Product Passport through Twinning of Circular Value Chains

Deliverable 3.1

Product Passport and Certification Tool v1

WP3: CRIS Integration and Deployment

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Executive Summary

This deliverable provides the first version of the Digital Product Passport framework of the Plooto project. It describes an initial approach for implementation, structured around four distinct stages: configuration, agreement, sharing, and termination.

The presented stages provide a roadmap for stakeholders to collaboratively develop and utilize the DPP, driving informed decision-making and promoting circular economy.

This methodology provides a structured framework for managing digital product passports, with flexibility for future enhancements based on evolving requirements and feedback.

This version is the first iteration of the DPP tool in Plooto project. Any updates or new functionalities will be reported in D3.2.

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1 Introduction

1.1 Purpose and Scope

This deliverable provides an overview of the intermediate progress of Digital Product Passport (DPP), implemented in the Plooto project. Towards this direction, it introduces the initial strategy for digital product passport implementation, structured around four key stages and provides guidance on the procedures entailed within each of these stages. Furthermore, this document describes how blockchain contributes to establishing trust in the exchange of product information within the system.

It has to be noted that for reasons of completeness (and in order the reader to have a reference for the DPP) the following sections have been retrieved from deliverable D1.5 "CRIS requirements and specifications v1":

- Section 2.1: Overall Strategy
- Appendix: DPP structures from the pilots

This deliverable is an interim version. It will be further enhanced and updated in.

1.2 Relation with other deliverables

This deliverable is a result of the requirements collection process from WP1. More particularly, it considered the proposed DPP structures from each of the Plooto pilots (D1.5) together with the basic framework for the DPP described also in D1.5.

1.3 Structure of the document

The document is structured as follows:

- Section 2 describes the overall structure of the DPP Framework
- Section 0 describes the implementation approach, the four phases of DPP lifecycle and the DPP tool navigation. For each phase we are describing both the user and component view.
- Section 0 describes how the DPP is ensured through blockchain implementation.

2 Overall Digital Product Passport Framework

The Eco-design Directive 2009/125/EC and proposed modifications, establish a framework to set eco-design requirements for specific product groups to significantly improve their circularity, energy performance and other environmental sustainability aspects. It aims to enable the setting of requirements for almost all categories of goods placed on the EU market, including: a) product durability, reusability, upgradability and reparability; b) presence of substances that inhibit circularity; c) energy and resource efficiency; d) recycled content; d) remanufacturing and recycling; e) carbon and environmental footprints; and f) information requirements.

In line with the said regulation, the Digital Product Passport (DPP) shall provide information about products' environmental sustainability (i.e., framework requirements). This information should be easily accessible, and help consumers and businesses to make informed choices when purchasing products, facilitate repairs and recycling and improve transparency about products' lifecycle impacts on the environment. Additionally, it shall enable to electronically register, process and share product-related information amongst supply chain businesses, authorities and consumers, which is intended to help public authorities to better perform checks and controls, create transparency, unlock circularity, and enable future and sustainable economic growth. [1] [2] [3] [4]

Plooto aims to set the foundations for the DPP in the three domains of the pilots. First of all, it is necessary to fill the information gaps along the supply chain, which are partially obscuring the actual footprint of a product, and to guarantee traceability throughout the product's life cycle.

In relation to the types of data to be included in the DPP and how to structure it, Plooto has looked at current initiatives, such as Product Circularity Data Sheet (PCDS)[5] and the Global Battery Alliance (GBA)[6].

Plooto will consider a generic approach to the DPP. This means that the platform should incorporate the necessary functionalities so that supply chains can model their own DPP format and monitor its execution and sharing in the operation phase. In principle, the DPP will consist of the following types of information:

- Textual information: about product, origin and anything that the company wants to incorporate into the DPP.

[1] https://oeil.secure.europarl.europa.eu/oeil/popups/ficheprocedure.do?reference=2022/0095(COD)&l=en
[2] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13682-New-product-priorities-for-Ecodesign-for-Sustainable-Products_en
[3] https://www.europarl.europa.eu/RegData/docs_autres_institutions/commission_europeenne/com/2022/0142/COM_COM(2022)0142_EN.pdf
[4] https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products/ecodesign-sustainable-products-regulation_en
[5] https://pcds.lu/pcds-system/#glossary
[6] https://www.globalbattery.org/action-platforms-menu/pilot-test/

- System Information coming from sensors, services or other sources: this information will be integrated through the telemetries monitored inside Plooto.

The proposed structure for the DPP is represented in Figure 1. The corresponding structure for the three pilots has already been defined and it is reported in Appendix A.

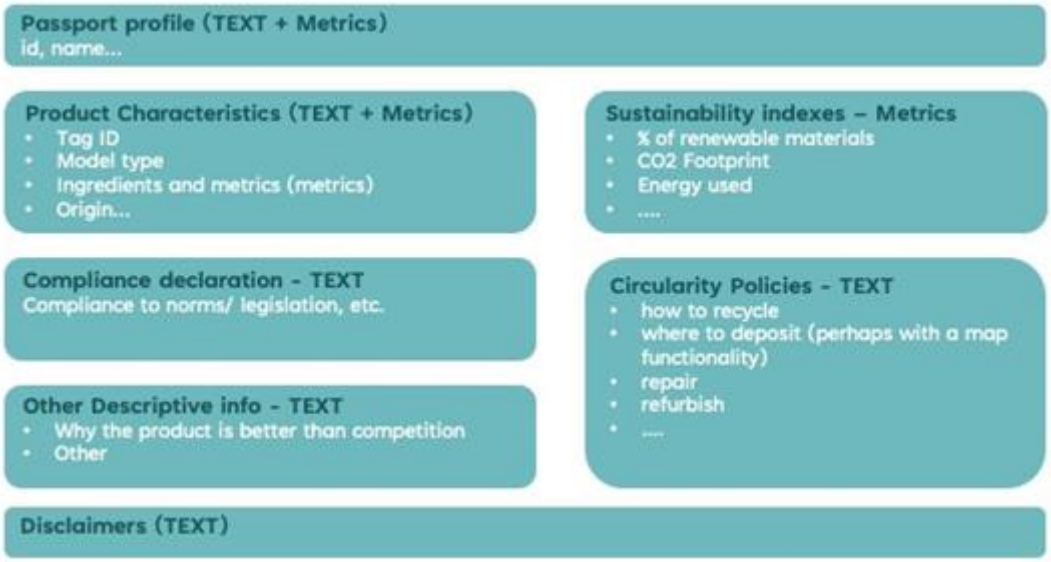


Figure 1: Plooto DPP data structure

The DPP needs to provide useful data to those who handle the product at the end, therefore it must be generated incrementally, adding data corresponding to individual components and material as it passes along the chain.

Therefore, when detailing the collaborations along the supply chain, the DPP corresponding to the (semi-)final product transmitted should be included among the agreed data shared.

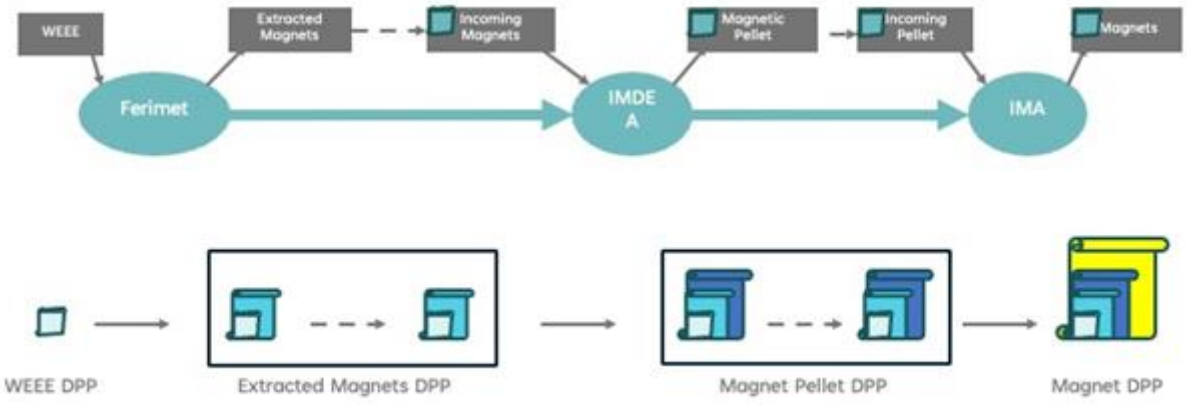


Figure 2: Linking assets with DPPs in value network

From an operational point of view, it means to link the shared asset and DPP in the value network. As it can be seen in Figure 2 , the final DPP links all the DPPs from previous steps, in this way it is possible to ensure traceability and assess the actual footprint of the final product.

Having modelled the supply chain as networks of DTs ensures the possibility to collect the necessary information that will be included in the passport from the corresponding (shared) assets and production telemetries.

Figure 3 provides a graphic overview of both business and operational actions of DPP implementation.

