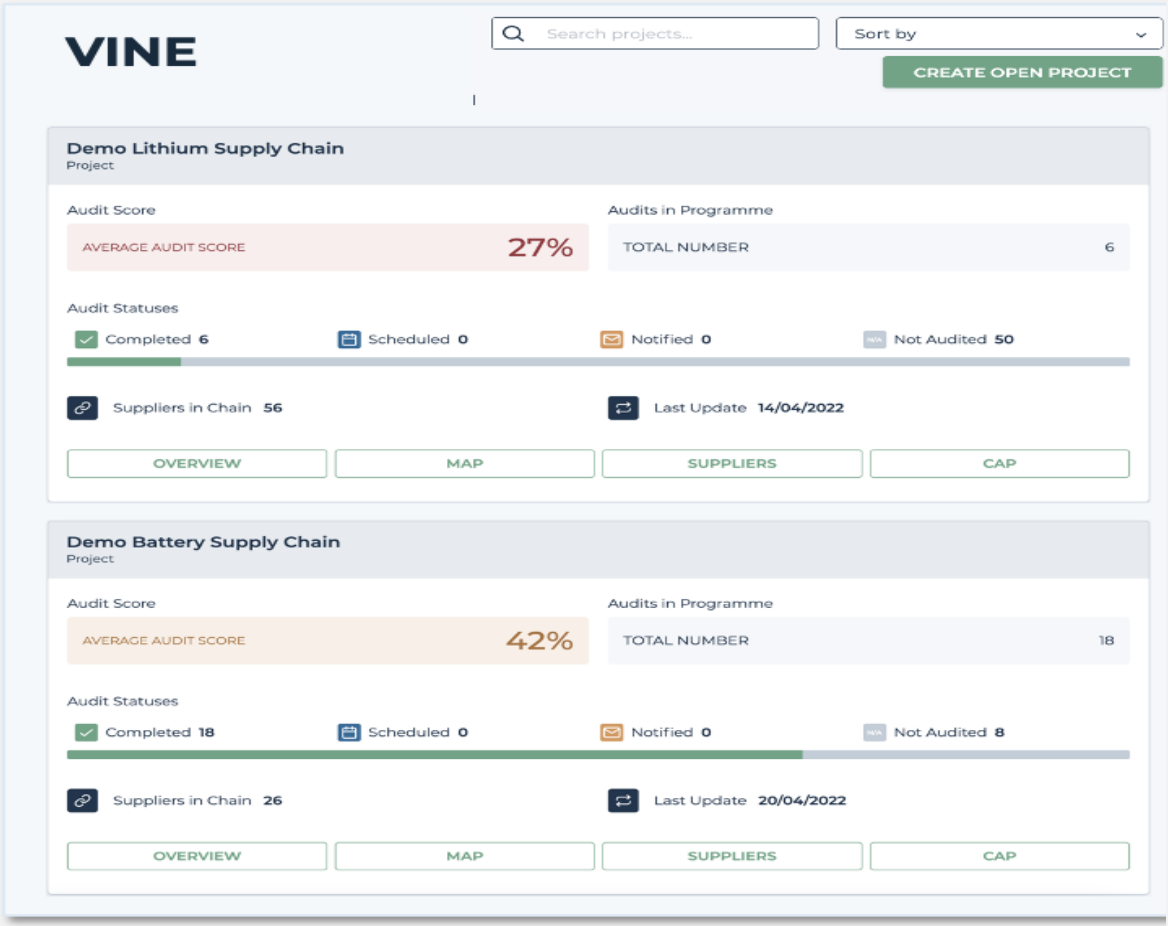
The idea of Vine is to be a central element of multi-tool platform for multiple ESG and sustainability due diligence and risk management tools tailored towards particular business use cases (so the platform could work in connection with RCS Battery Passport & RCS Trace and other, depending on the business goals and case of the customer).


VINE
RCS | GLOBAL GROUP
WELCOME TO VINE
Email address
Enter e-mail
Password
Forgot password?
LOG IN
Terms and Conditions


Overview
Map
Suppliers
CAP
Search suppliers...
SUPPLIER FILTERS
Supplier Type
Country
Material
Supplier Status
Training Received?
AUDIT FILTERS
Audit Score
Audit Status
Type of Audit
Audit Material Type
Conformance Scores
Report uploaded?
ISO 14001
ISO 45001
CAP status
CAP File Uploaded?
Mapped only?
CLEAR ALL
SEARCH
Supplier Name
Status
Supplies to
Type
Audit Score
Country
Demo Battery Su... Verified Demo OEM 11 Battery Supplier 1% Canada
Demo Battery Su... Verified Demo Refiner 41 Battery Supplier 37% South Sudan
Demo Battery Su... Verified Demo OEM 11 Battery Supplier 1% Indonesia


OEM SUPPLIER
BATTERY PRODUCER
CATHODE PRODUCER
REFINER
TREATMENT UNIT
INDUSTRIAL MINE
ASM MINE





3.1.32 ZVEI DPP4.0

DPP 4.0

The Digital Product Passport 4.0 (DPP4.0) is an industry-ready way of collecting and providing product information in a human- and machine-readable format for different parties, such as

companies, authorities, and users. The DPP4.0 can include all product information of the complete product lifecycle, which enables different use-cases. Furthermore, by having the product documentation that today must be provided in paper in a digital format, paper waste can be reduced across the industry and sustainability can be increased.

Mapping with respect to the reference framework							
Product ID	**Type**	Instance		Category			
	Granularity	Model	Batch	Prod. order	Single item		
Product data carrier	**Type**	RFID	QR Code	Digital watermark	Bluetooth label	Bar Code	Other
	Machine readable data carrier	Yes		No			
	Resolver	Yes		No			
Digital connector	**ID minting**	Centralized		Decentralized			
	Data storage location	Centralized		Decentralized			
IT architecture : Data transport	**Openness level**	Standardized	Proprietary		Data ports	Others	
	Data packaging	Data transfer		API			
IT architecture : Access control	**Level**	Simple		Advanced			
	If advanced	Attribute based		Role based			
IT architecture : Data use	Labelling	Enforcement		Others			
IT architecture : Data mgmt features	**Evidence**	Blockchain		Verifiable Credentials		Others	
	Convenience	Wallet		Data Ports		Others	
	Data protection	PETs		Anonymization		Others	
	Traceability	Tagging (QR, NFC, RFID)		Others			

Unique technical aspects

The DPP4.0 combines the unique identification of product instances, product types, batches or lots via identification link (IEC 61406) and information transfer with the Asset Administration Shell (AAS, IEC 63278) that offers a semantically unambiguous description of product information in a machine-readable format in accordance with ECLASS and/or IEC CDD. Via the ID-Link, the information can be accessed and used in different processes across companies, authorities, and users. In the AAS product information is organized in sub-models which are a collection of properties that can be standardised. Additional submodels can be added based on use-cases. Access to the information can be controlled via attribute-based access control. The AAS can be

stored/hosted decentrally, e.g., on the infrastructure of the companies as well as on infrastructure offered by third parties and data-providers. The identification link and the AAS are IEC standards to ensure that the DPP4.0 is accessible and usable for all companies and products.

