Designing Digital Industrial Platforms for the Circular Economy: A Requirements Catalog

Short Paper

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Abstract

This article explores how digital industrial platforms can support data ecosystems in the circular economy, addressing the need for more sustainable economic models that aim to minimize waste, reuse materials, and improve resource efficiency. In this context, we present an ecosystem process model that maps the lifecycle of complex products, such as electric vehicles, and a requirements catalog for such digital industrial platforms, developed through a design science research project involving literature review and expert interviews. This catalog outlines six meta-requirements to guide platform design: data governance, actor engagement, development & implementation, circular economy-related services, general services, and foundational premises. The research makes both theoretical and practical contributions, guiding the design and development of platforms that support circular economy practices across industries. Future work includes prototyping, demonstration, and iterative refinement with the goal of transforming industry operations towards sustainable and resilient economic models.

Keywords: Digital industrial platform, circular economy, design science research

Introduction and Background

The transition from a linear economy to a circular economy (CE) is increasingly recognized as essential to mitigate the detrimental effects of human activity on the planet. Escalating climate change, pervasive waste pollution, and serious threats to biodiversity are direct consequences of an economy that relies heavily on fossil fuels and unsustainable linear production models characterized by a "take-make-dispose" approach (UN DESA, 2022; Zeiss et al., 2021). These practices not only deplete natural resources but also pose long-term risks to ecological stability and human well-being. The need for sustainable alternatives is urgent, and the CE offers a transformative solution by advocating for the minimization of waste, the reduction of primary resource use, and the implementation of closed-loop systems that continuously reuse products, parts, and materials (Ellen MacArthur Foundation, 2020; Morseletto, 2020). By increasing resource efficiency and significantly reducing greenhouse gas emissions, the CE positions itself as a viable economic strategy that operates within the Earth's ecological limits (Moraga et al., 2022), thereby providing a path to economic resilience by decoupling economic growth from resource consumption (Stål & Corvellec, 2018).

Despite the promise of CE, significant challenges remain in the area of *data sharing and utilization* – critical components for navigating the complex landscape of international and local regulations related to waste management and materials recycling. The effectiveness of CE practices depends on the ability to share data among different stakeholders, which presents key challenges such as ensuring data privacy, achieving interoperability between IT systems, and maintaining high data quality over time. These challenges are compounded by the complexity of circular supply chains, where data must be shared across different systems and formats (Antikainen et al., 2018; Ribeiro da Silva et al., 2023). This highlights a critical issue: existing information systems (IS) are not adequately designed to support the complex data sharing needs of CE, requiring innovative solutions that can overcome these barriers (Fassnacht et al., 2023).

To address this need, recent advances in big data analytics and artificial intelligence (AI) offer promising opportunities to improve traceability and lifecycle management within CE frameworks (Heinz et al., 2023). These technology-enabled innovations can significantly improve the accuracy of material tracking, resource optimization, and decision-making that are critical to the success of circular business models (Lopes de Sousa Jabbour et al., 2018). However, the development of such solutions requires a focused approach to the design requirements and solutions for digital platforms that can support these complex data ecosystems within the CE (Fassnacht et al., 2024; Heinz et al., 2022).

Given the central role of data in supporting CE practices and strategies, this research seeks to explore the design of digital industrial platforms (DIPs) specifically tailored to data ecosystems within a CE. DIPs represent a significant evolution in the use of digital technologies to enhance industrial processes by orchestrating the collection of data from a wide range of assets and devices and fostering an ecosystem in which third-party organizations can develop and deploy complementary solutions (Beverungen et al., 2021; Pauli et al., 2021). These platforms are characterized by three core elements (Jovanovic et al., 2022): (1) an enabling *platform architecture* that includes data collection technologies, analytics, and AI enablement; (2) *governance mechanisms* that define the boundaries of actor collaboration and enable the integration of different types of participants, activities, and interfaces; and (3) *services* such as monitoring, reporting, optimization, or automated advice that are centrally provided by the platform.