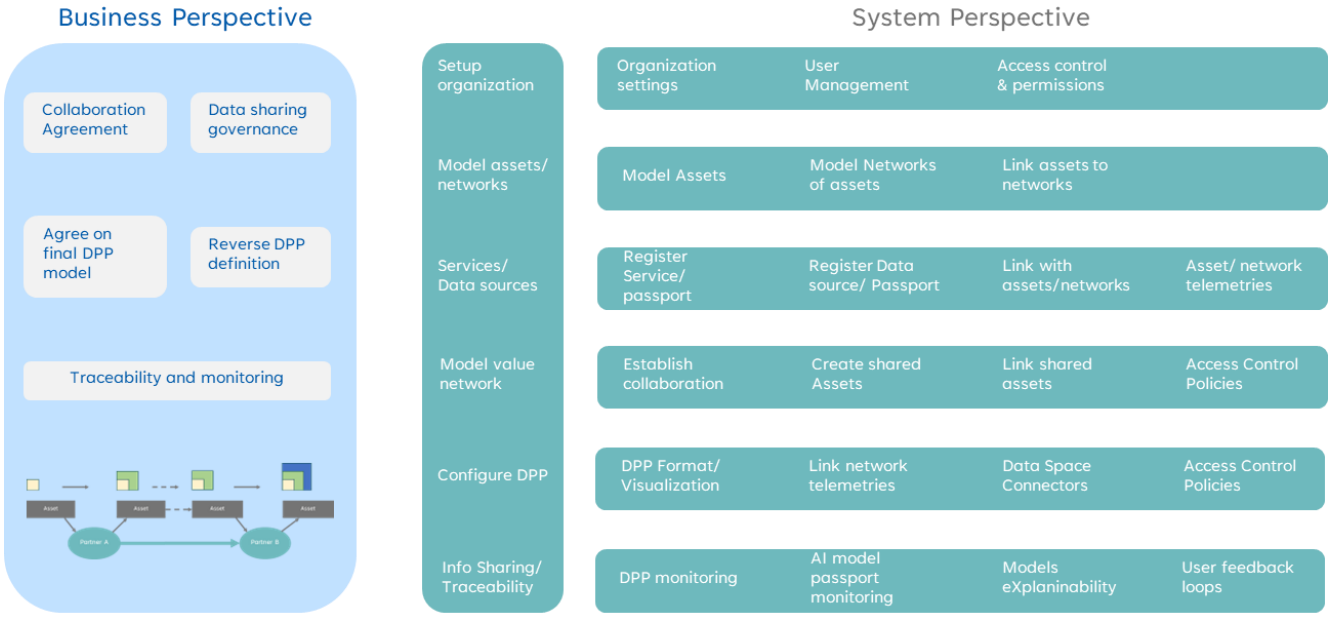


Figure 3: DPP main ICT framework and usage scenarios

The **business perspective** summarises the actions to be performed at business level to establish the value network. These include definition of the collaboration agreements, but also the identification of the data to be share along the supply chain (in compliance with Plooto data governance) and the definition of strategies for traceability and monitoring along the supply chain.

The **system perspective** details the actions to be carried out on the platform. Here the three bottom groups of functions are specific of the value network and allow to model the supply chain, configure the DPP, and define the data sharing and traceability strategies.

The DPP will be securely stored (blockchain) and can be scaled to be made available through readable artefacts (e.g. link in a web page, QR code, etc.) and depending on the case.

3 Implementation approach

Plooto DPP Framework is implemented based on a methodical four-stage process:

- **Configuration**: Refers to the creation of the DPP template. At this stage, the actor is required to set up the details and the structure of the passport. Specifically, the user fills in some basic information about the DPP, such as the name, collaborator, and description of the shared document and then customizes it by adding text and telemetry widgets, which include metrics and real-time data related to the asset they are providing to their collaborator. This setup ensures that all relevant product information is captured and presented clearly.
- **Agreement**: The collaborator that receives the created DPP is requested to review and agree to the provided document and the embedded information. This step ensures that all parties are aligned, and that the data shared in the DPP is accurate and accepted by everyone involved.
- **Sharing/monitoring**: Allows all parties to view the information that has been shared and received. During this stage, users can access the DPPs to see the details exchanged between collaborators. Additionally, they can monitor any updates to the shared data, ensuring that everyone stays informed about the latest information and changes. This stage promotes transparency and effective communication among all partners involved.
- **Termination**: Occurs when the creator of the DPP decides to terminate the existing template to replace it with a new one, potentially including updated information that is required.

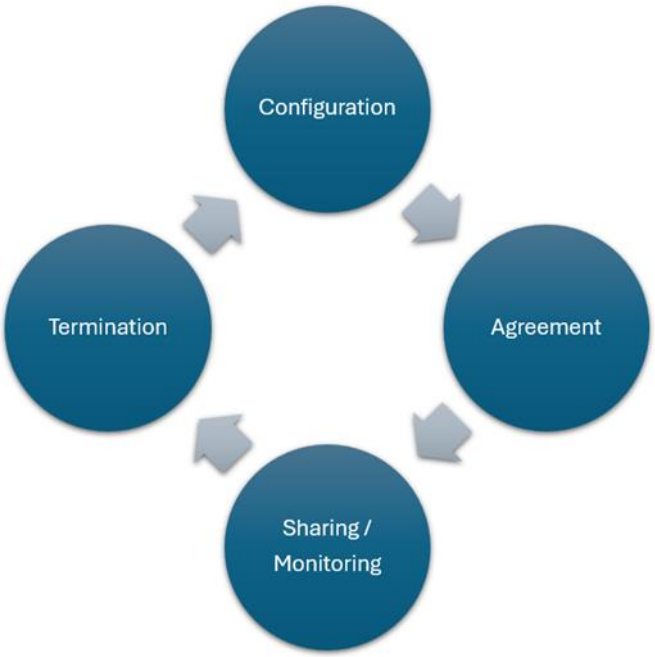


Figure 4: Plooto DDP structure

3.1 Basic assumptions

The DPP operates on several foundational assumptions that ensure its effective implementation and functionality. Specifically:

- Every DPP issued by an organisation comes from a data source derived from the organisation's data lake.
- Each DPP template is connected to a specific lot number or ID (see Figure 5).

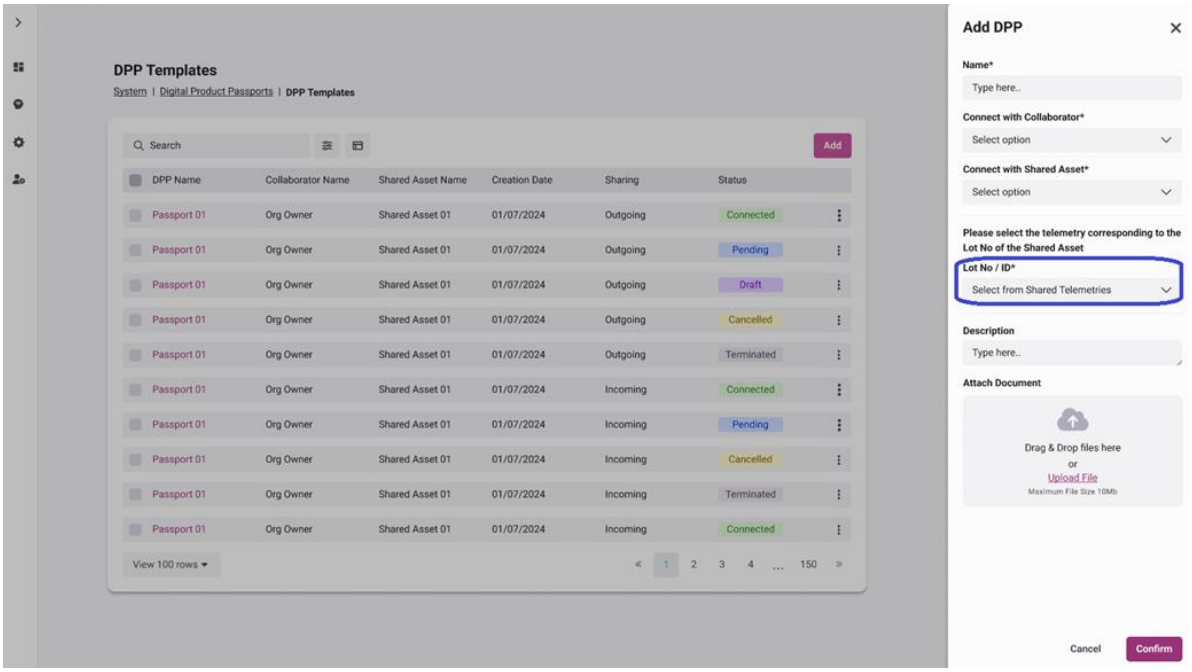


Figure 5: DPP creation

- Updated data are treated as instances of the original DPP template, allowing for continuous data integration without altering the fundamental structure of the DPP, as depicted in Figure 6.