Maturity level and application sectors

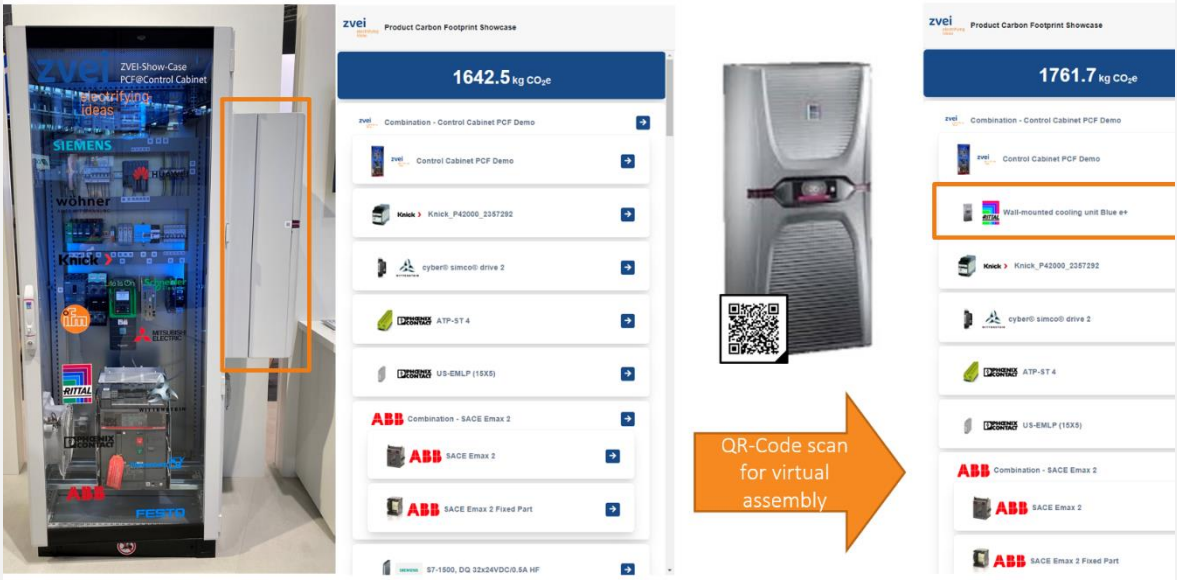
The identification link connects a physical asset with its digital representation in form of the AAS. The AAS is an IEC standard in development and used by many companies in the industrial sector. For the AAS especially, a user organisation in form of the IDTA (Industrial Digital Twin Association) was found in 2021 with 23 members which increased to more than 70 members today. Associated companies are mainly in the electric and digital industry, the battery sector as well as manufacturing. On the SPS Nuremberg 2022, 27 companies presented use-cases that included the AAS. The ZVEI manages the project "ZVEI-Show-Case PCF@Control Cabinet" to demonstrate the DPP4.0 with the example of a control cabinet. Around 30 companies are associated with this project of which many were able to provide the needed AAS and ID-Link for the DPP4.0. Note that the DPP4.0 is not limited to these sectors as the underlying technology can be used in different sectors as well.

Link to ZVEI-Show-Case: ZVEI-Show-Case PCF@ControlCabinet - zvei.org

IDTA Members and Partners: Members & Partners - IDTA English (industrialdigitaltwin.org)

The ZVEI-Show-Case on the Digital Summit 2022:

How the DPP4.0 can be used in company processes across the supply chain using the example of product carbon footprint (PCF) calculations:



Left shows the control cabinet and its digital twin without the climate control unit (orange box). The blue box of the digital twin shows the current PCF value. When the climate control unit is added in the assembly process, the ID-Link can be scanned to retrieve the product information for the climate control unit. This information can than automatically be used to update the digital twin of the now completely assembled control cabinet, including its PCF value.

4. Analysis of the framed DPP-oriented reference architectures

In this section, the activities carried out within Step F of the overall benchmarking procedure are reported. In particular, we propose an analysis of the set of DPP-related initiatives, excluding standards, mapped using the excel tool and using the online tool (answers received before December 23, 2022), representing a total of 80 initiatives. Since answers were not provided to all questions, certain results are presented in percentages rather than in number of initiatives.

Results are laid out with the objective to identify **trends** and **common aspects** in the DPP-related initiatives under development and to highlight the **gaps** with respect to the envisaged requirements for the DPP currently described in the ESPR Proposal. In line with the proposed classification framework (Table 1), the analysis is performed on an individual pillar basis, namely Product ID, Product data carrier, digital connectors, and IT architecture. Except for the two yes/no answers under data carrier ('Machine readable data carrier' and 'Resolver'), the initiatives could select multiple options per category. Using data collected in the initiative characterisation section of the survey, we first observe that **71% focus both on supply chain data exchange and on data exchanges concerning the finished good**, as seen in Figure 7. The evaluation shows that many DPP initiatives have realized that this extended use of product identifiers beyond the supply chain is possible and useful without additional technical overhead.

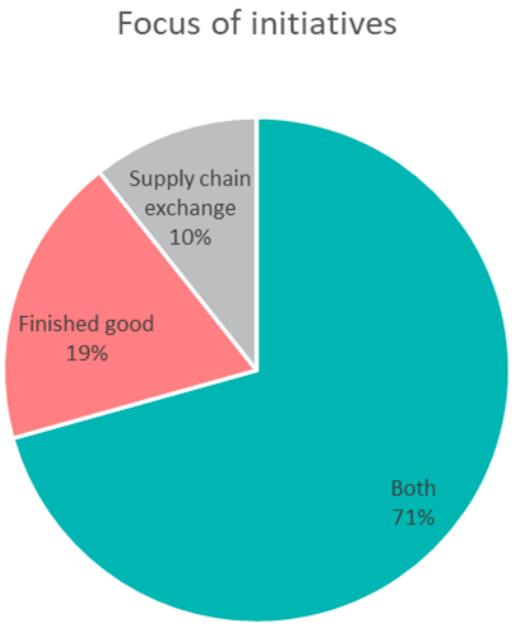


Figure 7 Focus of initiatives analysed in this chapter

4.1 Mapping of existing solutions: Product ID

The mapping of the "product ID" pillar is divided between 'type' and 'granularity'. The responses collected for the 'product ID – type' are shown in Figure 8 and capture the distribution of initiatives supporting only category type, only instance type, both instance and category, and finally both instance, category and additional aspects. As seen in Figure 8, most of the initiatives identify themselves as addressing instantiated types of identification schemes with a significant set of initiatives identifying themselves as addressing categorical identification schemes.

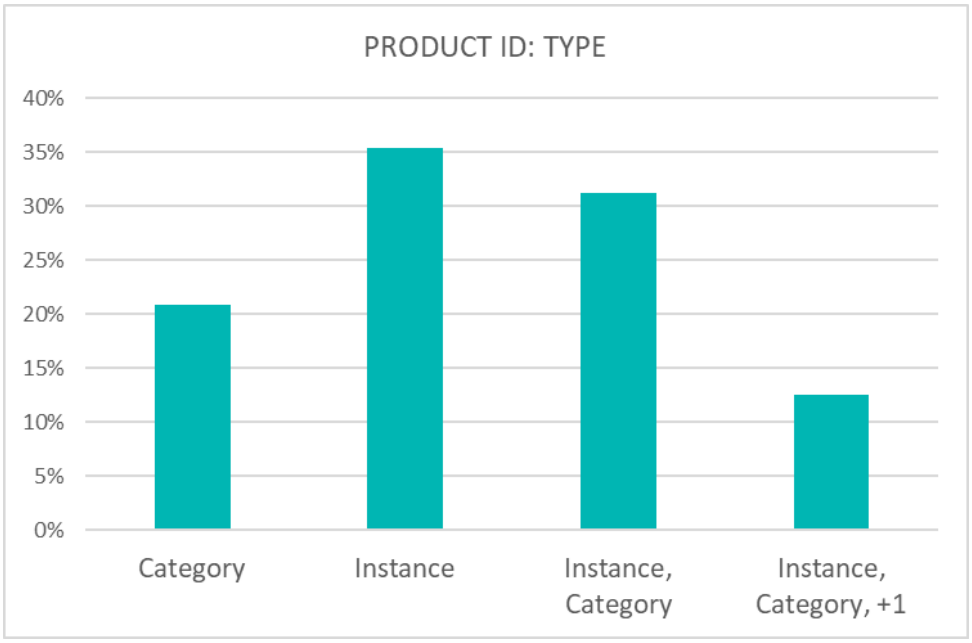


Figure 8 Initiatives' response to Product ID – Type

Concerning the "product ID" – "granularity", captured in Figure 9, the responses show the percentage of initiatives that selected exclusively "model", exclusively "batch", exclusively "single item"

