# Architecture for a Digital Product Passport System based on the Ecodesign for Sustainable Products Regulation and the corresponding Standardisation Request

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**Abstract**
This paper outlines an architecture for a Digital Product Passport (DPP) system, designed to meet the Eco Design for Sustainable Products Regulation (ESPR) and the corresponding Standardisation Request (SReq). The proposed architecture divides into three main components: EC Central Services, distributed DPP System Services, and Third-Party Services. The EC Central Services, managed by the European Commission, oversee the system's governance, while the dis-tributed DPP services, operated by Economic Operators or designated providers, handle day-to-day operations. Third Party Services, run by external entities, supplement these functionalities.

**Keywords** [1]
Digital Product Passport, System Architecture

## 1. Introduction

The advent of the European Green Deal in 2019 marked a pivotal shift towards addressing the pressing climate and environmental challenges facing our planet. As a cornerstone of this ambitious plan, the European Union set forth a strategy aimed at molding an equitable, thriving society underpinned by a modern, resource-efficient, and competitive economy. Central to this vision is the objective to reach net-zero greenhouse gas emissions by 2050, all the while dissociating economic expansion from resource use.[1]

In a significant stride towards realizing this vision, March 2022 saw the launch of the Sustainable Products Initiative (SPI), featuring the Proposal for the Ecodesign for Sustainable Products Regulation (ESPR)[2]. This regulation lays the groundwork for a broad adoption of digital product passports (DPP) across a variety of product categories, heralding a new era of circular economy practices. The pioneering EU Battery Regulation 2023/1542[3] further exemplifies this approach by covering the entire lifecycle of products and introducing the first DPP at the European level, starting with the digital battery passport. This initiative underscores the EU's commitment to sustainable product management by ensuring transparency across the battery value chain through digital means.

The digital battery passport not only serves as a model for the sustainable and circular handling of batteries but also sets the stage for the broader application of DPP systems across multiple sectors, including textiles and electronics [4]. This pilot project underscores the necessity for a technologically adaptive framework that can support the expansive vision of the DPP ecosystem.

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Concurrent with the development of the ESPR and Battery Regulation, the European Commission embarked on a mission to establish the technical standards essential for the DPP system's implementation. By May 2023, a draft Standardisation Request (SReq) was proposed to key European Standardisation Organisations, marking the beginning of a consultative process aimed at refining the regulatory backbone of the ESPR and Battery Regulation. The establishment of the Joint Technical Committee JTC 24 in December 2023 represents a critical step in this journey, tasked with crafting the standards needed to bring the vision of a comprehensive DPP system to fruition.

This paper delves into the intricate IT architecture underlying the Digital Product Passport system that underpins this innovative approach.

## 2. DPP System components as required by SReq, ESPR and Battery Regulation

As part of our efforts, an analysis was undertaken to align with the requirements set forth by the ESPR, the Battery Regulation, and the SReq. The objective was to identify all the system components required by regulation. The following table summarizes the key system components identified for the DPP system, categorized by their type and referencing the specific clauses in the ESPR, Battery Regulation, and Standardization Requests (SReq) that mandate or describe their necessity [5]:

| **DPP-System components as defined in the SReq** | **Type of component** | **Reference to SReq, ESPR, Battery Regulation** |
|---|---|---|
| Unique identifier for product, economic operator, facilities and DPP unique identifier | Alphanumerical Code | Module 1 of SReq, ESPR version Post-meeting Version of Technical Meeting on December 15, 2023, Article 11(4a) |
| Data carrier | Medium holds the unique identifier with link | Module 2 of SReq, ESPR version Post-meeting Version of Technical Meeting on December 15, 2023, e.g. Article 11(4a) |
| Registry | Database | ESPR version Post-meeting Version of Technical Meeting on December 15, 2023, Recital 34 |
| EC User web portal | Software | ESPR version Post-meeting Version of Technical Meeting on December 15, 2023, Recital 34a |
| Individual distributed data repository | Database | ESPR version Post-meeting Version of Technical Meeting on December 15, 2023, Recital 103a, Module 3 of SReq |
| API for CRUD of data | Software | Module 8 of SReq |
| System for access rights management | Software | Module 3 of SReq |
| Verification of authentication | Method | Module 7 of SReq |
| Verification of DPP conformance | Method and software | Module 7 of SReq |
| Data verification of data integrity and originality | Method and software | Module 7 of SReq |
| Logging and monitoring | Method and software | Module 7 of SReq |
| Querying of passport data | Method and software | ESPR version Post-meeting Version of Technical Meeting on December 15, 2023, Article 9(1), Module 8 of SReq |
| Back-up service | Software | Module 6 of SReq |
| Data modelling | Method | Module 5 of SReq |

## 3. Proposed DPP system architecture

This chapter presents a detailed proposal for the architecture required to integrate and extend the identified components into an operational digital product passport (DPP) system. It lays out an

overarching view of the system architecture, subsequently delving into the intricacies of each component to provide a comprehensive understanding.