While these elements are essential, the design of DIPs must be grounded in a clear understanding of the specific design requirements of the ecosystem that forms around them, consisting of different actors such as organizations and institutions, that must be met in order to successfully overcome the data sharing challenges associated with a CE today (Pauli et al., 2021). This research therefore focuses on delineating these needs, which include ensuring data privacy, facilitating interoperability, and enabling high data quality across complex supply chains. In addition, DIPs can significantly advance CE objectives by supporting resource reduction, reuse, and recycling strategies. They enhance product traceability and longevity through advanced data analytics and connectivity, which are critical for effective resource management throughout the product lifecycle (Zeiss et al., 2021). By providing robust data integration capabilities, these platforms enable the optimization of resource use and facilitate the conversion of waste into valuable inputs for other processes (Kirchherr et al., 2017).

Real-world initiatives such as Gaia-X and International Data Spaces aim to lay the foundation for a more connected and efficient industrial landscape by providing legal and technical artifacts for robust data ecosystems using DIPs for industrial applications (Otto et al., 2021; Solmaz et al., 2022). However, successfully establishing DIPs within the CE requires that CE-specific issues, such as the complexity of data integration, compliance with regulations related to waste management and material recycling, and the need to centralize CE-specific services, are effectively addressed (Heinz et al., 2023). Moreover, the effectiveness of these platforms in promoting sustainable practices depends on the willingness of actors to engage in data sharing and collaborative innovation (Ribeiro da Silva et al., 2023; Serna-Guerrero et al., 2022). In response to these challenges, our research seeks to contribute to the evolving discourse by using design science research (DSR) to design DIPs specifically tailored to CE. The research question guiding this DSR project is: *How can a digital industrial platform be designed to support data ecosystems in a circular economy?*

To answer this question, this research lays the groundwork for a comprehensive DSR project by developing an ecosystem process model and a requirements catalog that addresses the prevalent challenges and maximizes the opportunities inherent in the CE framework. The DSR approach involves inductive analysis of scientific literature and expert interviews to inform the design requirements in the requirements catalog. By anticipating technological and regulatory developments, the designed DIPs will not only meet current needs but also adapt to future challenges, facilitating a transformative change in the way industries operate towards a sustainable and economically viable future. Ultimately, this research-in-progress aims to provide a foundation for the design and development of DIPs that enable effective inter-organizational data sharing and utilization, thereby contributing to both academic knowledge and practical applications in CE practices and supporting the broader goals of sustainable development (Velenturf & Purnell, 2021).

Methodology

This study adopts the DSR approach as outlined by Peffers et al. (2007) and Tuunanen et al. (2024), which emphasizes iterative development and rigorous evaluation to produce innovative artifacts. The methodology guiding this research helps to address the need to overcome significant data sharing challenges within the CE by designing, implementing, and establishing *digital industrial platforms for the circular economy* (DIP4CE) that facilitate these practices.

Research Context. Our research context focuses on circularity in the electric vehicle (EV) industry, specifically as it relates to electric powertrain and battery components. This ecosystem was selected due to the increasing demand for EVs, driven by new regulatory frameworks and a shift in consumer preferences towards sustainable mobility. Automotive supply chains, known for its early adoption of IS technologies and the potential for significant economic impact from improved data practices, provide fertile ground for this DSR study (Meng et al., 2022; Ribeiro da Silva et al., 2023).

Overall DSR Project. Following the DSR paradigm, our project unfolds through a series of interrelated, sequential phases (see Figure 1). So far, we have carried out the problem analysis by outlining an ecosystem process model to consider the relevant stakeholders of the artifact, as well as the objectives definition, resulting in a requirements catalog for a DIP4CE. The next phases include the design and development of a prototype platform, a demonstration to the relevant stakeholders in the form of a proof of concept, and the evaluation of the design and artifact, testing the platform's capabilities and confirming its effectiveness and relevance to the stakeholders, finally highlighting the value that DIP4CE adds to the CE.