granularity, and combinations of the previous elements. The predominant response is a combination of different granularity types; it can be a first order combination ("model" and "batch"; "batch" and "single item") or a higher-level combination, with the addition of sector-specific granularity (ex. "model", "batch", "production order", and "single item"). 56% of the initiatives address at least the "model" level of granularity, the 50% at least the "batch" level of granularity, and the 29% at least the "production order" level of granularity. It is worth mentioning that, overall, **about 75% of the initiatives address at least the "single item" level of granularity**, a result confirmed by Figure 9 for initiatives addressing at least Instance-level identification. This is good news, especially for enabling product life-time extension strategies for higher value goods because the ability to address single items (i.e.,, instances) of goods potentially allows the integration of product history, repairs and other lifetime information out of the box for already 75% of the evaluated systems.

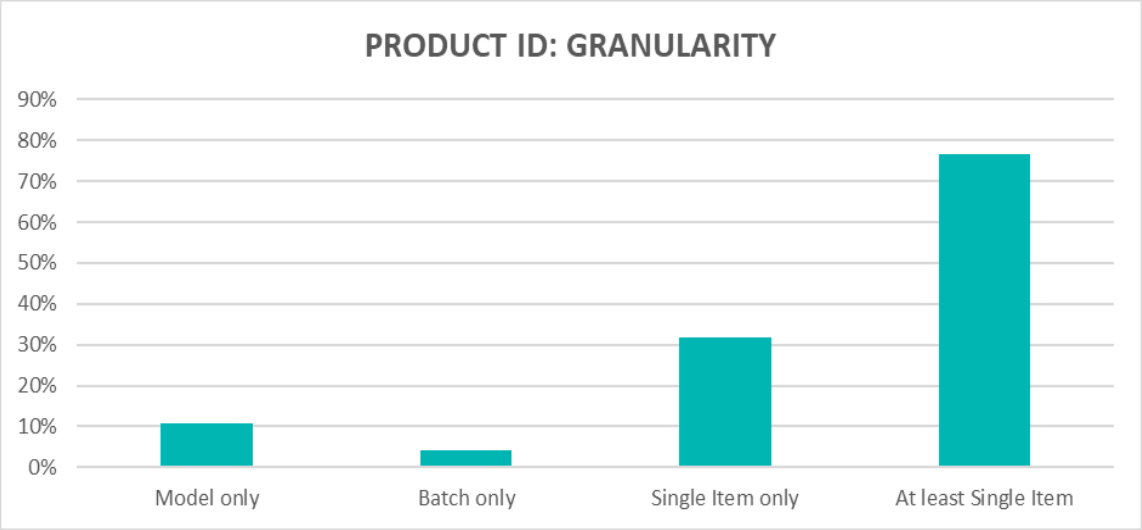


Figure 9 Initiatives' response to Product ID - Granularity

4.2 Mapping of existing solutions: Product Data Carrier

The mapping of the initiatives according to the "product data carrier" pillar covers three aspects: (i) the "type of carrier", (ii) the "machine readability" of data carrier, and (iii) the presence of a "resolver" to the data carrier. The responses for the "type" of data carrier shows a predominance of "QR codes" as the type, while the combination of "QR code" with other carriers are significant, as seen in Figure 10. Other provided answers include 'Data Matrix' and 'Electronic components, e.g. coming from the Battery Management System'. From the data collected, one can conclude that a system must allow for more than one type of data carrier. But every one type of data carrier will come with its own reading mechanism which imposes a system where several readers could sit side by side. Already mobile phones can scan QR codes but also detect a Bluetooth label and some can even read RFID tags. The wide variety of solutions retained shows that in the future, new data carriers may emerge and should be integrated into an overall DPP system.

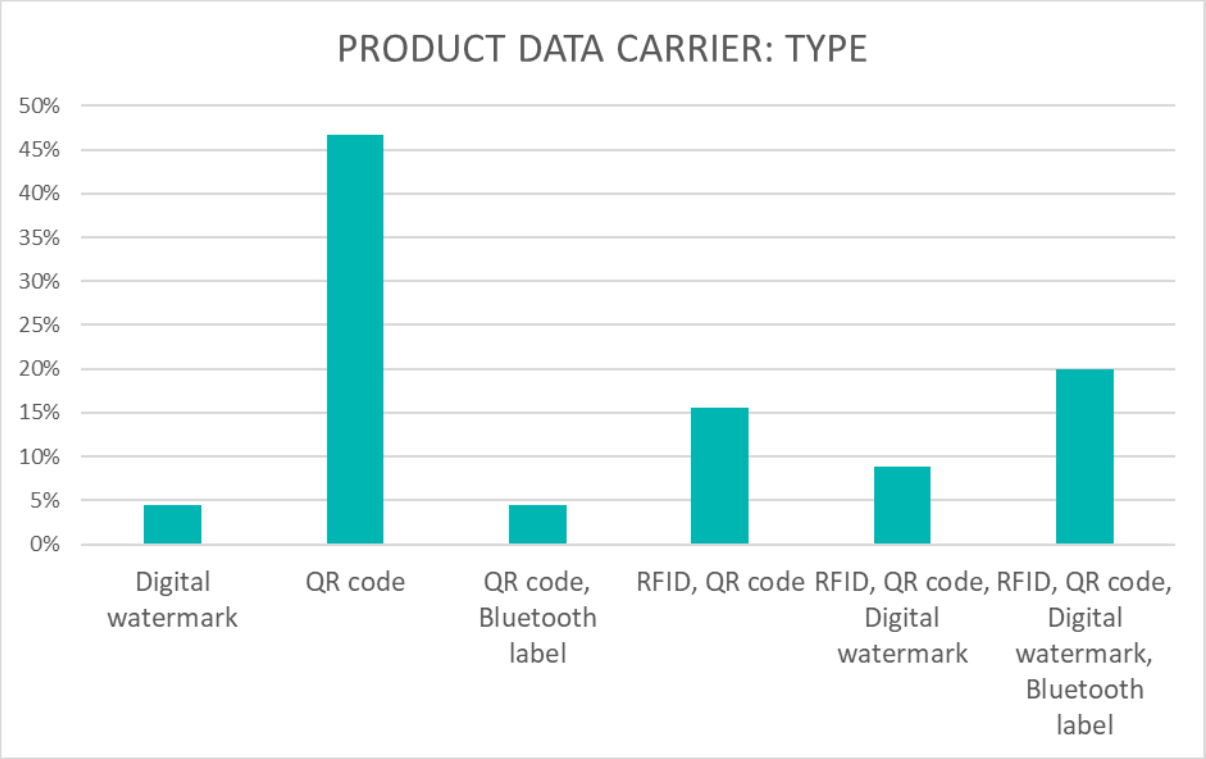


Figure 10 Initiatives' response to Product Data Carrier- Type

The response for the Boolean parameter "machine readability" is captured in Figure 11. As the figure highlights, the overwhelming preference of the existing solutions, with 87% of share, is towards a "machine readable" data carrier.