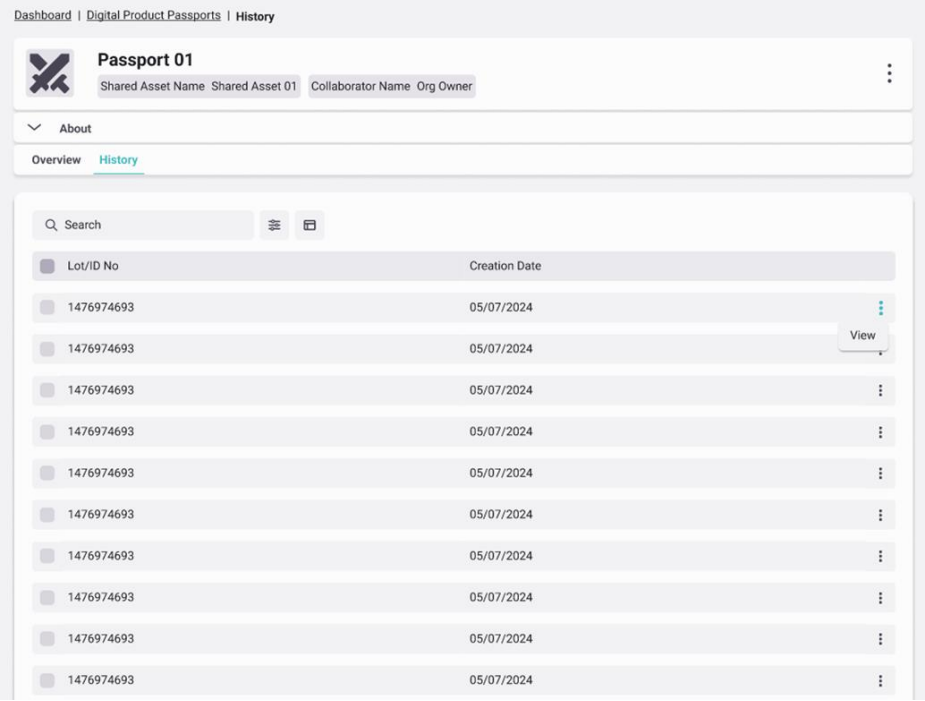


Figure 6: DPP history

- The creation of a DPP is considered a semi-automated process. While the initial DPP template is created manually by the actor, the instances of the DPP template are automatically generated when data sources are updated.
- Once a DPP has been shared, users cannot overwrite the existing document. Instead, they must create a new DPP from scratch if updates or changes are required. This ensures that all historical data remains intact and accessible, as presented in Figure 7.

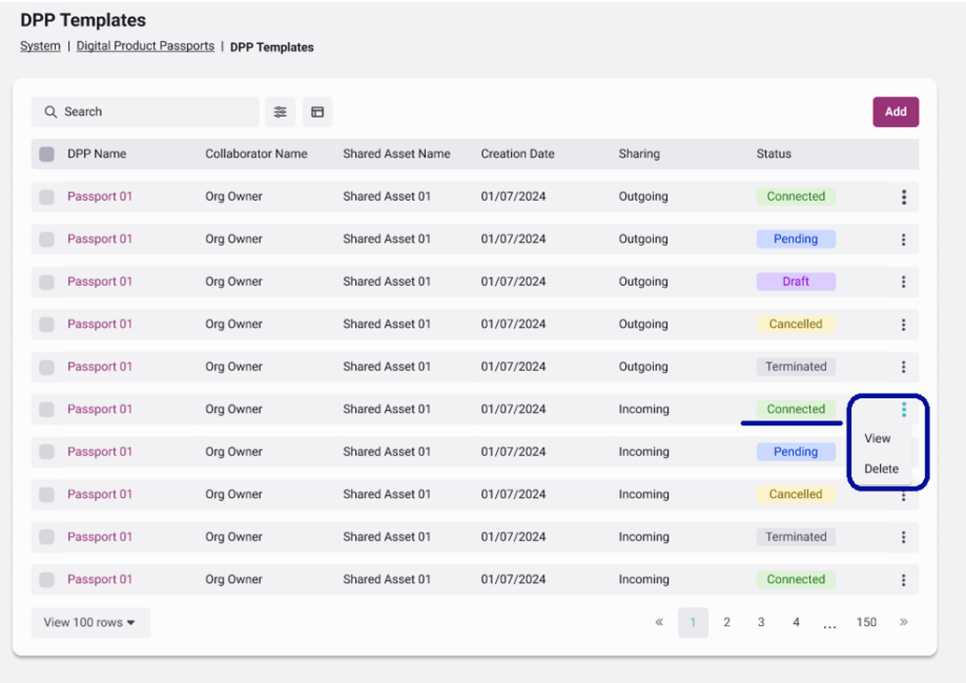


Figure 7: List of DPP templates and actions

- Only the collaborator that provides the asset is able to send a DPP to ensure the correct flow of information within the supply chain.

3.2 DPP Configuration

3.2.1 User view

The configuration stage is the first step in the DPP sharing process that begins with the DPP Template creation. This can be achieved via two paths. The first path requires the user to select a specific menu item (System/Digital Product Passports/DPP Templates), click on the ***Add New*** button and provide some details (name, Collaborator, Shared Asset, Lot No/ID and description of the shared document). The second way allows user to create a DPP directly into the profile of the shared asset with a collaborator, clicking on ***View*** option in the row of the collaborator to whom they want to send the DPP so and executing the same steps as followed in the first case. Both cases of the initial DPP creation views in Plooto platform are presented in Figure 8 and Figure 9.

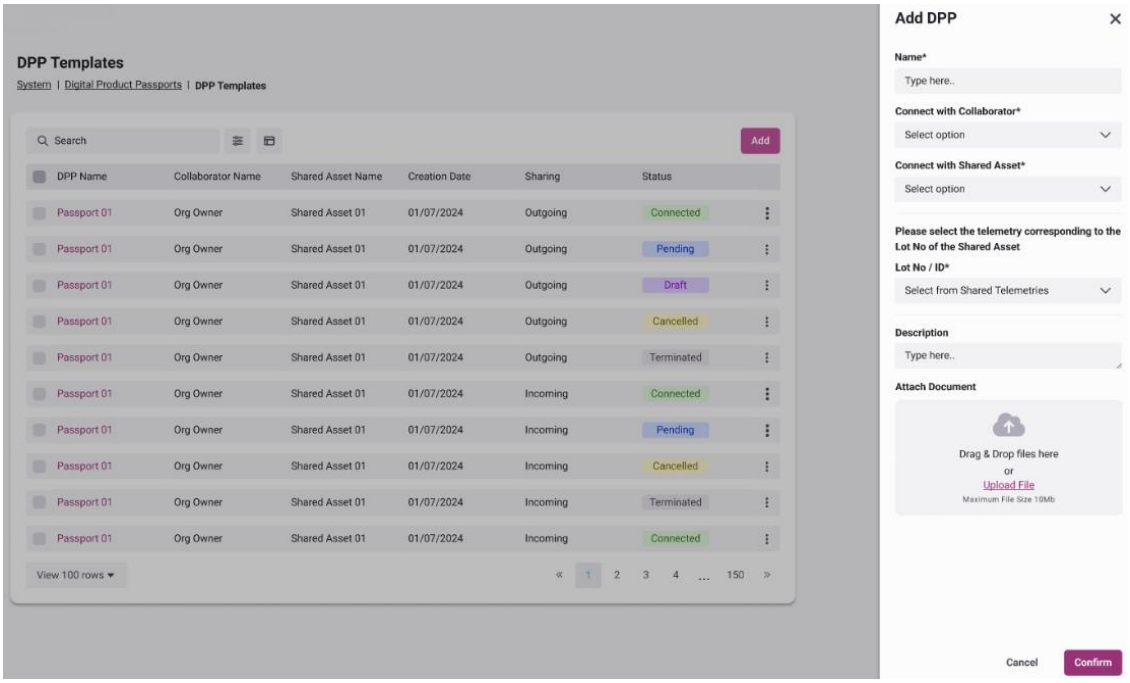


Figure 8: DPP template creation (overall list of DPPs)

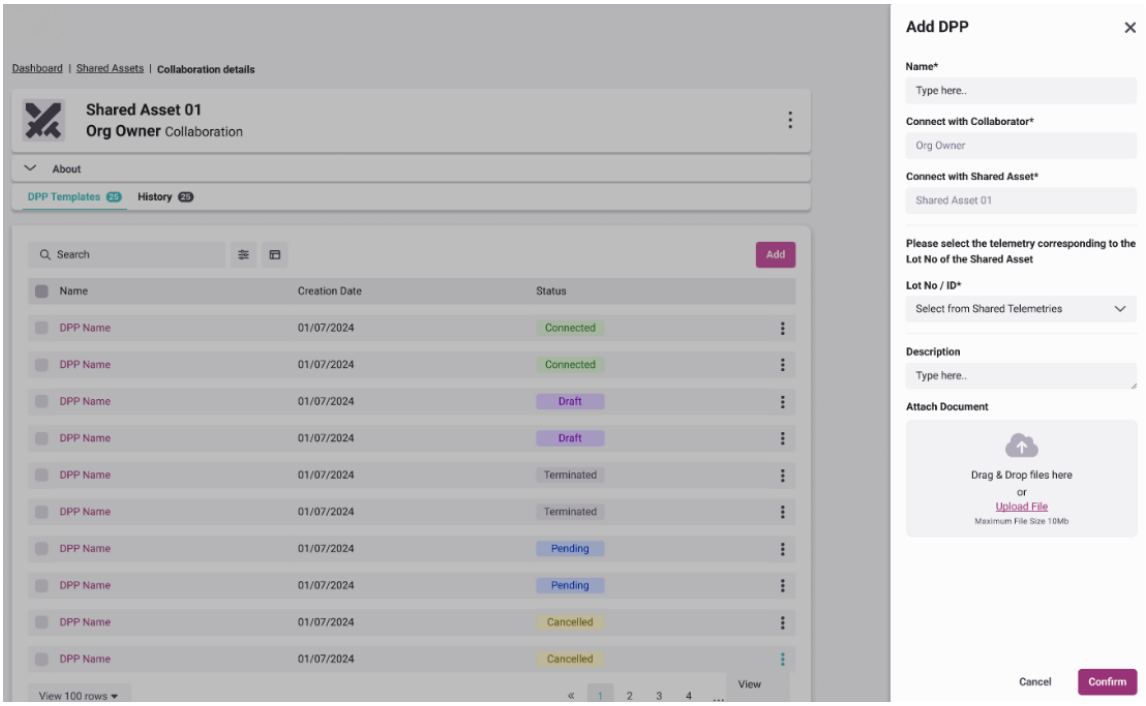


Figure 9: DPP template creation (from shared asset collaboration profile)

Once all the requested information is filled in, the system enables the configuration of the DPP. Specifically, the users can now click on the ***Customize*** button followed by the ***Add Widgets*** button, that allows them to select and include widgets that capture essential product information into the DPP, as presented in Figure 10.