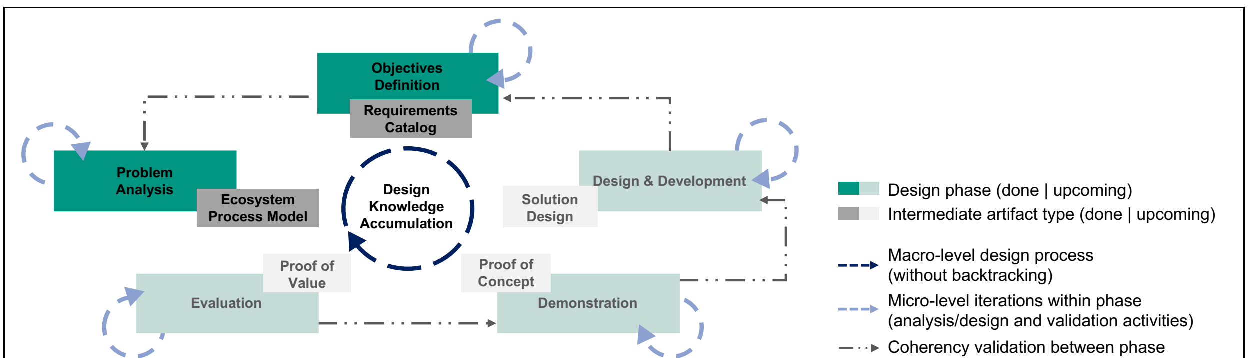

Figure 1. Overview of DSR project based on Tuunanen et al. (2024)

Problem Analysis. In this phase, we developed an *ecosystem process model* that maps the material flows within the lifecycle of EV components. This model incorporates a subset of strategies from the 10R framework (recycle, repurpose, remanufacture, repair, and reuse), selected for their significance of impact and their focus and relevance in the research context of the automotive industry. The model serves as a basis for capturing the economic relationships and interdependencies critical to addressing data-related challenges within the ecosystem. The model synthesizes existing frameworks (basic representations of CE processes (Özceylan et al., 2017) iteratively enhanced with aspects of the more refined model of Ahuja et al. (2020)) and is extended with insights gathered from six expert interviews (Table 1) with industry partners of the consortia that served as the research context, ensuring a detailed representation of all CE strategies targeted in the DSR project. The interviews were semi-structured and included questions focused on the role and engagement of actors in the ecosystem and the requirements for an ecosystem that collects, processes, exchanges, manages, and secures product-related data and information. In a second iteration, we refined the model with six academic experts in an interactive workshop.

ID	Role	Firm Size	Stakeholder Group	Experience	Length
I1	Team Lead	Small	Business, Development	4 years	0:58 h
I2	Research Vice President	Medium	Business, Development	23 years	1:03 h
I3	Key Account Manager Research Student	Small	Business Research	4,5 years 0,5 years	1:01 h
I4	Head of Software Engineering	Large	Development	8 years	0:33 h
I5	Sustainability Analyst	Large	Business, Development	20 years	1:04 h
I6	Head of Remanufacturing	Medium	Business	5 years	0:56 h

Table 1. Overview of Interviewees

Objectives Definition. To develop a comprehensive *requirements catalog for DIP4CE*, we started with an exploratory literature review of 17 relevant papers. We followed two search approaches: First, we focused on an IS-centric perspective with no connection to CE, using search terms such as 'digital platform', 'digital industrial platform', and 'data sharing in company ecosystems' to avoid bias toward CE. Second, we targeted CE-specific requirements by searching for, e.g., 'data sharing in circular ecosystems', 'circular economy digital platform', and 'circular economy data sharing'. After screening the search results, we decided on 17 papers, 12 of which had a stated focus on CE. We selected only papers that contained at least one requirement relevant to our context, were written in English, and were peer-reviewed. This initial 'rigor cycle' helped establish a baseline understanding of both general and CE-specific requirements, setting the stage for further analysis. In addition to the literature review, we reanalyzed the expert interviews with industry professionals (Table 1) to gain qualitative insights into the roles and expectations within the CE ecosystem. These interviews highlighted critical data sharing and system requirements essential for effective CE implementation, referred to as the 'relevance cycle'.