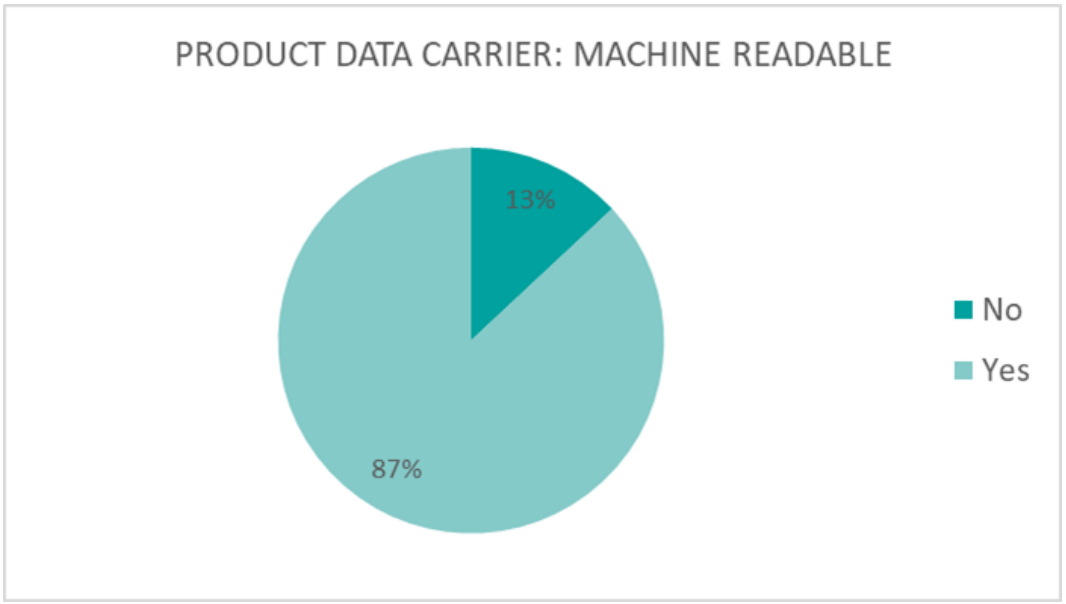


Figure 11 Initiatives' response to Product Data Carrier – Machine Readable

4.3 Mapping of existing solutions: Digital Connector, ID Issuing and Data Storage

To the question if the ID links directly to information on the web or if there is there an intermediate resolver, 67% of collected responses replied favourably (Figure 12).

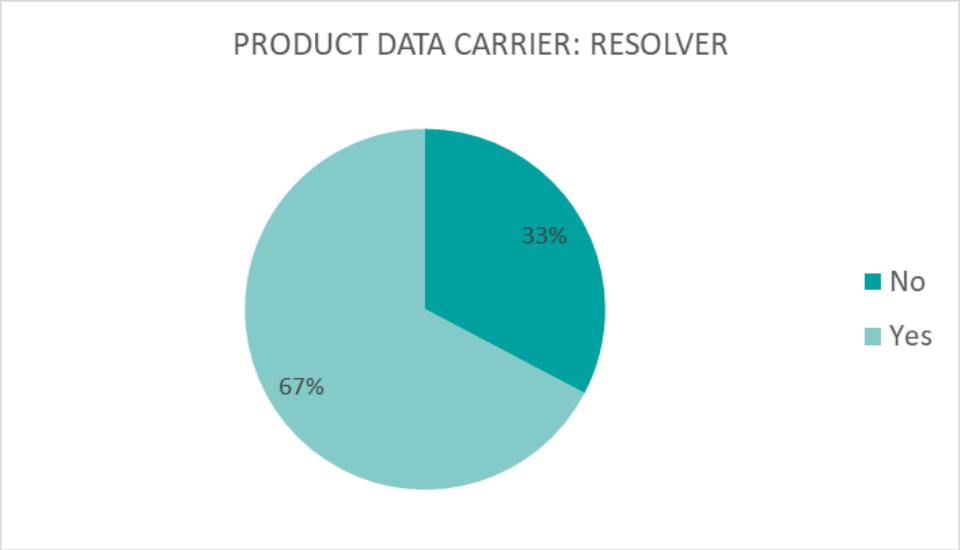


Figure 12 Initiatives' response to Product Data Carrier – Resolver

The mapping of the following section of the analysis is divided into "ID minting" and "data storage location". Both mapping parameters are Boolean and can either signify centralised or decentralised approaches. The share in preference regarding the "ID minting" is captured in Figure 13, between a centralised and a decentralised solution. As illustrated by Figure 12, **a 50% share of both solutions is evidenced, meaning there is no clear privileged solution**.

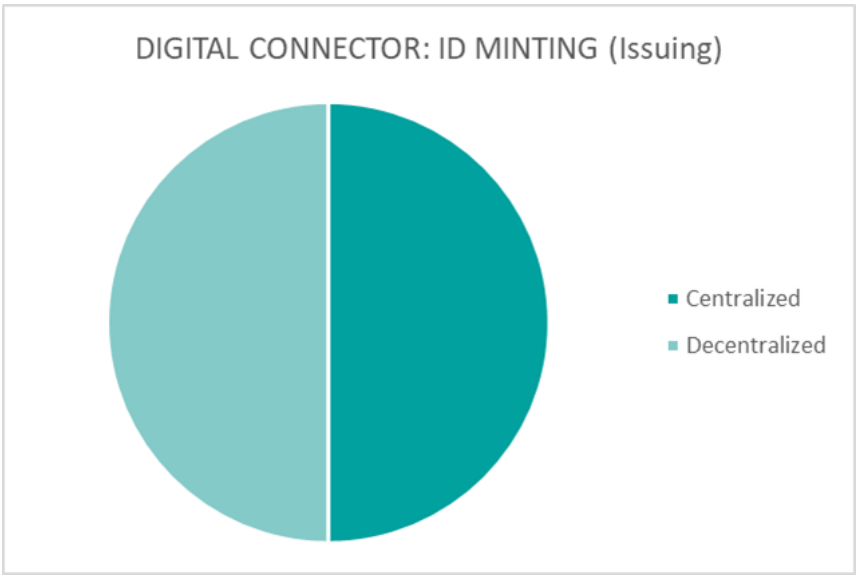


Figure 13 Initiatives' response to Digital Connector - ID Minting (Issuing)

Instead, for the "data storage location"**, a slight favouring from 57% of existing solutions towards a decentralised data storage is observed** in Figure 14. It is worth to highlight that some of the classified initiatives feature hybrid, federated, approaches, that were self-classified as "centralised" due to the lack of complete decentralisation.