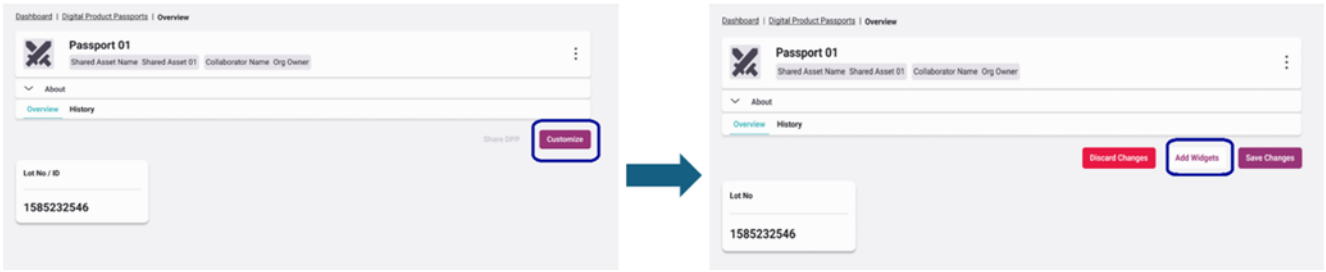


Figure 10: DPP customization process

In this version, two types of widgets have been created. Those widgets are represented in Figure 11 and they include:

- **Text Widgets**: Provide detailed information about the product's origin, materials used, environmental impact, manufacturing data, and production procedures.
- **Telemetry Widgets**: Depict properties and metrics through real-time data feeds, allowing for accurate monitoring of product characteristics and performance.

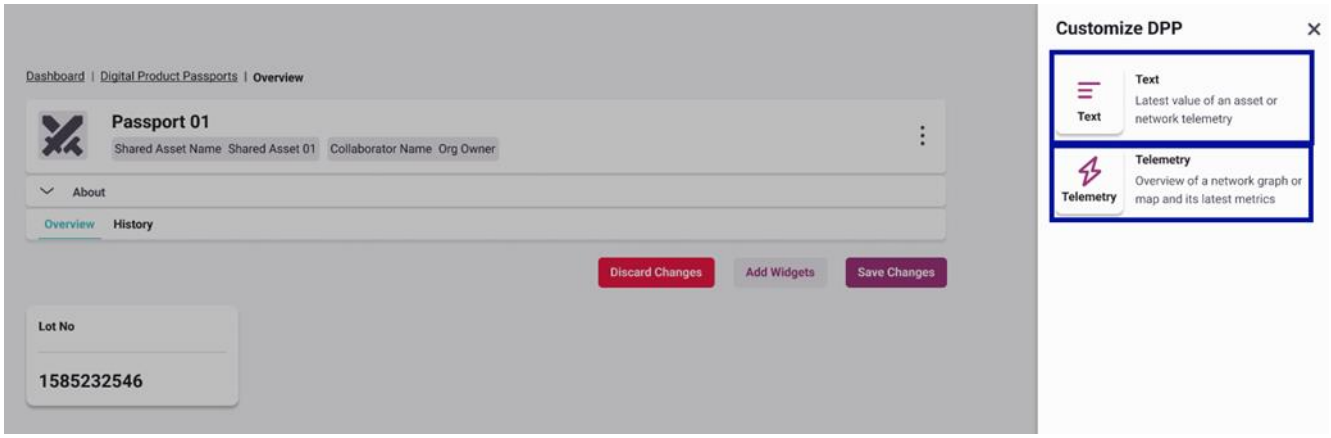


Figure 11: DPP widgets customization

Finally, the actor is able to review the created DPP, ensuring all information is accurate and complete. They can then either send it to the selected collaborator by clicking on the ***Share DPP*** option or save it as a draft version, in case further configuration is needed (Figure 12).

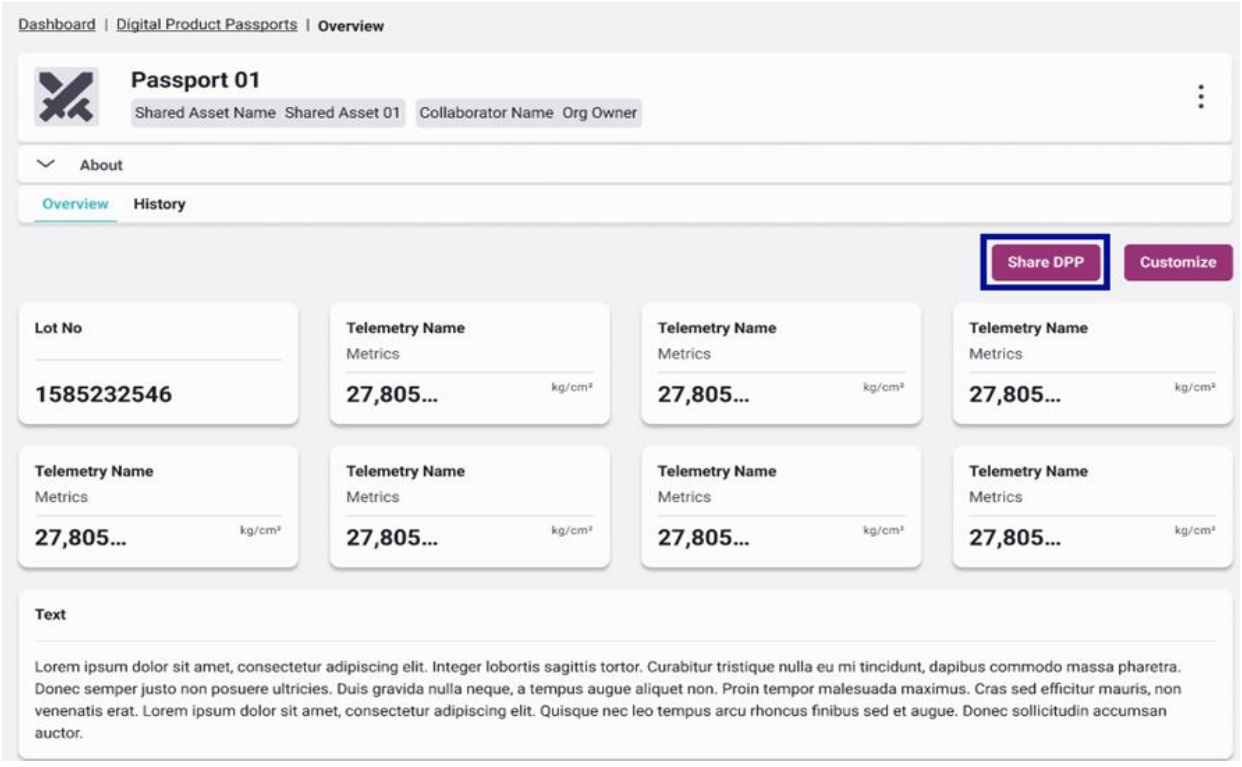


Figure 12: DPP overview

3.2.2 Component view

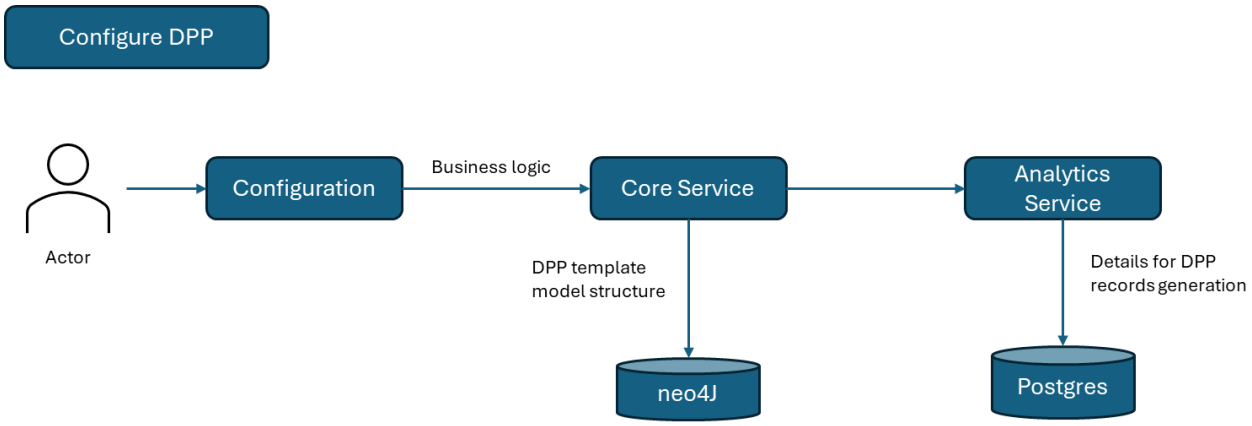


Figure 13: DPP configuration component view

In the configuration phase, the actor through a UI defines the DPP structure making use of the widgets functionality. When saved, the business logic of the DPP structure is stored into the core services, which stores the DPP template model structure in Neo4j.