The insights from both sources were then systematically analyzed using a three-step coding approach (Gioia et al., 2013). First, we used open coding to distill 34 requirements (e.g., data protection, implementation strategies, capacity building CE) from the literature and 31 from the interviews (e.g., data products, CE decision support, dismantler support), that were categorized as first-order concepts. These were aggregated into second-order categories through provisional coding in the subsequent phase. The process culminated in the clustering of these themes into aggregated meta-requirements (MRs) using provisional coding, with the goal of improving the clarity and applicability of the requirements in the design process. An internal expert workshop with five academic experts in the domain under study was conducted to validate and refine the requirements catalog. Using completeness, simplicity, understandability, and fidelity to real-world applications as validation criteria (Sonnenberg & vom Brocke, 2012), feedback from the workshop helped to consolidate the catalog into 46 distinct requirements organized into 18 second-order categories and six MRs. This final set of requirements was carefully assessed against our ecosystem process model from the previous phase to ensure relevance and applicability to different lifecycle stages, including pre-use, in-use, and post-use phases, thus ensuring a tailored approach to CE implementation.

Preliminary Results

In this section we present the intermediate results of our DSR project: an ecosystem process model resulting from the problem analysis and a requirements catalog resulting from the objectives definition phase.

Ecosystem Process Model. In our DSR process, the ecosystem process model serves as a central tool during the problem analysis phase. This model leverages the methodological approach proposed by Parida et al. (2019) for transforming traditional business ecosystems into circular ones. This involves mapping the ecosystem and identifying material-level linkages, which serves as a blueprint depicting the ecosystem dynamics in the automotive sector and is essential as it not only visualizes, but also guides the development of solutions that ensure sustainable and economically viable material flows.

The model, shown in Figure 2, provides a holistic view of typical processes and their corresponding material flows between the core actors of a circular ecosystem for EVs, and is applicable to many other industries with comparable product complexity. Using a role-based approach, the model is designed to be universally applicable, allowing companies within the circular ecosystem to assume one or more roles. This versatility is essential for integrating diverse functions and interactions within the ecosystem. Furthermore, the emphasis on connections between roles underscores the importance of collaborative interactions, which are central to the model's effectiveness in facilitating non-hierarchical and efficient data sharing (Adner, 2017).