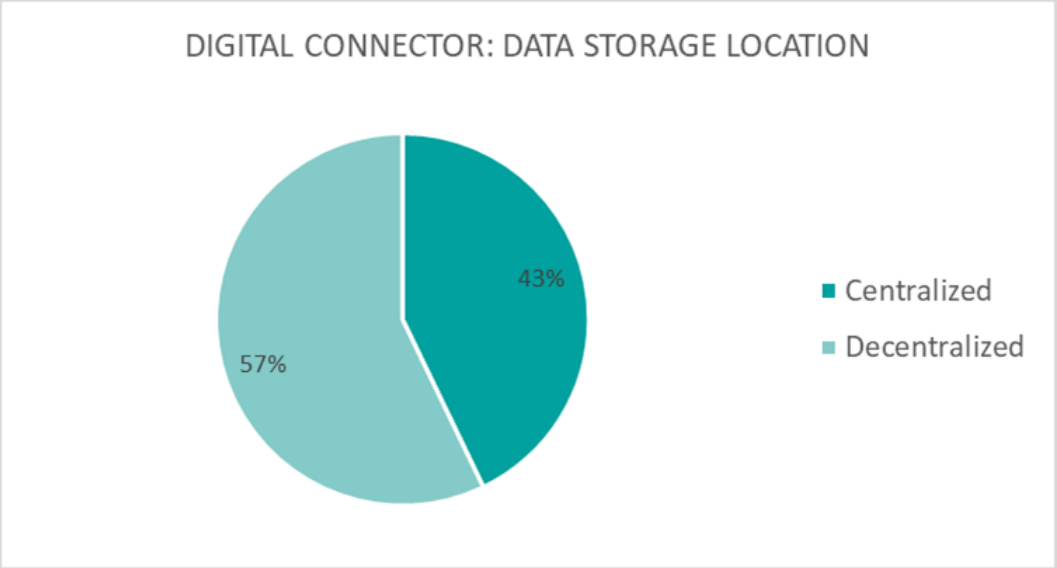


Figure 14 Initiatives' response to Digital Connector - Data Storage Location

4.4 Mapping of existing solutions: The IT architecture

In this section, the pool of initiatives being analysed is constrained to only the 32 initiatives presented in section 3.1, having provided entries to the IT architecture pillar. Since multiple answers could be provided to a given question and some questions being left unanswered, the sum of answers is rarely equal to this number. The IT architecture pillar is divided into the following four categories: (i) the data transport, (ii) the access control, (iii) the data use, and (iv) the data management features.

The "IT Architecture" – "Data Transport" is further divided into the "data packaging" and "openness level". Figure 15 shows the responses to the two subcategories. It can be noted that API-based data packaging is preferred to data transfer with 25 initiatives. As for the openness level, a standardised data transport is preferred by 22 initiatives to other types as proprietary, data ports, or others. Responses for 'Others' include 'SFTP', 'blockchain-based application', 'multi-protocol channels', 'user-dependent information access restrictions via the ID-Link', and web portal.

The important learnings here are first, that there are systems transferring product data to downstream actors. This means that the DPP system should not only provide an API to the DPP, but should take the use case of data transfer into account. The second result is that a large majority of systems already use some sort of standardised transport. If the source format and the target format are standardised and free of proprietary rights, it is easy to implement transforms from one format to another. The International Dataspace Association (IDSA) calls those transforms "connectors". Connectors are used to make systems interoperable. The presence of standardized formats means easier interoperability, but isn't a guarantee in itself for interoperability as systemic conflicts may appear if systems are looked at in detail.

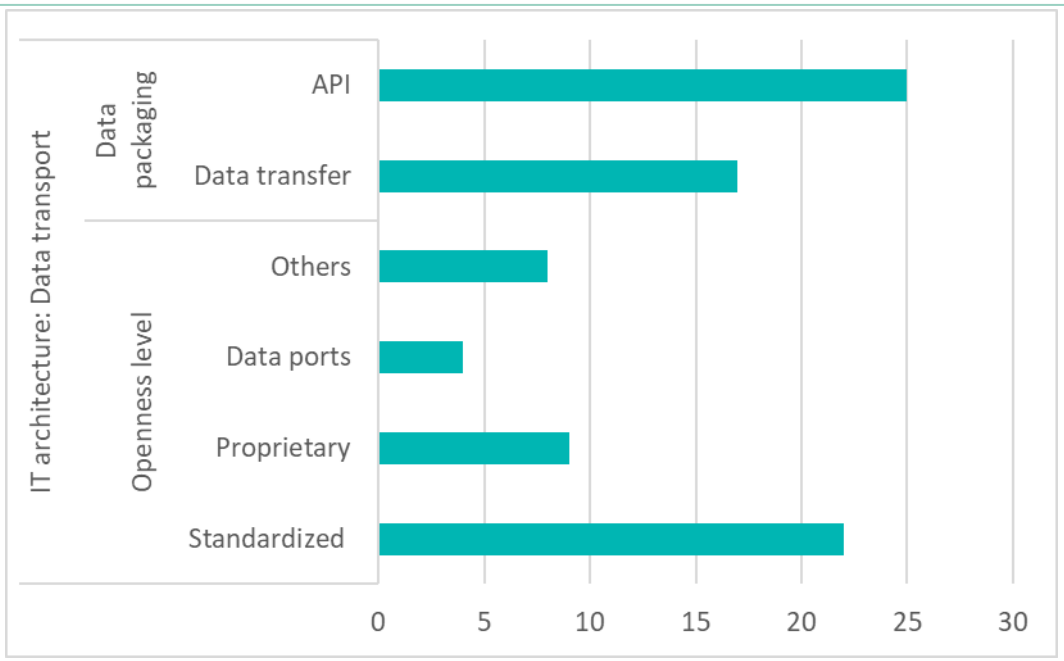


Figure 15 Initiatives' response to IT Architecture – Data Transport

Following with the "IT Architecture" – "Access control", captured in Figure 16, it can be noted that an advanced level of access control is used by 24 initiatives. This opens a follow-up categorisation of whether it is "role based" or "attribute based". Initiatives can select one or more of these options, but a preference towards "role based" advanced access control, with 18 initiatives, is evidenced. Most projects thus anticipate a complex societal model and accommodate that complexity already.

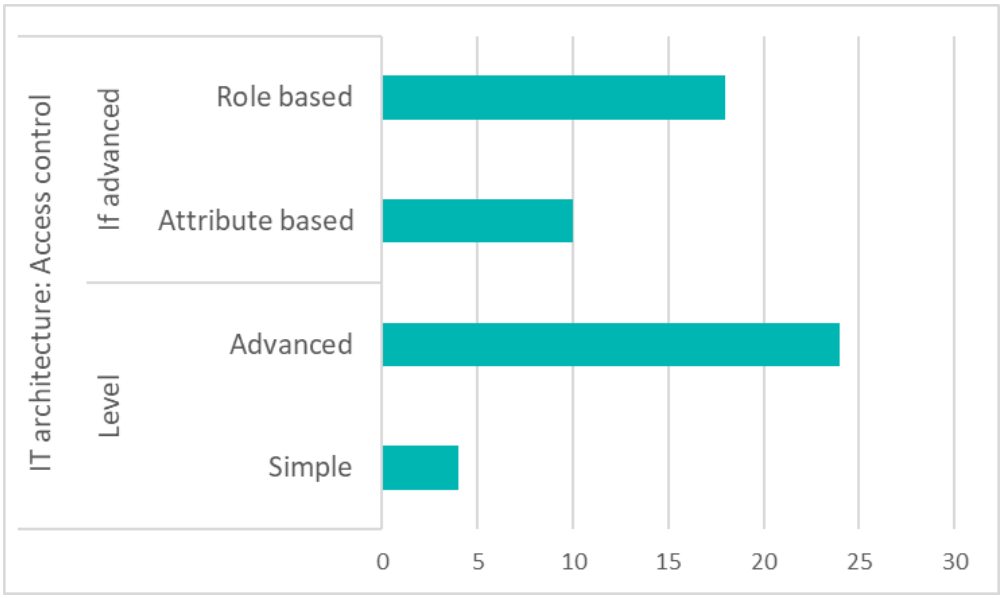


Figure 16 Initiatives' response to IT Architecture – Access control

Regarding the "data use" class, the responses displayed in Figure 17 show a preference to different types of data use other than "enforcement" or "labelling", such as 'role based' and 'GAIA-X labeling concept,' indicating the potential for further investigation into this aspect. The counts in the figure clearly show that labeling and the use of other policy frameworks is decisively more widespread than the technical enforcement of data use. This does not imply that the other options are not enforced, because labeling can be enforced using contract law. What it does mean is that policy and labeling

play a much bigger role in DPP systems than enforcement. This also suggests a certain level of trust within those DPP systems.