The business logic is also sent to the Analytics services which stores in PostgreSQL the details for DPP generation based on the data streams.

3.3 DPP Agreement

3.3.1 User view

The agreement stage begins when one partner (Actor A) shares the created DPP with another partner (Actor B). For the DPP sharing process to be established, the receiver must review and agree to the received via email DPP document (Figure 14).

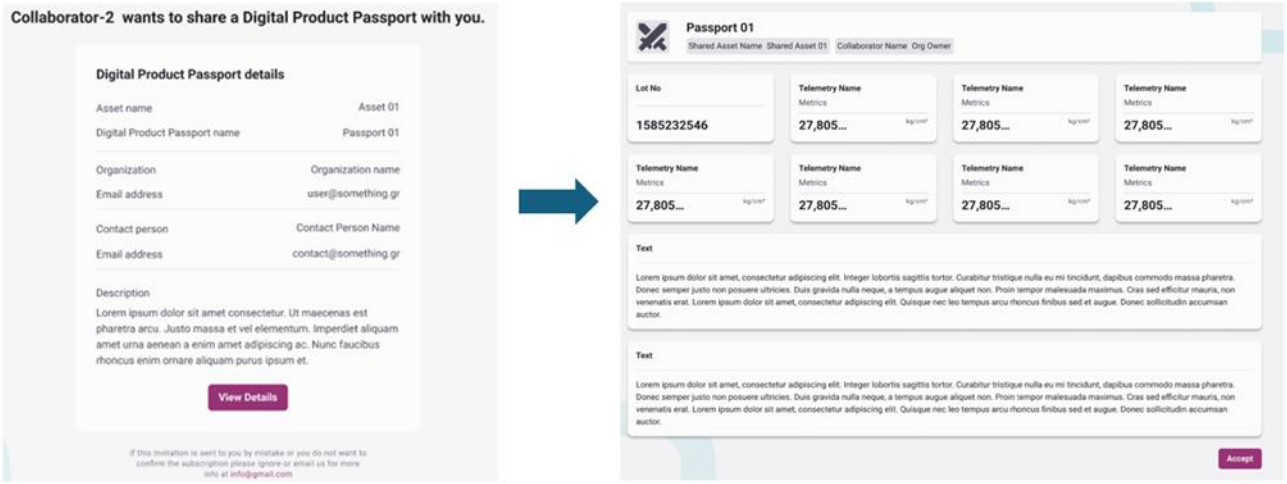


Figure 14: DPP agreement

This agreement ensures that all parties are aligned on the content and details of the DPP, maintaining data integrity and compliance.

3.3.2 Component view

The DPP Agreement follows the negotiation logic of the collaboration establishment. The Actor creates the DPP structure (for the particular collaborator) and publishes into the core service. The core services component sends an email/notification to the collaborative party which accepts the DPP structure. through Neo4j we monitor the statuses of the DPP negotiation (draft once published, connected once agreed, terminated).

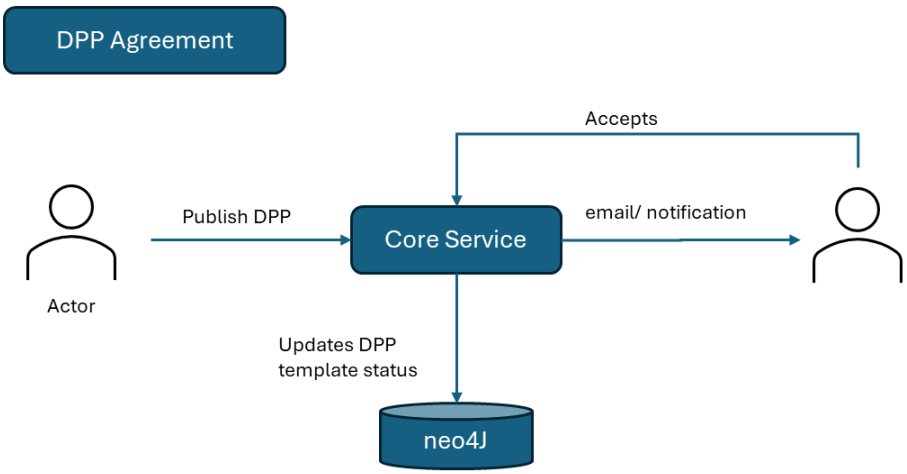


Figure 15: DPP agreement component view

3.4 DPP Sharing/Monitoring

3.4.1 User view

Once the Digital Product Passport has been reviewed and agreed upon by all stakeholders, the sharing process is established. Users can now view all the DPPs.

Specifically, DPP Templates are accessible by selecting the menu item (System/Digital Product Passports/DPP Templates), while all the records of each template appear when the user selects (System/Digital Product Passports/DPP Records), as presented in Figure 16 and Figure 17.

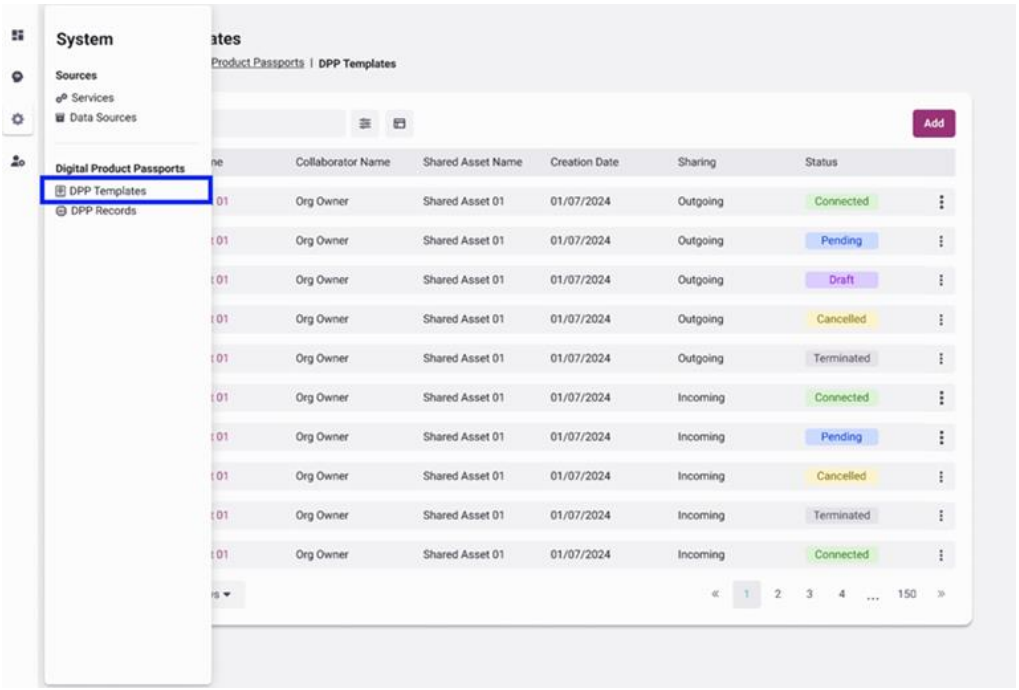


Figure 16: DPP templates

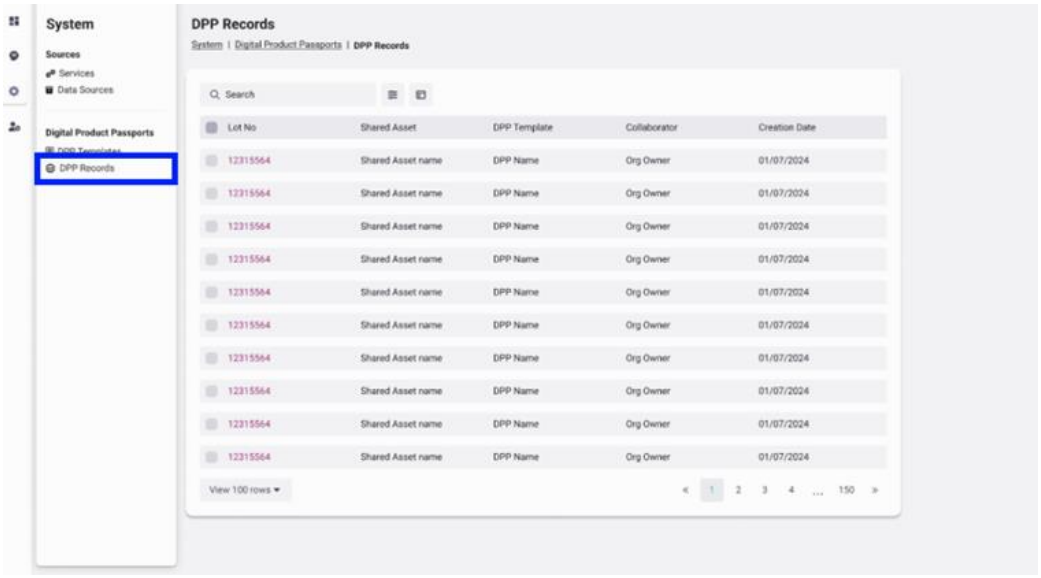


Figure 17: DPP records

Those user interfaces allow all parties to access the DPP templates they have created, as well as all the DPP instances (both shared and received) within each DPP template's history. Each DPP template includes a corresponding status (Connected – Terminated), reflecting the latest updates and ensuring that actors can easily track the current state of all shared information.