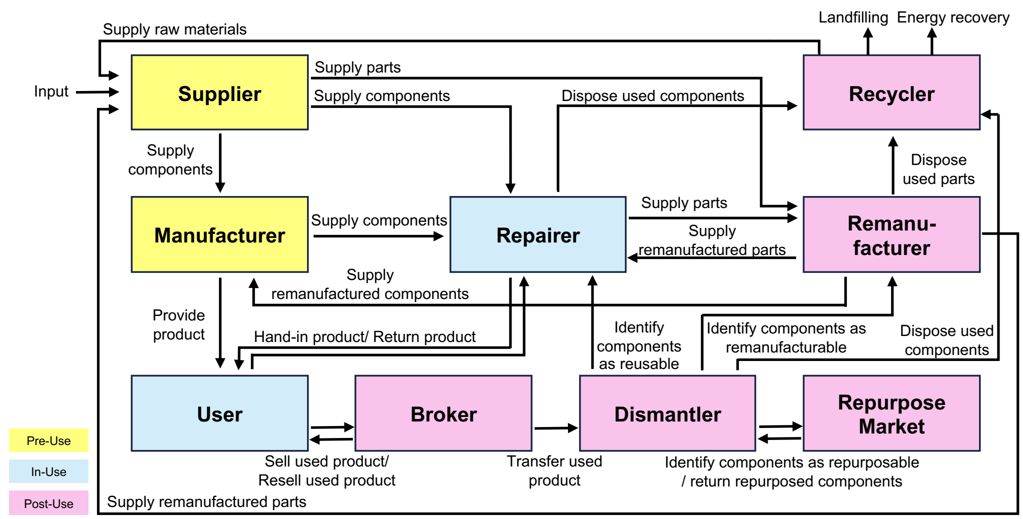

Figure 2. Ecosystem Process Model

Our analysis results in a set of processes that represent the full lifecycle of a circular product, intentionally excluding the early stages of material extraction and processing to focus on more impactful downstream activities. Within these processes, nine key roles were identified, each with a unique contribution to the functioning of the circular ecosystem: supplier, manufacturer, user, repairer, broker, dismantler, repurpose market, remanufacturer, and recycler. This role-based mapping extends throughout the ecosystem, highlighting the activities of each role and their interdependencies, helping to understand how data sharing can affect business relationships and activities within the ecosystem.

Such an understanding is important for our DSR project, which aims to design DIPs that effectively support these complex interactions. The model delineates the economic relationships between actors by identifying the supplier and customer dynamics for each role, which helps to understand the business transactions that a platform needs to facilitate, thus ensuring that the platform's architecture, governance, and services can support efficient and effective data flows aligned with these economic exchanges. The insights gained from this step directly inform the subsequent creation of a requirements catalog for a DIP tailored to enhance CE practices and provide the necessary foundation for subsequent phases of solution development.

Requirements Catalog. In the following, we present a comprehensive requirements catalog for the design of a DIP4CE, an intermediate artifact resulting from the objectives definition phase of our DSR project. The catalog includes a holistic set of requirements that guide the design, implementation, and performance evaluation of the DIP4CE. The catalog contains 46 first-order requirements that are aggregated into 18 second-order categories and grouped into six MRs: *data governance*, *actor engagement*, *development & implementation*, *CE-related services*, *general services,* and *foundational premises*. These MRs collectively address the key facets of design and deployment needs relevant to a DIP4CE. MR1 (*data governance*) and MR6 (*foundational premises*) serve as an overarching framework that provides the foundation for the other MRs. The catalog also categorizes the specificity of the requirements to the CE context (or not). Based on insights derived from the ecosystem process model, these CE-specific requirements are further classified according to their relevance to the product lifecycle (pre-use, in-use, or post-use). Figure 3 provides a visual representation of the catalog, while a detailed overview of each requirement, its description, CE specificity, and lifecycle classification is provided in the Appendix.

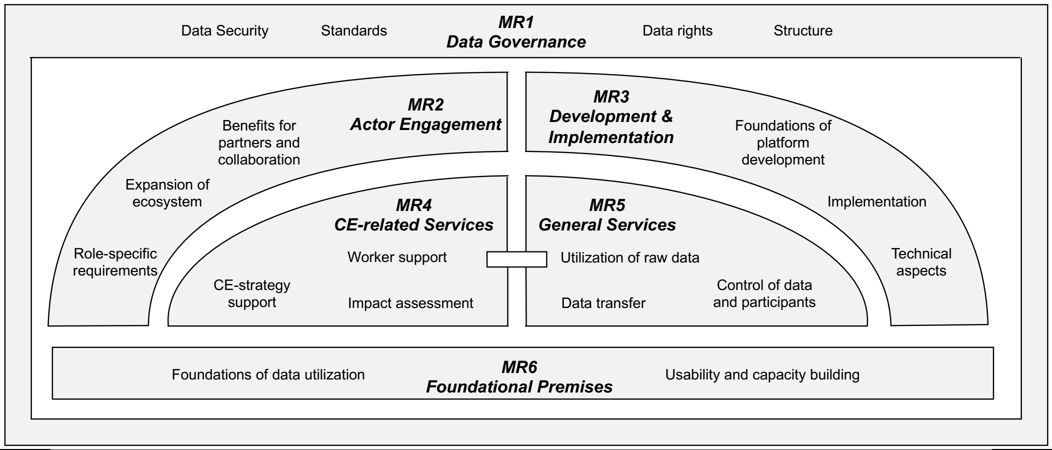

Figure 3. Visual Representation of the Requirements Catalog

MR1: Data Governance. The first MR is critical to establishing secure and effective data management within the DIP4CE. It includes establishing a framework for data sharing that mitigates risks such as data breaches or unauthorized access, and delineating essential organizational underpinnings for data sharing and utilization such as access rights and usage policies. Both the literature and practitioners emphasize that data governance is critical for effective platform coordination (e.g., Abraham et al., 2019). This MR includes the second-order categories of *data security, standards, data rights,* and *structure*.