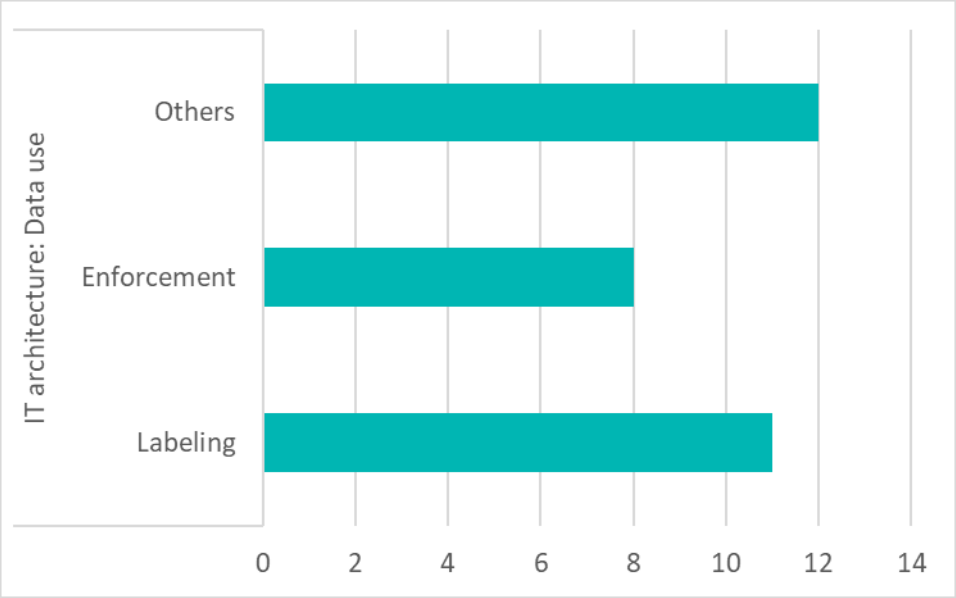


Figure 17 Initiatives' response to IT Architecture – Data Use

Finally, the data management features of the "IT Architecture" are captured in Figure 18. This item is subcategorised into the following four categories: (i) "traceability", (ii) "data protection", (iii) "convenience", and (iv) "evidence". Starting from "Product - Traceability", tagging options as QR code, NFC or RFID are validated by 21 initiatives, while other types of traceability, beside tagging, are also noted to be relevant by a third of the approached initiatives. This is a similar question to the one on data carriers. Following with the "data protection", the anonymization option is favoured by 17 initiatives, followed by other types of data protection and privacy enhancing technologies (PETs), including 'Data Contracts', 'Tokens' and authentication, data encryption, and access control. Regarding the "convenience", wallets are seen to be more prominent than data ports. 18 initiatives selected "other type of data convenience" as relevant and include data space connectors, mobile applications, web interfaces, portals and simple user management schemes (public and private levels). Finally, the "evidence" of data management shows a slight preference to verifiable credentials. Yet significant responses are noted for blockchain and other evidence types which include 'validation through schematrons', blockchain, 'daily operations evidences', self-declarations and certified credentials, transaction certificates, scope certificates, audits, certifications and other supporting documents. This was designed as an open question in order to see how advanced DPP projects are in their use of cutting-edge data usage control and how they organize themselves. A strong response on product traceability was expected given the community asked. It was also expected that anonymization is used to overcome privacy concerns where personal data is not needed. The strong use of verifiable credentials is, in turn, a slight surprise but coincides with the relatively widespread use of Distributed Identifiers (DIDs). There are relations between points in this question. There is a certain overlap if a verifiable credential is stored on a blockchain. This source of very light bias has not been corrected.

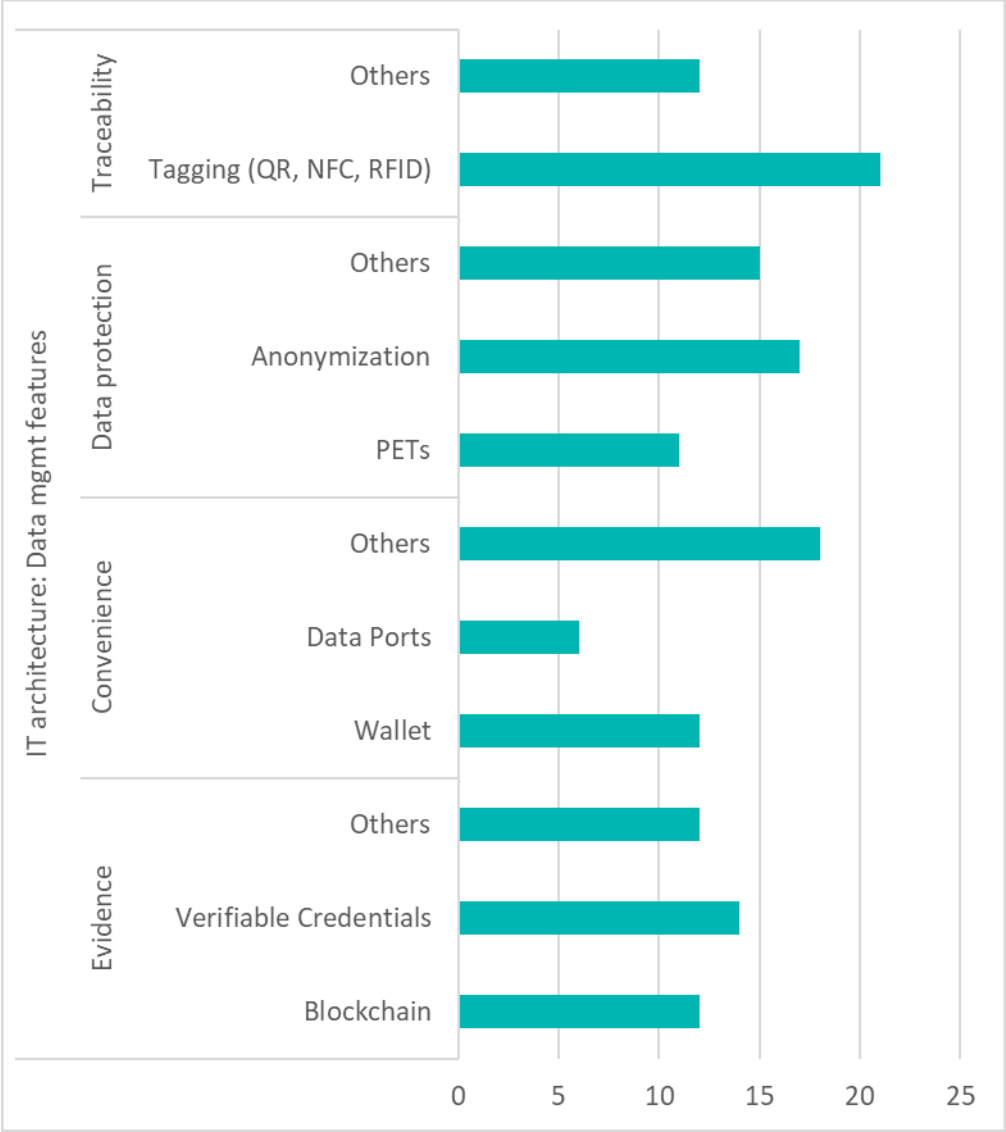


Figure 18 Initiatives' response to IT Architecture – Data Management Features

5. Lessons learnt and DPP-oriented reference architecture insights

In this section, the quantitative analysis of the technical trends and solutions adopted in existing DPP-related initiatives, reported in the previous section, is compounded by a qualitative analysis of the macro-trends, in view of the alignment of the described benchmarking activity with the ESPR Proposal goals. The next section summarises the main lessons learnt while Section 5.2 discusses recommendations to be considered and addressed in future work within CIRPASS Work Package 3 (WP3) as well as in the framework of the ongoing DPP-related actions at European level.