Additionally, by visiting the records page, users can search for DPPs using a lot number or ID. This feature ensures that they can access specific information at any time, providing easy and quick retrieval of relevant product data (see Figure 18).

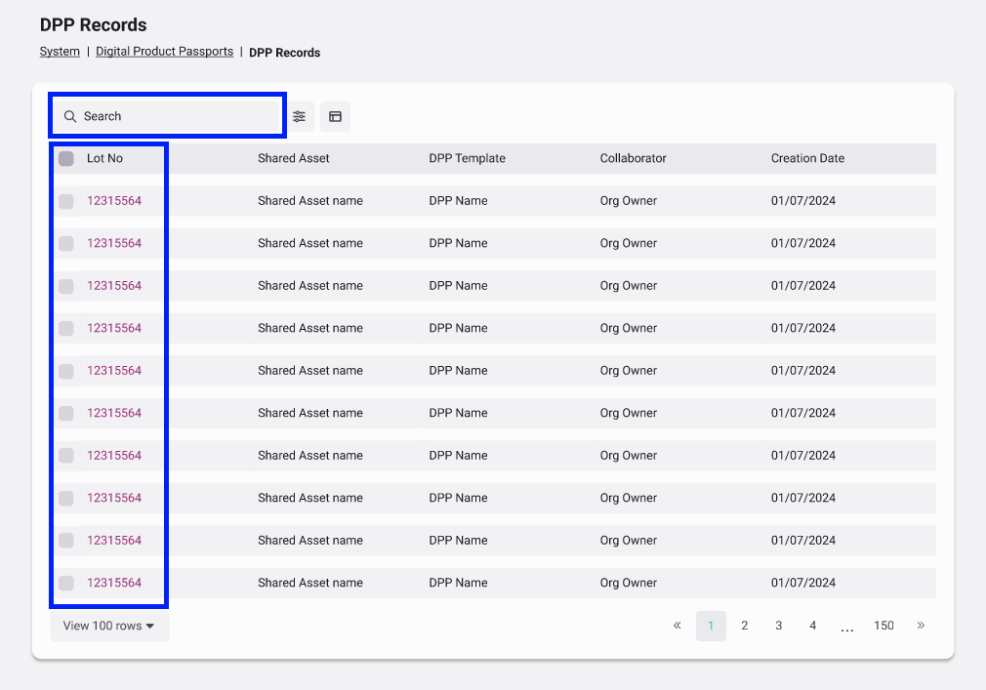


Figure 18: DPP record search by lot No/ID

3.4.2 Component view

From technical perspective, a DPP is generated from a data source: once a new entry in the source is created, this is passed through the RabbitMQ to the Analytics Service which reads data and generates the DPP record based on the details on how this is generated (see Figure 19).

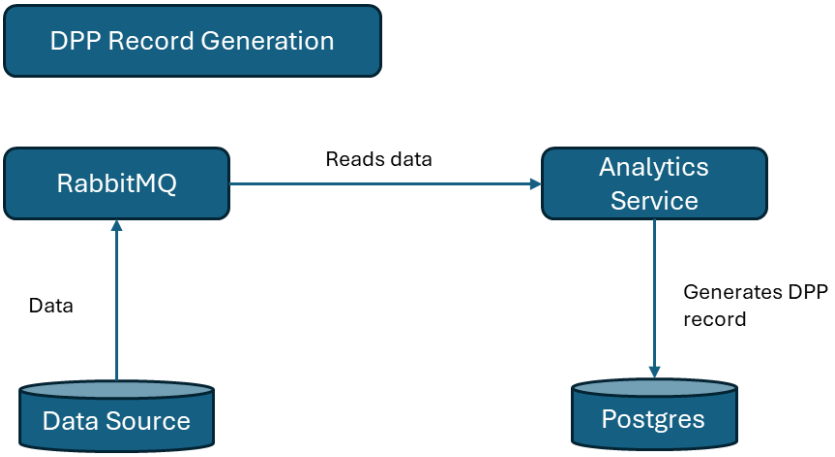


Figure 19: DPP generation component view

Once the DPP is generated it is shared with the collaborator through whom there is an agreement on DPP Sharing.

At the collaborator side, the actor can retrieve the details of the DPP through the UI. The Core services read the request, and checks against the business logic stored in neo4j (see configuration phase). Then the request is sent to the Analytics Service which retrieves the DPP record and then is sent back to the end user.

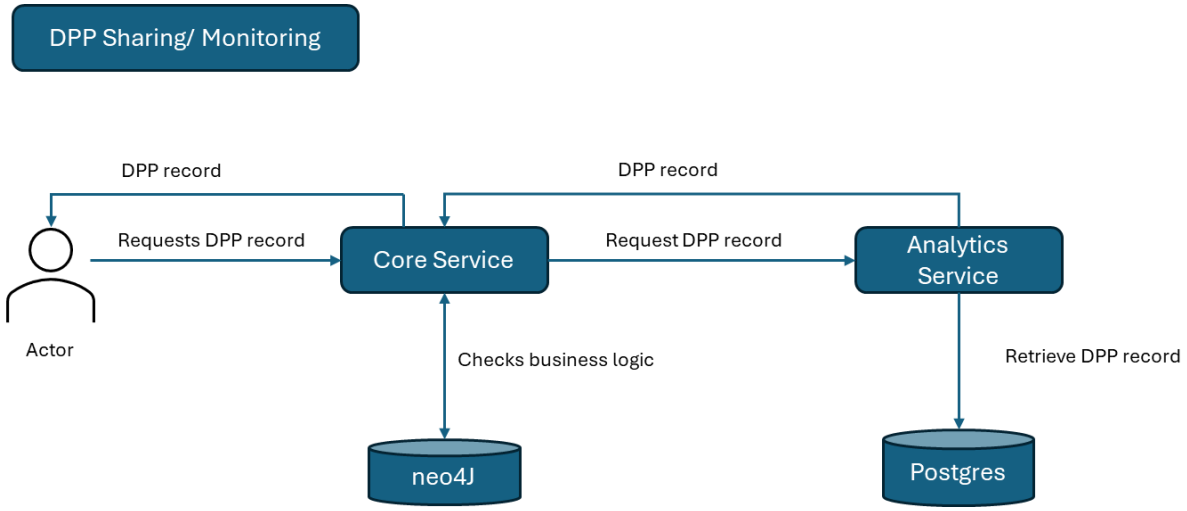


Figure 20: DPP sharing/monitoring component view

3.5 DPP termination

3.5.1 User view

The termination stage occurs when the initiator of the DPP decides to terminate the existing template. This step is necessary to create a new template, potentially with updated information that is required. This process is manually achieved, requiring the user to navigate to the connected DPP template and select the "Terminate" option available, as illustrated in Figure 21.

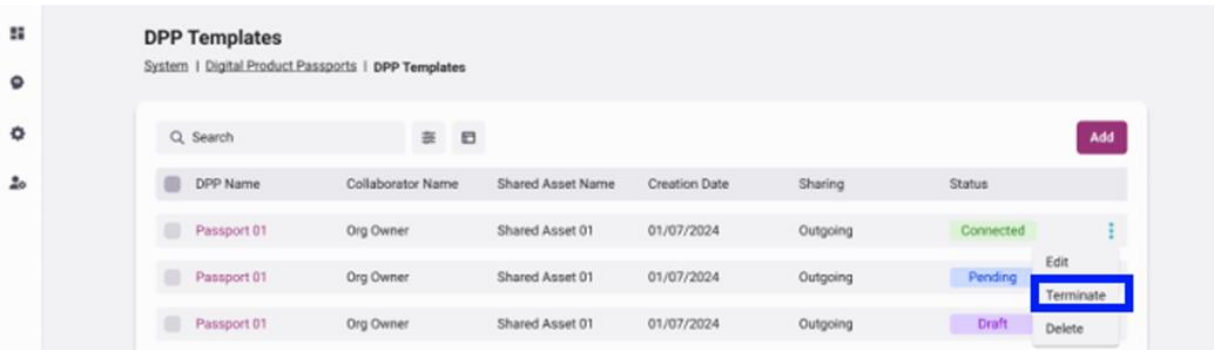


Figure 21: DPP termination

Once the existing template is terminated, a new DPP template can be created and shared, maintaining the integrity and relevance of the product information.