MR2: Actor Engagement. This MR aims to foster collaborative efforts through the motivation, opportunity, and ability of actors to engage in the DIP4CE. Therefore, the design of a DIP4CE must enable key actors to ensure sustained intrinsic motivation to participate in the platform, while providing a flexible design to accommodate potential fluctuations in participating actors over time. The detailed requirements provided in the Appendix are organized into three categories: *benefits for partners and collaboration, expansion of ecosystem*, and *role-specific requirements*.

MR3: Development & Implementation. MR3 addresses the practical deployment of the DIP4CE, including requirements for easy data access, smooth implementation, and necessary prerequisites for development. The second-order categories structure the requirements listed in the Appendix into *platform development, technical aspects,* and *implementation*.

MR4: CE-related Services. This MR aggregates platform requirements for services related to CE-specific processes as depicted in the ecosystem process model, embodying the CE focus of a DIP4CE. Requirements here are focused on facilitating data sharing within ecosystems for CE applications, with second-order categories including *support for workers*, *CE-strategy-specific support*, and *impact assessment*.

MR5: General Services. This MR focuses on general services provided by DIP4CE to support and guide how data is exchanged through the platform and utilized within the ecosystem. While these requirements do not explicitly target CE applications, they cover fundamental functionalities necessary for a DIP focused on data sharing. Categories include *data transfer*, *utilization of raw data*, and *control of data and participants*.

MR6: Foundational Premises. The final MR ensures alignment with the overarching objectives of the DIP4CE and enhances the ability of participants to share and utilize data. It guides platform development at a strategic level and delineates objectives to which other MRs contribute. Second-order categories are *foundations of data utilization* and *usability and capacity building*.

Discussion & Outlook

This article explores the design of DIPs specifically tailored to support data ecosystems within the CE. Using a DSR approach, the study develops an ecosystem process model and a requirements catalog that together delineate the specific design requirements necessary for DIP4CEs. The requirements catalog serves as a foundational tool for the design and implementation of DIP4CEs, ensuring that the diverse needs of stakeholders, as represented in the ecosystem process model, are effectively addressed. Divided into six

MRs with 46 individual requirements, the catalog addresses key aspects of DIP design related to its governance, architecture, and services, and aligns them with the data sharing and utilization needs central to the dynamics of the CE. These contributions not only address common challenges associated with CE, but also support leveraging the opportunities presented by digital technologies.

The development of the requirements catalog advances our understanding of how DIPs can be used effectively to support CE initiatives. By focusing specifically on the data sharing needs of CE, this research differs from broader studies of data governance within platform ecosystems. This work contributes to the relatively underexplored literature on data management in CE by providing a structured approach to addressing these challenges. For practitioners, our findings serve as a detailed roadmap for developing DIPs that meet the nuanced needs of stakeholders within CE frameworks. By providing guidelines on how to design DIPs that promote effective inter-organizational data sharing, we address the pressing need for organizations to adopt sustainable practices that not only meet regulatory standards but also promote long-term economic resilience. In complex CE ecosystems where data sharing is a fundamental yet challenging necessity, the catalog provides a structured approach to ensure that DIPs can effectively address needs such as data governance. By bridging the gap between the abstract concept of a DIP4CE and its practical implementation, the catalog facilitates the broader adoption of circular business models that are both sustainable and economically viable.