5.1 Lessons learnt

The reported quantitative analysis provides a comprehensive view of the macro-trends within the DPP-oriented initiatives under development. Some general lessons learnt and take-home messages are qualitatively summarised in the following:

- *Variety of solutions and lack of a dominating approach*. As shown in the analysis, the absence of a dominating approach is evidenced. For example, Figure 18 shows an almost uniformly distributed set of solutions concerning the data management features of existing DPP-related initiatives. These characteristics reflect the current under-defined DPP requirements and the bottom-up nature of the existing DPP initiatives, leading to further opportunities for the definition of requirements for reference standards (WP4) and for clear guidelines for implementation (WP3), leading to recommendation R1 in the next section.
- *Granularity of the DPP implementation:* Within the ESPR Proposal document 2022/0095 (COD), item 27, page 25, the following statement on the granularity of the DPP data is reported "*To take account of the nature of the product and its market, the information to be included in the product passport should be carefully examined on a case-by-case basis when preparing product-specific rules. To optimise access to the resulting information while also protecting intellectual property rights, the product passport needs to be designed and implemented allowing differentiated access to the information included in the product passport depending on the type of information and the typology of stakeholders. Similarly, to avoid costs to companies and the public that are disproportionate to the wider benefits, the product passport should be specific to the item, batch or product model, depending on for example the complexity of the value chain, the size, nature or impacts of the products considered".* The quantitative analysis reported in Figure 9 shows a good alignment with this view, in the sense that the granularity of the DPP data is differentiated with respect to the specific sector and context of application of the initiative. It would be of interest to further investigate the reported initiatives with the objective to analyse the possibility to generalise the links between the sectors and the suitable granularity level of the DPP information in a first instance, and, later, to correlate the characteristics of a sector and the required granularity level, with the objective of generalising the approach to new sectors and products in the future. This observation gives origin to recommendation R2 in the next section.
- *Centralised vs. Decentralised approach:* The graphs in Figure 13 and Figure 14 show an equal share of initiatives considering centralised or decentralised ID issuing (minting) and DPP data storage approaches. Although it is true that a non-negligible share of the reported initiatives propose hybrid, federated solutions a clear positioning towards this technical characteristic towards future DPP architectures should be achieved (WP3). Indeed, although this aspect is technical, it leads to important business and eco-system implications that should be thoroughly discussed and investigated in the future towards an industry-accepted, fair and balanced business implementation. Within the ESPR Proposal document 2022/0095 (COD), item 32, page 26, the following statement on the data system is reported: "*To ensure that the product passport is flexible, agile and market-driven and evolving in line with business models, markets and innovation, it should be based on a decentralised data system, set up and maintained by economic operators. However, for enforcement and monitoring purposes, it may be necessary that competent national authorities and the Commission have direct access to a record of all data carriers and unique identifiers linked to products placed on the market or put in service*". This gives origin to recommendation R3 in the next section.
- *Analysis of stakeholders developing DPP-initiatives*. Figure 19 reports the analysis of the type of stakeholders leading the development of the analysed DPP-initiatives from the point of view of the IT architecture, including industrial consortia, sector-specific solution providers, cross-sectorial solution providers, EU or member state project consortia, research organisations and other types of stakeholders. This analysis is meaningful to understand the

players that will be involved in the DPP architecture development and market uptake. As the figures suggest, the analysis of the developing stakeholders does not reflect homogeneity. In particular, although industrial stakeholders, mainly start-ups, dominate the market, an important share of initiatives emerging from research and innovation project consortia is evidenced, at European and local levels. This consideration further strengthens the innovative nature and the industrial value-chain transformation potentials of the DPP concept. In parallel, a future challenge will be to promote and identify viable routes for the exploitation and industrial market uptake of these initiatives, giving origin to recommendation R4 in the next section.

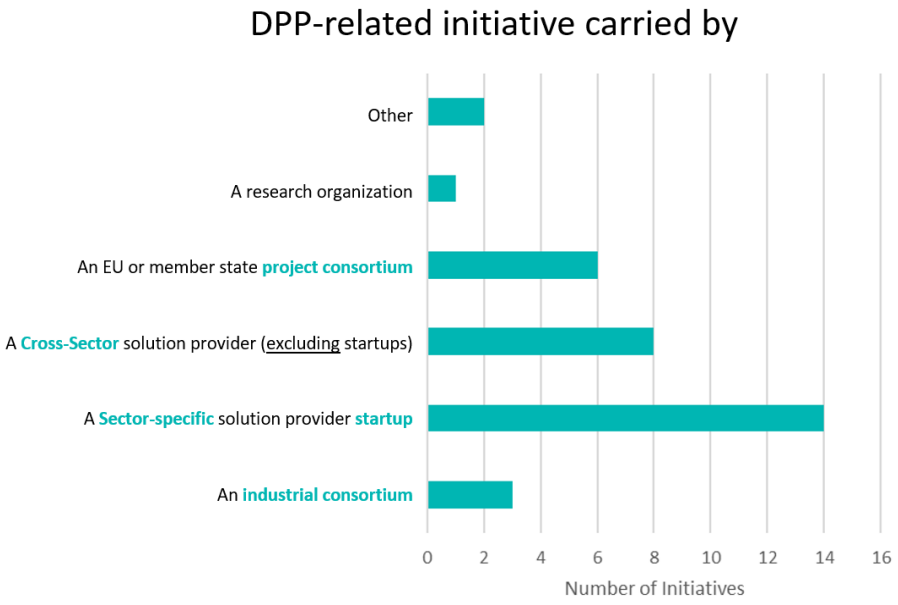


Figure 19 Stakeholders leading the development of DPP initiatives.

5.2 Recommendations and outcomes

In this section, the aforementioned considerations are translated into six recommendations for future actions that would support an efficient, widely accepted and fair deployment of the DPP concept at European level.

- *R1: Focus on standards and knowledge formalisation activities for variability reduction.* Large variety in the characteristics of the DPP initiatives under development has been shown. The activities of the CIRPASS project should consider this baseline situation and should contribute to the systematisation of knowledge and the harmonisation of requirements, in view of the ESPR Proposal goals. Two mechanisms can be fostered and synergically developed to target this objective. On the one hand, the existing standards should be revised and positioned according to the four pillars of a DPP system, providing a clear overview on the existing gaps and opportunities towards future standardisation initiatives (WP4). On the other hand, the functional and non-functional requirements of a DPP architecture should be collected and formalised by involving multiple stakeholders, with the objective of identifying a DPP system architecture blueprint that is coherent with these requirements and aligned with the ESPR Proposal (WP3). The combination of these knowledge formalisation and systematisation activities is expected to contribute to the emergence of better focused and interoperable DPP architecture implementation initiatives, featuring common minimum requirements and

characteristics, while maintaining free space for additional customisation and differentiation features.