3.5.2 Component view

The component view is the same with Figure 20. The only difference is that the status of the DPP template in Neo4j is marked as “terminated”.

4 Ensuring Trust through Blockchain integration

4.1 Blockchain in supporting the lifecycle of Digital Product Passports

Blockchain technology is suitable and common approach to support Digital Product Passports (DPPs). The decentralized and immutable ecosystem that this technology offers are ideal for recording and verifying the lifecycle of DDPs, from creation, sharing, to termination. The integration of blockchain into the DPP framework and certification mechanisms that this technology offers, provide a robust mechanism for ensuring data integrity, transparency and trust among stakeholders. In the context of Plooto, we designed and developed an asset management framework to support the sharing of DPPs based on Hyperledger Fabric, while offering a blockchain explorer with a dedicated user interface that allows stakeholders to track and view records of transactions for further investigation and reassurance.

The use of blockchain within the DPP framework ensures compliance with data protection regulations and enhances security through:

- **Decentralization:** No single point of failure, reducing the risk of data tampering.
- **Immutable Records:** Ensuring that once data is written, it cannot be altered without detection. Providing an audit trail for all transactions.
- **Verification DPPs:** The blockchain ensures that a unique identifier of a DPP is stored securely and can be verified at any time, maintaining the integrity and authenticity of the documents.

4.2 Validation and Verification of DPP transactions

Integrating blockchain technology into a DPP framework provides a secure and immutable method for storing data. Blockchain's decentralized nature ensures that once data is written, it cannot be altered or deleted without detection, making it ideal for recording the entire lifecycle of products, from creation to termination. This immutability guarantees that every transaction and data entry is permanent and tamper-proof, fostering trust and reliability among stakeholders.

In the context of the DPP framework, this ensures that all data entries and transactions are accurate, consistent, and follow predefined rules. Each transaction on the blockchain is verified by multiple nodes within the network, ensuring consensus before any data is added to the chain. Additionally, external services can verify the existence and acceptance of a hash on the blockchain. This process confirms that the data, represented by a hash value, are indeed recorded on the blockchain and has been accepted by all relevant parties. To support the above features and the needs of Plooto, as an initial integration effort we have deployed a pre-configured blockchain network with the basic smart contracts needed. Each transacting entity is represented by its dedicated peer in this peer-to-peer network and abides by the same rules (smart contracts) that dictate the processes that this network follows.

The Hyperledger Fabric (HLF) framework employed to support the blockchain network supports smart contracts, known as chaincode, where each feature/rule is represented by a function in the code. An initial set of functions have been developed to facilitate the key features needed in the creation and sharing of DPPs. There functions govern the creation, reading, updating and deletion of agreements and transactions of DPPs.

The DPP lifecycle stages are currently supported with the following workflow integration:

1. **Configuration**: Function CreateAgreement is called to log the initial DPP Hash Value on the blockchain.
2. **Agreement**: The collaborator reviews and agrees to the DPP, the function acceptAgreement is invoked to update the blockchain, marking the agreement as "accepted".
3. **Sharing & Monitoring**: The immutable nature of blockchain ensures that once an agreement is recorded, it cannot be altered without consensus. Function getAgreement is used to fetch the current status and details of any or all the DPPs, providing real-time transparency.
4. **Termination**: When a DPP needs to be terminated and potentially replaced, the function deleteAgreement can be employed to remove outdated agreements, ensuring that only relevant and current information is accessible.

4.3 Certification and Blockchain Explorer

Blockchain technology offers certification and transparency over the transactions. Transparency is tightly associated with the ability to trace the records of transactions and one of the most significant advantages of integrating blockchain into DPP framework. Every transaction and data entry are time-stamped and linked to previous entries, creating a complete and unalterable history of the product's lifecycle. This traceability ensures that all actions, from the creation of the product to its final termination, are recorded and can be reviewed at any time by the members of the network. This level of detail is crucial for compliance, auditing, and ensuring the authenticity and integrity of the product information. By providing a transparent and traceable record, stakeholders can easily verify the provenance and history of each product, enhancing trust and accountability within the ecosystem.

To offer this functionality to the Plooto end users, we have deployed a Blockchain Explorer in which each transacting entity/organization can log-in using its credentials and inspect the actual records of the blockchain ledger. It provides a user-friendly interface to view, search, and analyze blockchain data, as can be seen in Figure 22 bellow. This is not part of the main PLOOTO interface, rather an important extension that allows for a deeper investigation of the transactions' history. For the DPP framework, the Blockchain Explorer offers several key benefits:

1. **Transparency**: Users can view all transactions and blocks, providing complete transparency into the DPP lifecycle. This transparency is crucial for building trust among stakeholders.

2. **Auditability**: The explorer allows for the auditing of all transactions. Each action taken on the blockchain (e.g., creating, updating, or deleting agreements) is recorded and can be traced back to its origin.
3. **Real-Time Monitoring**: Stakeholders can monitor the state of agreements in real-time, ensuring all parties have up-to-date information.
4. **Detailed Records**: Users can drill down into specific transactions to view detailed information, including timestamps, involved parties, and the hash of the agreement file. This level of detail can support compliance and regulatory requirements.
5. **User-Friendly Interface**: Since the blockchain network stores and validates the transactions in the background, the explorer simplifies any interaction needed with the blockchain, making it accessible to users without deep technical knowledge. This encourages broader adoption and usage of the DPP framework.

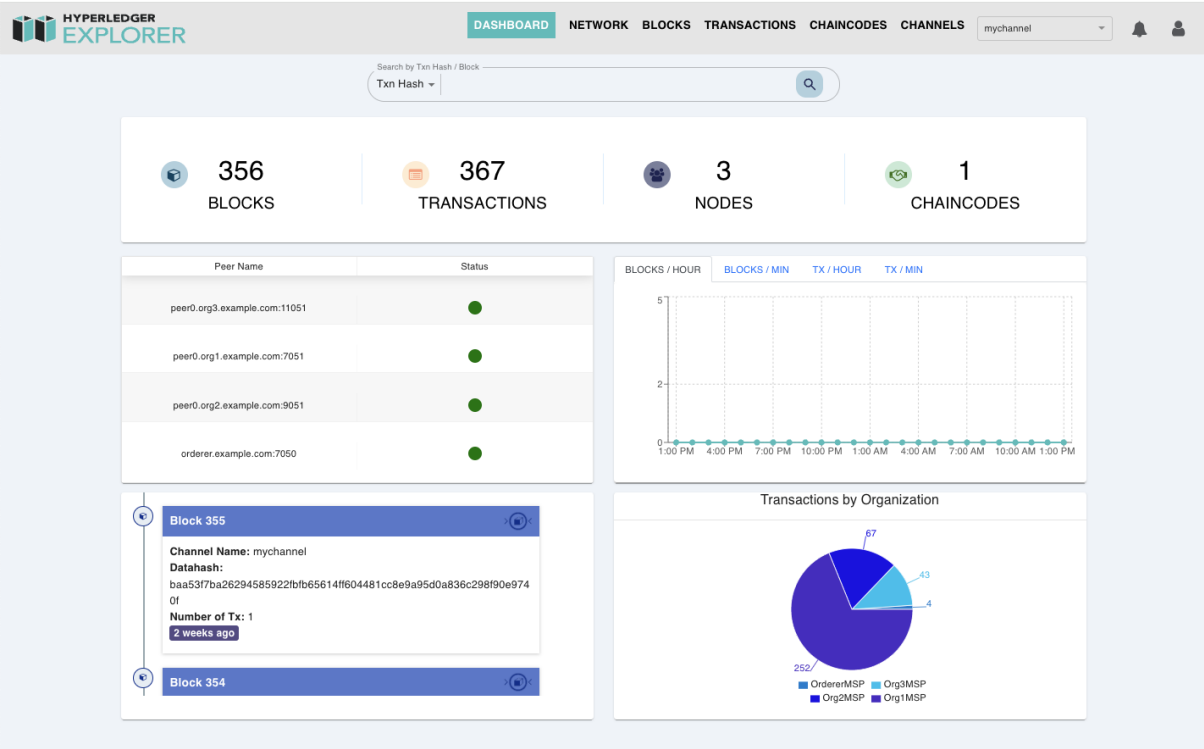


Figure 22: Blockchain Explorer main dashboard

Integrating blockchain technology, including blockchain storing, validation and verification, traceability, and a blockchain explorer, within the Digital Product Passport framework significantly enhances trust, transparency, and security in the management and exchange of product information. By leveraging these capabilities, stakeholders can confidently participate in a transparent and verifiable digital ecosystem. Through the integration efforts and the relevant Work Package, the smart contracts developed will be enriched and updated, to support all the necessary interactions between organizations in the most suitable way.

Conclusions

This deliverable provides a comprehensive overview of the Digital Product Passport (DPP) framework, offering insights into its initial implementation strategy structured around four key stages: configuration, agreement, sharing, and termination. Each stage is presented, together with the steps and screenshots. Additionally, the document highlights the integration of blockchain technology to ensure trust and immutability in the exchange of product information.