However, the study is currently limited by its reliance on qualitative methodology and its specific research context within the EV industry, which may not fully capture all the nuances involved in DIP design for CE applications. Recognizing these limitations, future research will include the development a DIP prototype based on the requirements catalog, followed by a proof-of-concept demonstration involving relevant stakeholders. This approach will enable an evaluation of the DIP's capabilities and provide opportunities for iterative refinement, ensuring that the DIP is both robust and adaptable to the evolving needs of CE stakeholders. Looking ahead, the project aims to broaden its scope beyond the EV industry and explore the applicability of a DIP4CE across a wider range of industries. Ultimately, this work aims to contribute to a transformative shift towards sustainable economic models, empowering businesses to operate within ecological limits while promoting long-term economic resilience. By addressing the critical challenges of data sharing and governance within CE, this research advances academic knowledge and offers practical solutions that can drive the widespread adoption of circular practices in diverse industrial contexts.

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Appendix: Requirements Catalog

Category	Requirement	Requirement Description	Main Sources
MR1 – Data Governance: The DIP4CE allows to secure intellectual property of stakeholders and defines the base for successful data exchange.			
Data Security	Data protection	The DIP4CE must ensure compliance with the basic principles of data protection law (particularly the protection of personal data).	Pauli 2021, I5
	Confidentiality	The DIP4CE should ensure confidentiality with regard to handling partners' business information.	Serna-Guerrero 2022, Pauli 2021
	Data encryption	The DIP4CE should use encryption for data transmission	I4
Standards	Data format	The DIP4CE must use defined data format standards to which all participants adhere and which ensure the exchanged data's usability.	Halstenberg 2017, Orko 2022, Serna-Guerrero 2022, I3
	Data transmission	The DIP4CE must use a defined data transmission standard to which all participants adhere and which enables data exchange.	Pauli 2021, I3
	Data granularity	The DIP4CE must define a binding data granularity for each data product to fulfil the requirements of the data usage processes.	Ribeiro da Silva 2023, I1
	Data Quality	The DIP4CE must require participants to comply with minimum data quality standards where possible.	Ribeiro da Silva 2023
Data rights	Access rights	The DIP4CE must take into account the different levels of confidentiality of the data (e.g. through classification) and define clear requirements for the allocation of access rights depending on these.	Orko 2022, Expert workshop
	Usage policies	The DIP4CE should define data usage policies that are mutually agreed upon by the partners in the ecosystem.	Orko 2022, Expert workshop
	Data sovereignty	The DIP4CE should ensure data sovereignty, giving data owners the power to decide on how the data is used.	I3
Structure	Platform provider	The DIP4CE should be managed by one organization, which is responsible for governance and operation to ensure simple communication and decision.	I2
	Platform owner	The DIP4CE can be owned by a consortium of participant companies.	Pauli 2021, I2
MR2 – Actor Engagement: The DIP4CE ensures ability and motivation for collaboration considering characteristics of the actors.			
Benefits for partners and collaboration	Communication	The DIP4CE should facilitate and promote communication between the participants.	Serna-Guerrero 2022
	Guaranteed incentive	The DIP4CE must provide individual incentives for each participant to share data, especially the actor who currently has the majority of data at its disposal.	Ribeiro da Silva 2023, I6
Expansion of ecosystem	Participant integration	The DIP4CE should be able to expand by integrating new ecosystem partners.	Pauli 2021, Expert workshop
	Onboarding process	The DIP4CE should offer a standardized onboarding process for new participants.	Schoeppenthau 2023
Role-specific requirements	Data access for users	The DIP4CE should allow to provide users with access to data on material origin and sustainability.	Orko 2022
	Dismantler support	The DIP4CE should equip the dismantler with necessary digital tools to capture and transmit data on disassembled parts, facilitating informed decision-making throughout the reverse logistics chain.	I2
MR3 – Development & Implementation: The DIP4CE's design is aimed at easy data accessibility and ensures efficient implementation.			
Foundations of platform development	Existing data sharing solutions	The DIP4CE must leverage existing data sharing solutions within the ecosystem (e.g., disassembly guides) and incorporate industry-wide best practices for broader applicability and enhanced value creation.	I5, Expert workshop