The system's architecture is strategically divided into three principal service-oriented sections (see Figure 1): EC Central Services, DPP System Services distributed across various locations, and Third Party Services. Oversight of the EC Central Services is the responsibility of the European Commission. The distributed DPP System Services are mandated to be set up and operated either by the Economic Operator themselves or through a service provider appointed for this purpose. Establishment of Third Party Services, on the other hand, is required to be done by an independent service provider, as specified by regulatory mandates.

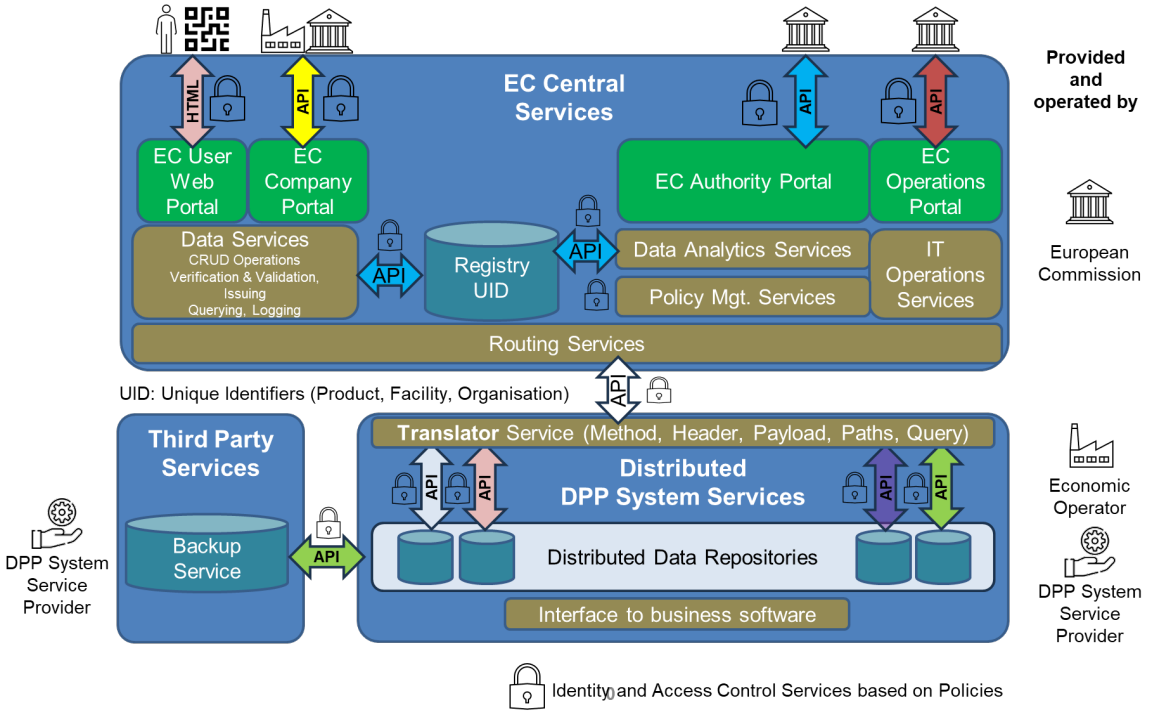


Figure 1: DPP System Architecture [6]

## 3.1. EC Central Services

The *Identity and Access Control* segment incorporates several components represented by lock symbols, designed to safeguard API endpoints and restrict data access within the battery passport ecosystem. These components are tasked with assessing and implementing access control policies, taking into account the verified identities and roles of stakeholders.

The battery passport system relies on *Application Programming Interfaces* (APIs) for the exchange of data between various stakeholders and software components. These APIs, depicted by two-sided arrows of different colors, serve diverse functions and stakeholders. An exception is the representation in the top left corner of the system architecture figure, which illustrates the EC User Web Portal delivered to users as an HTML website, incorporating embedded battery passport data, but not transmitted via an API.

Another crucial part is the provisioning of portals for different stakeholder groups:

- The *EC User Portal,* managed by the Commission is publicly accessible, allowing stakeholders such as customers and economic operators to search for and compare information contained in product passports, in accordance with their access rights [2].
- The *EC Company Portal* facilitates manual execution of services defined in the system, catering to the needs of economic operators.

- The *EC Authority Portal*, dedicated to national authorities, the Commission, and market surveillance offers elevated access rights and functionalities, including data analytics services, to fulfill regulatory responsibilities.
- The *EC Operations Portal*, serving as the central command center, enables administrators and authorized personnel to manage and oversee the DPP ecosystem efficiently.

Data Services provide necessary functionalities for basic data operations:

- *Verification Services* are critical for cryptographically proving or verifying the correctness of data inputs within the system, including the verification of signatures in Verifiable Credentials or Presentations.
- *Validation Services* scrutinize the quality and specificity of the data entered into the product passport system. The absence of data validation could lead to the acquisition of erroneous data that fails to conform to the required data structure and values. This process entails the comparison of structured or semi-structured data against the product passport data models to ensure a match. Having all necessary validation schemas and criteria in place is crucial for the timely execution of validation checks; without these, validation cannot proceed, resulting in the rejection of incoming data accompanied by a descriptive error message. Similarly, data failing to meet validation standards must also be discarded.
- *CRUD Operations* such as Create, Read, Update, and Delete are essential for data management within databases and web applications.
- *Issuing Service*, dedicated to the publication of DPPs, ensuring compliance and accessibility.
- The *Querying Service*, involves the retrieval of specific data from databases or datasets, facilitating the extraction of relevant information based on defined criteria.
- The *Logging Service* provides practice of recording events, actions, or transactions within the system for later analysis, troubleshooting, and auditing.