- *R2: Customise the suitable granularity levels on a sector-to-sector basis and/or on a stakeholder-to-stakeholder basis*. As commented in the previous section, the ESPR Proposal will allow differentiated access to the DPP depending on stakeholder access rights. In the future, such mechanism might be further exploited to further customise data needs of stakeholders as well as sector-dependent granularity levels of DPP data. While the second requirement is aligned with the DPP-related initiatives under development, as reflected by the reported analysis, more emphasis should be devoted towards the customisation of data needs, in terms of granularity and specific instances, that would support an increase in efficiency and performance of the operations performed by different stakeholders within the targeted cross-sectorial circular value-chains. This activity shall be systematically promoted through a stakeholder-to-stakeholder data requirement collection, an in-depth analysis of the most suitable granularity level demanded by each stakeholder and, in a second stage, through the transferring of these findings into technical requirements for the DPP system, ultimately leading to the validation and KPIs measurement within representative demonstration pilots. Some of the reported initiatives have already started this process. An interesting approach, that shall be further investigated within the WP2 of CIRPASS, is the introduction of user-oriented "*digital services*". These services are made interoperable with the DPP system and exploit DPP data to provide specific functionalities to different stakeholders of the circular value-chain as well as to the entire eco-system, including public administration, municipalities, customs, and citizens.
- *R3: Provide a clear definition of "decentralised" system, to be adopted by DPP-oriented initiatives.* As shown within the reported analysis, although the ESPR Proposal expectations are towards decentralisation of the DPP system, the DPP initiatives under development present a multitude of solutions, freely interpreting this concept and positioning at different levels of an ideal scale between full centralisation and full decentralisation, with a significant range of initiatives targeting a federated approach. The provided CIRPASS WP3 classification framework has made an attempt to contribute to clarifying this relevant concept, differentiating between the "ID minting (issuing)" and the "data storage" phases. Given the strategic implications of this aspect, having important business-related impacts, a more structured definition of the "decentralisation" concept is envisaged. This would support both DPP system developers in increasing the compliance with the ESPR and future industrial DPP issuers in selecting ESPR-compliant DPP solutions among the potential plethora of solutions that will be made available in the market by different IT solution providers in the future.
- *R4: Monitor and foster the industrial uptake of the promising platforms emerging from ongoing EU projects*. As shown in the reported analysis, a non-negligible set of relevant DPP-oriented initiatives is emerging from ongoing European and local projects. Although these initiatives may (i) privilege the focus on specific stakeholders of the circular value-chain, (ii) be focused on specific sectors, (iii) consider only low granularity levels (product model), and (iv) consider only nominal product data and not in-use product data, a considerable set of DPP-system implementations and demonstration pilots is reasonably expected as outcomes emerging from these projects. However, these results are expected to cover an intermediate maturity and technology readiness level that may require further investments and clear exploitation and market uptake strategies before achieving the required industrial maturity level. It will then be advisable to ground and elaborate on the existing, publicly funded, DPP

efforts and pilots emerging from these projects in the transition towards the industrial implementation of the DPP concept. A first move could be represented by the creation of a permanent aggregation of projects, through, for example, project *Clusters*, animated by the CIRPASS Consortium to collect best practices and guide the individual project developments towards market readiness and compliance with the ESPR. Within this new framework of cross-project interaction, another concrete opportunity would be to identify "lighthouse" initiatives among the individual project demonstrators that may be used as first success stories to boost the DPP eco-system maturity towards future adoption.

- *R5: Adopt the CIRPASS reference framework for systematic DPP initiative mapping:* This deliverable reported a first classification framework to map specific characteristics of DPP-related initiatives. The reported results showed that the framework well supports benchmarking activities and helps positioning DPP systems according to different technical characteristics, in synergy with the demanded features described in the ESPR Proposal. Based on the experience gained in this first mapping attempt, it would be then advisable to improve this classification framework and make it a dynamic and systematic tool to support developers, that can better verify the compliance to the ESPR, and future industrial users, that can more consciously select the most suitable market solutions. In this context, developers could be invited to position and map their DPP approach and IT architecture with respect to the reference framework, still leaving space for customisations and ad-hoc developments.
- *R6: Publish the set of data gathered within CIRPASS as open research data, promoting wider analysis by the scientific community.* During the activity of the WP2/WP3/WP4 task force, a relevant set of structured data on more than 90 DPP-initiatives has been populated. An interesting idea would be to publish the gathered structured data as open data, with the objective to foster additional research activities performed by scientists outside the CIRPASS Consortium aiming at extracting and generalising knowledge grounded on these data. For example, the research questions and hypotheses posed within item 2 in the previous sub-section could be further investigated and answered by a higher order analysis of the correlations between sector characteristics and adopted DPP granularity levels.

The set of recommendations are summarised in the following table.

Table 3 Summary of recommendations

ID	Title	Expected outcomes	Target stakeholder(s)
R1	*Focus on standards and knowledge formalization activities for variability reduction*	Contribute to the emergence of better focused and unified DPP architecture implementation initiatives	CIRPASS consortium
R2	*Customize the suitable granularity levels on a sector-to-sector basis and/or on a stakeholder-to-stakeholder basis*	Increase user-orientation, achieve effective use-case definition, supporting the real needs of different stakeholders in the cross-sectoral circular value-chains.	CIRPASS consortium, European Commission, DPP initiative developers.
R3	*Provide a clear definition of "decentralized" system, to be adopted by DPP-oriented initiatives*	Provide the IT community with clear technical definition of key ESPR Proposal requirements, to achieve wide compliance.	CIRPASS consortium, European Commission

R4	*Monitor and foster the industrial uptake of the promising platforms emerging from ongoing EU projects*	Ground on existing, publicly funded, DPP efforts and the related pilots to establish "lighthouse" initiatives to boost the DPP eco-system maturity towards adoption.	European Commission
R5	*Adopt the CIRPASS reference framework for systematic DPP initiative mapping*	Develop a tool for the dynamic and systematic mapping and positioning of the DPP initiatives under development, supporting future industrial users in the selection of the most suitable market solution.	European Commission, DPP initiative developers.
R6	*Publish the set of data gathered within CIRPASS as open research data, promoting wider analysis by the scientific community*	Provide opportunities to perform a wider analysis of the gathered data. Foster the maintenance and continuous update of the CIRPASS data repository.	CIRPASS consortium

6. Conclusions and future activities

This deliverable reported the main outcomes of the activities performed within T3.1 of WP3 concerning the benchmarking of existing DPP-oriented reference architectures. A common classification framework has been proposed to support the mapping of the existing solutions from the point of view of the adopted reference architecture characteristics. The activity has been conducted in close cooperation and synergy with the other related tasks of CIRPASS, in an open and inclusive environment with the objective to gather the largest possible set of insights on the overall DPP-related architecture implementation trends. Highlights are also provided on a subset of initiatives, already having moved a step towards the implementation of DPP-oriented IT architectures, at different levels of maturity. The subsequent analysis led to the identification of relevant macro-trends and specific implementation aspects that will form the basis to support the next activities of WP3. In particular, the existing gaps for supporting the implementation of the core aspects reported in the ESPR Proposal documentation have been discussed in view of a more in-depth analysis that will be carried out in the remaining activities of WP3. A set of six high-priority recommendations are also reported that, if properly addressed, could accelerate the wide market penetration and acceptance of the DPP concept within circular industrial value-chains.