	Interoperability	The DIP4CE must have interoperability with external platforms.	Schöppenthau 2023, I3
Technical aspects	DIP4CE as Middleware	The DIP4CE can provide data storage, processing capabilities and an operating system for applications.	Pauli 2021
	Technical realization of data access	The DIP4CE should use two possible ways to access data. One option is via the platform itself and one option is via the physical product (or product component).	I1, I6
	Data referencing on product itself	The DIP4CE should guarantee permanent access via the product (or product component) by using an access point that is not endangered by wear and tear).	I6
Implementation	Implementation Strategies	The DIP4CE should be supported with use-case specific implementation strategies to ensure the quick accession of all participants to support a quick enabling of the platform's benefits.	Pauli 2021
	Customizable Solution	The DIP4CE should be customizable to ensure customer-specific characteristics and requirements.	Pauli 2021
MR4 – CE-Related Services: The DIP4CE supports the ability of users to exploit data sharing possibilities for CE use-cases.			
Worker support	CE decision-support	The DIP4CE should support the remanufacturer in making decisions e.g. choosing the most economical of the technically feasible CE strategies.	I6
	Disassembly instructions	The DIP4CE should provide disassembly instructions for the worker (e.g. by differentiating between manual and automatic disassembly steps) depending on the condition of the product.	I4
CE-strategy specific support	Component matching	The DIP4CE can include a service for matching used components and existing used parts of components that may be used for repair/remanufacturing.	I1
	Predictive maintenance	The DIP4CE must support predictive maintenance and preventive repairs by analyzing live usage data.	I5
	Quality assessment	The DIP4CE should offer a data-based assessment of the current quality of the product and its components with calculation of "rest of useful life' (time before it is no longer suitable for use in the car)	Ribeiro da Silva 2023
Impact assessment	Sustainability data provider	The DIP4CE should be able to provide CE indicators (e.g., CO2 footprint and recycled content) that can later be used for reporting or internal and external benchmarking.	Ribeiro da Silva 2023, Orko 2022
MR5 – General Services: The DIP4CE enables transaction of data and improves utilization of data.			
Data transfer	Data requests	The DIP4CE must provide a standardized process for requesting data, which can be answered positively or negatively by the data owner.	I3, I6, Expert workshop
	Data trading	The DIP4CE must support dynamic and possibly context-dependent payment for data usage rights.	Okro 2022, I5
	Data products	The DIP4CE should provide the possibility to create modular data packages ('data products') as part of a data catalogue that can be reused across various modules and services within the DIP4CE.	I5
Utilization of raw data	Data visualization	The DIP4CE should be able to visualize the platform data for users.	Halstenberg 2017
	Metadata analysis	The DIP4CE must offer metadata analysis to interpret and use the raw data.	I2, I6, Expert workshop
	Forecasting ability	The DIP4CE must be able to create forecasts based on existing data sets.	Expert workshop
Control of data and participants	Data traceability	The DIP4CE should enable traceability with regard to data collection, data retrieval and data adjustments.	Orko 2022, Expert workshop
	Participants compliance	The DIP4CE should be complied with by each participant to ensure his contribution to the ecosystem.	Orko 2022
MR6 – Foundational Premises: The DIP4CE fundamentally improves the participants ability to share and use data.			
Foundations of data utilization	Exchange speed	The DIP4CE should ensure a rapid exchange of information.	I1
	Improving transparency	The DIP4CE should facilitate improved transparency across all service processes and the supply chain to build trust, credibility and confidence to support the establishment of new circular resource integration patterns.	Ribeiro da Silva 2023
	Product design insights	The DIP4CE should promote the integration of insights from disassembly into the product design.	I1
Usability and capacity building	Usability	The DIP4CE should have a good usability for participants.	Orko 2022
	Capacity building CE	The DIP4CE should support participants in understanding and building knowledge in the field of CE.	Pauli 2021
	Data handling capacity	The DIP4CE should promote data handling expertise.	Orko 2022

CE-specificity: Non-CE-specific | CE-specific **Especially relevant for pre-/in-/post-use:** Pre-use | In-use | Post-use