The DPP tool operates on specific assumptions, ensuring effective implementation and functionality. These assumptions include data sourcing from a central data lake, connection of DPP templates to specific lot numbers or IDs, and the treatment of updated data as instances of the original DPP template.

The implemented DPP tool will be finally integrated within the CRIS platform thus providing an additional functionality for formulation and monitoring of circular supply chains.

Appendix A: DPP structures from Plooto pilots

Italian Pilot

	Raw Materials		Re-qualification procedure	Production procedure
Info to be included in the DPP	Expired prepreg in form of rolls	Prepreg waste pieces (arise from the cutting phase)	Properties: - Thermal properties (T_g) - Rheological properties (Viscosity vs temperature) ** To be modified after the tests in the pilot. Maybe more properties will be added.	Component production date
	Dimension of the roll	Geometry of prepreg pieces	New process window for the material: - Temperature - Pressure of polymerization - Time	Production method: - Times - Temperatures - Pressure
	Supplier of raw materials		Re-qualification date	Quality inspection results: - Visual inspection - Void content - Thickness measurements
	Quantity		New expiry date (for the production procedure)	
	Technical Datasheet (regarding the prepreg) - Technical properties			
	History of source materials: - Production date of the source material - Expiry date of the source material - Storage conditions			

Greek Pilot

Molasses Product Passport

Product description:

ASPIS SA, with many years of experience in food production and guided by the utilization of high-quality raw materials of Greek origin, sustainability and the circular economy, has proceeded to the production of feed products.

Our feed is produced from the processing of citrus peels and pulp with different processes, covering the needs of our customers.

Recognizing the importance of and linking the production of safe feed with the production of safe food, we provide feed products of high energy and nutritional value.

Derived from the citrus processing by-products, feed grade molasses is among the most popular molasses-based animal feed sold worldwide. Easy handling and high palatability make it an ideal animal-feed solution.

Molasses is to be stored in original containers or in on-site molasses specific tanks. Molasses should be stored out of direct sunlight, at less than 20°C and avoid contact with water. If stored in the correct manner, molasses will have a shelf life of 12 months from manufacture date, unless otherwise stated.

Molasses production adopts all the relevant standard procedures and undergoes a process of Quality Assurance to render the product fit for animal-feed production.

Lot No.:

Nutritional Analysis:

Component	Concentration (g/kg molasses)	Dry Matter Basis
Calcium		
Nitrogen		
Magnesium		
Phosphorous		
Potassium		
Sodium		
Soluble Sugars (NSC)		
Sulphur		
Dry Matter		
Cobalt		
Copper		
Iron		
Manganese		
Zinc		
pH		

Specifications

Physical & Chemical Specifications	
Polarization value (% Sucrose)	
Ash (%)	
Colour (IU)	
Moisture (%)	
Particles size	
Viscosity	

Brix	
Microbiological Specifications	
Aerobic Plate Count	Absent

Environmental Impact (LCA):

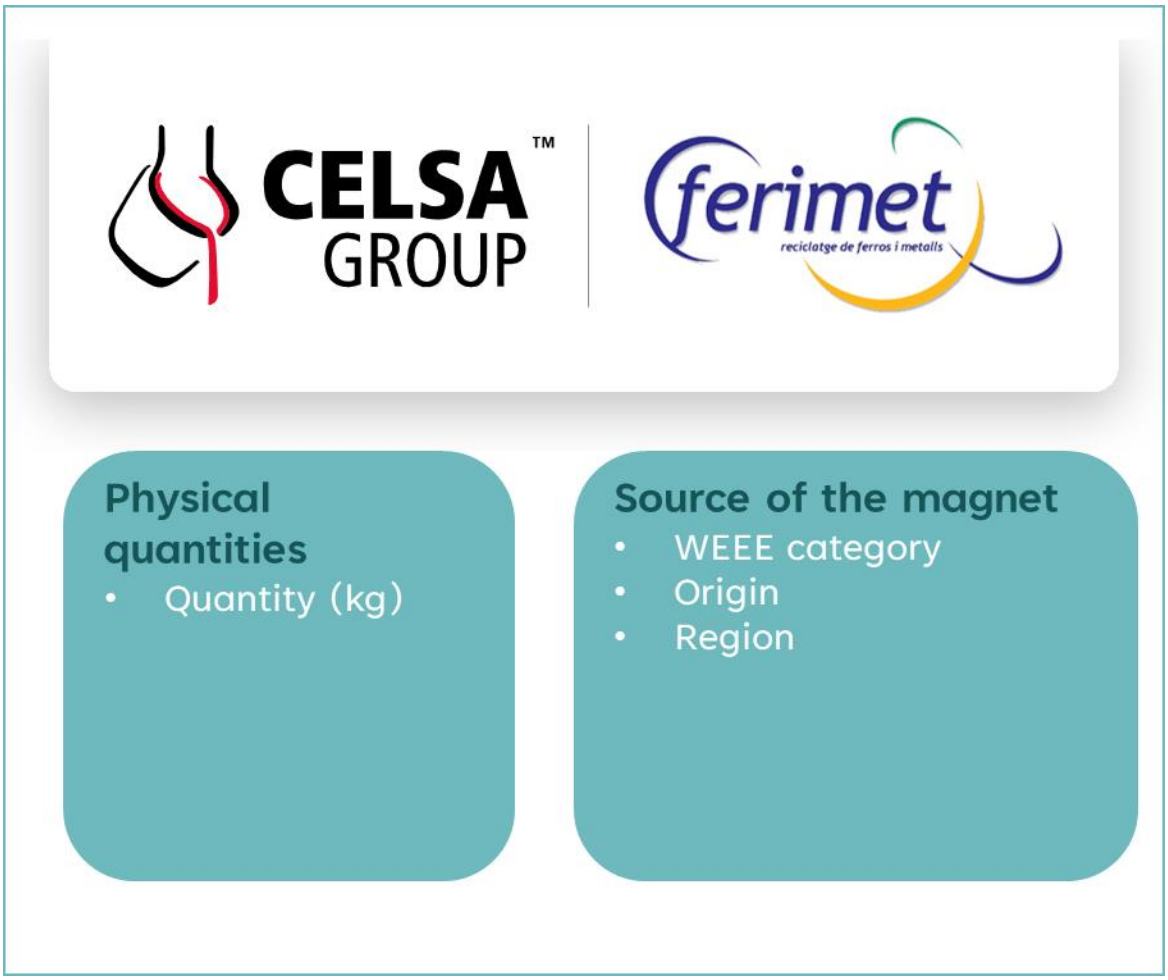
LCA analysis was carried out in accordance with the Standard ISO 14001.

Studied Category	Value (per kg of molasses)
Climate change, default, excl biogenic carbon [kg CO_2 eq.]	

Spanish pilot

Ferimet DPP

DPP per batch of magnets.



PARAMETERS	**Information/ units (S.I.)**
WEEE category	From the 6 general categories defined by the EU. Currently: • Large equipment, small equipment and/or Small IT telecommunications equipment.
Origin of the magnet	Original device from which the magnet was extracted (home appliance, washing machine, microwave, electronics or other type of WEEE)
Region of the WEEE	Code of the region where the WEEE waste comes from (es, it, fr, …)

IMDEA DPP

Where: Physical quantities and source of the magnet come from Ferimet, the other blocks contain information generated by IMDEA, which are detailed in the following tables.

Material Safety Data Sheet	
PARAMETERS	UNITS (S.I.)/ Text
Material Name	
Polymer Base	%wt
Magnetic Powder	%wt
Magnetic Properties	
• Br	T
• Hc	kA/m
• BHmax	kJ/m³

Material density	kg/m³
Maximum Temperature	ºC
Personal Protective Equipment	EPIs (Safety needs)
Temperature to Decompose	ºC

Data Sheet	
PARAMETERS	UNITS (S.I.)
Required drying time	s
Pre-drying Temperature	ºC
Maximum Temperature	ºC
Temperature to Decompose	ºC
Temperatures for each injection zones	ºC
Temperatures nozzle	ºC
Required time for each injection zone	s
Required time wait before open the mold	s

IMDEA sustainability data - other data	
PARAMETERS	UNITS (S.I.)/ text
% wt of recycled material	%wt
Quantity	Kg

IMA DPP

Sustainability data	
PARAMETERS	UNITS (S.I.)/ text
Informative message	"In order to improve the sustainability of the magnets, IMA is using magnetic material recovered from different EOL WEE. In this magnet contains magnetic materials from different recycled sources."
% wt of recycled material	%wt
Source of the magnet	*from Ferimet's DPP*
Information to recycle If possible	

Material certificate	
PARAMETERS	UNITS (S.I.) or text
Dimensional values	Mm/ª/ .. drawing specifications

weight	g
Magnetic properties	
• Gauss	kG
• Flux	(μVs·cm)
• Sample Volum	Mm^3
• Magnetic properties with temperature loss	Comparing flux or Gauss values. Tmax (°C) and %loss
Material control	
• Br - remanence	T
• HcB - coercitivity	kA/m
• BJmax – maximum energy product	kJ/m^3
Magnetic Force	N
Coating thickness	μm
Coating composition	Data values from equipment (%wt stimated)