The *Data Analytics Services* are tailored for authority use, this component comprises intermediate data storage for aggregated product passport data, a data analytics component for performing predictive and prescriptive analytics, and search components for detailed data exploration.

Following IT Service Management Forum (ITSMF) guidelines, the *IT Operations Services* include Service Management and Service Desk Software for monitoring, analysis, reporting, and support within the system, ensuring adherence to Service Level Agreements (SLAs).

The Commission is tasked with establishing and managing a secure digital *Registry* to safeguard critical identifiers, such as unique product identifiers, operator identifiers, facility identifiers, and a registration identifier. This registry will also include the product commodity code and unique identifiers for batteries, specifically for those products undergoing the 'release for free circulation' customs process, as detailed in Article 77(3) of Regulation (EU) 2023/1542. Access to the registry's data will be granted directly to national and customs authorities as well as the Commission itself. To enhance enforcement capabilities, the Commission may also determine the need to record additional information in the product passport within the registry [2]. Future delegated acts will clarify further details to be documented in the registry, aiming to authenticate the product passport's validity and enhance the effectiveness and efficiency of market surveillance and customs inspections.

*Routing Services* ensure that DPPs, stored in distributed data repositories, can be accessed centrally through a portal or an API, facilitating seamless integration and access across the system.

Policy Management Services managed by the European Commission, are responsible for the creation, enforcement, and monitoring of policies and guidelines within the DPP system.

Part of the Distributed DPP System Services are the *Distributed Data Repositories*, which serves as a storage and management hub for battery passports. The management of this repository is recommended to be under the responsibility of either an economic operator or a designated DPP-as-a-service provider, who is authorized to represent them. Such management could be undertaken by a provider offering DPP services. Various technical solutions can be employed for its implementation. The system's interoperability is achieved through the adoption of a semantic data model, which is based on a universal, platform-independent semantic framework. The DPP data repository's API is

designed to facilitate standard Create, Read, Update, and Delete (CRUD) operations. Additionally, a translator service is in place to convert generic API calls into specific calls compatible with the system.

*Translator Services* are essential for translating generic API calls into system-specific ones. This service is based on the Model Driven Architecture approach, facilitating seamless integration across different technical implementations.

Interface to Business Software: This interface integrates company-specific backend systems (e.g., ERP, SCM, PLM) with the DPP system, ensuring that data is processed, aggregated, and mapped to the standardized data model of the battery passport.

*Interfaces to Business Software*, such as ERP, SCM, PLM, and Traceability Solutions, will be the primary source of data for product passports. These systems enable the collection of crucial upstream value chain data, which significantly contributes to various attributes of the battery passport, including Product Carbon Footprint (PCF) and recycled content. The duty to integrate these systems with the battery passport lies with the economic operator. The data must be processed, compiled, and aligned with the battery passport's standardized semantic data model to ensure it meets the specific data attribute requirements. Recognizing that not every company has the resources or willingness to develop their own DPP data repository, the ESPR suggests delegating this responsibility to a DPP-as-a-service provider. This arrangement enables economic operators to adhere to the Battery Regulation and associated ESPR guidelines without significant capital expenditure. Furthermore, the ESPR requires economic operators to ensure the availability of a backup copy of the product passport. This is to be facilitated through an independent DPP-as-a-service provider, who will also offer the necessary backup services, guaranteeing continuous access to DPP data.

## 4. Conclusion and outlook

The European Green Deal and subsequent initiatives like the Sustainable Products Initiative, the Ecodesign for Sustainable Products Regulation, and the EU Battery Regulation represent transformative steps toward a sustainable and circular economy in Europe. By setting ambitious goals for net-zero greenhouse gas emissions by 2050 and emphasizing the decoupling of economic growth from resource use, the EU has positioned itself as a global leader in environmental stewardship and climate action. The development and implementation of the Digital Product Passport (DPP) system, as detailed in this paper, are central to these efforts. This system not only facilitates transparency and efficiency in the lifecycle management of products but also pioneers the integration of digital solutions in sustainable product management across various sectors.

The intricate IT architecture of the DPP system, comprising EC Central Services, DPP System Services, and Third-Party Services, showcases a sophisticated approach to ensuring data integrity, accessibility, and security. Through its service-oriented architecture, the system addresses critical needs for identity and access control, data validation and verification, and seamless interaction among stakeholders. The establishment of technical standards and the creation of the Joint Technical Committee JTC 24 underscore the EU's commitment to a consultative and inclusive process for regulatory development and implementation.

This paper sets the stage for ongoing developments in digital integration within the circular economy paradigm and can serve as a blueprint for future initiatives aimed at making the circular economy a reality and contribute to the ongoing work of the JTC 24.

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## Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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