Product Development using Digital Product Passport - DIPP

Public rapport

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Projekt inom FFI Circular Economy

FFI Fordonsstrategisk Forskning och Innovation
VINNOVA Energimyndigheten TRAFIKVERKET
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1 Sammanfattning

Denna rapport är resultatet av ett förberedande projekt för DIPP (2022-2023) som genomfördes inom FFI-programmet, där en vägkarta och ett föreslaget handlingsplan utarbetades för att nå en önskad tillstånd där initiativ som den digitala produktregistret inte bara är en nödvändighet att behärska och rapportera, utan också en källa till innovation och mer hållbara produkter. Eftersom utvecklingen av sådana behövs av nödvändighet måste utvecklas och accepteras av flera aktörer inom fordonsbranschen och även bortom den, är rapporten öppen och strävar efter att fungera som en samling av nuvarande uppfattningar, idéer och förväntningar. Den intensiva och pågående utvecklingen av teknik och normativa lagar påverkar praxis tillstånd ganska snabbt.

Denna rapport föreslår en vision för hur tillgänglig och spårbar data genom främst digitala produktregistret påverkar produktutvecklingspraxis och kan användas för att skapa nya lösningar. Visionen formulerades under workshops med deltagare som representerar olika roller inom fordonsvärdekedjan tillsammans med IT-tjänsteleverantörer. Visionen formulerades som:

"Smart användning av tillgänglig produktlivscykelinformation som möjliggör hållbara och cirkulära design i samarbetsnätverk."

Fordonssektorn är mycket medveten om de kommande instrumenten där EU förväntar sig att möjliggöra hög spårbarhet av produkternas innehåll och ursprung för slutkunden när det gäller deras påverkan på hållbarheten. På många sätt tvingar förmågan att spåra och rapportera rik produktinformation tillverkare tillsammans med leverantörer att utveckla både teknik, metoder och normer för att möta sådana förväntningar.

Även om fokus ligger på fordonsindustrin med speciellt intresse för hur det kan påverka produktutveckling, är det troligt att resultaten är relevanta även för andra branscher. Resultaten baseras på studier av konstens och praktikens tillstånd (litteraturstudier) och pågående initiativ relaterade till den digitala produktregistret. De viktigaste resultaten pekar mot följande luckor med DPP: i) oklart vilka hållbarhetskriterier som behövs för att uppfylla DPP-kraven och hur dessa kan representeras; ii) otillräcklig teknik och metoder för att transparent spåra hållbarhetsdata; iii) oförmåga att kvantitativt bedöma hållbarhetskonsekvenserna av alternativ i de tidiga designstadierna; och iv) otillräcklig designmetodik som inte tillräckligt hanterar faktorer som är avgörande för cirkulära lösningar, såsom hur man kan dra nytta av och integrera leverantörslösningar för cirkularitet.

Baserat på dessa resultat dras slutsatsen att även om DPP-instrumenten inte är fullt utvecklade, kan det vara en fördel för företag att förbereda sin organisation för implementeringen av DPP. Framtida forskning bör undersöka om DPP kan bidra till en snabbare övergång genom att kunna identifiera möjliga hållbarhetsutmaningar i värdekedjan i de tidiga produktutvecklingsfaserna. Dessutom bör det undersökas om det kan vara lättare att ställa tydliga hållbarhetskrav på leverantörer och andra aktörer i värdekedjan med stöd av DPP.

Slutlig roadmap och föreslagen handlingsplan för att åtgärda kritiska kunskaps- och kapacitetsluckor för att nå en önskad vision och gemensam vision om hur tillverkare kan dra nytta av DPP och utveckla mer hållbara produkter presenteras. Det rekommenderas att

lansera aktiviteter för att lansera kritiska åtgärder och ytterligare detaljera föreslagna åtgärder på flera nivåer av beredskap ur ett implementeringsperspektiv. ’

Rekommendationerna från DIPP-förstudieprojektet kan formuleras enligt följande:

Ett första kort projekt genomförs för att sammanställa och dokumentera en modell för cirkulär ekonomisk design som kan dra nytta av den rikare tillgängligheten av data som förväntas vara följden av Digital Product Passport och liknande incitament. Som ett andra steg, därefter rekommenderas tre parallella initiativ.
a) Det mest mogna och omfattande initiativet är en standard- och utbildningsinitiativ. Här har branschen flera pågående initiativ som kan stärkas med kunskap om konsekvenserna av ökad dataöppenhet och tillgänglighet. Samarbeten med standardiseringsorgan, pågående och planerade, är nödvändiga.
b) Demonstration av databerikade koncept för cirkulära ekonomifordon. Här är syftet att minska riskerna med cirkulära koncept, visa konsekvenserna och möjligheterna med datadriven design samt avslöja risker och konsekvenser som behöver hanteras i förväg för affärsinvesteringar.
c) Detta förstudieprojekt har identifierat en prioriterad uppsättning åtgärder, varav flera kräver kunskapsutveckling (forskning). Därför rekommenderas långsiktiga (3-5 år) initiativ för att utveckla kunskap, metoder och verktyg för datadriven hållbar och cirkulär design. Fokus för dessa initiativ är applicerbarhet inom design och nya affärer när data blir mer tillgänglig. Samarbeten och kompletterande initiativ, till exempel inom datavetenskaplig forskning, behövs för att koppla samman med fordonssystem och ingenjörskontext.
Slutligen rekommenderas att denna vägkarta revideras och förfinas när resultaten och lärdomarna från aktiviteterna ger nya resultat. Dessutom kräver den intensiva utvecklingen av teknik, marknad och lagstiftning att vägkartan behöver revideras, föreslås varannat år.

2 Executive summary in English

This report is a result of DIPP (2022-2023) preparatory project conducted in the FFI program, where a Roadmap and suggested Action Plan for what needs to be done to reach a desired state where initiatives such as the Digital Product Passport is not only a necessity to master and report, but also a source for innovation and more sustainable products. As the nature of such development by necessity needs to be developed and accepted within several actors in the automotive business, and even beyond, the report is open and seeks to function as a collection of current perceptions, ideas and expectations. The intense, ongoing development of technology and normative legislation impact state of practice rather rapidly.
This report propose a vision for how data becoming accessible and traceable through foremost Digital Product Passports impact the practice of product development and can be used to create new solutions. The vision was formulated during workshops with participants representing different roles in the automotive valuechain and together with IT Service providers. The vision was formulated as:
“Smart use of available product life cycle information that enable sustainable and circular designs in collaborative ecosystems”
The automotive sector is well aware of the forthcoming instruments where EU expect to enable a high degree of traceability of the contents and origins of products to the end customer when it comes to their impact on sustainability. In many ways, the ability to trace and report rich product information enforces manufacturers together with suppliers to develop both technologies, practices, and norms to meet such expectations.
Although the focus is on the automotive manufacturing industry within the specific interest in how it may impact product development, it is likely that the findings are relevant also for other industry sectors. The results are based on the State of the Art and State (literature study) of

Practice studies (survey and workshops), and on-going initiatives related to the Digital Product Passport. The main finding point towards the following gaps with DPP: i) unclear what sustainability criteria are needed, to meet the DPP requirements, and how these can be represented; (ii) insufficient technology and methods in place to transparently trace sustainability data; (iii) inability to quantitatively assess sustainability consequences of alternatives in the early design stages; and, (iv) design methodology not sufficiently addressing factors that are decisive for circular solutions, such as how to benefit and integrate supplier solutions for circularity.
Based on these results, it is concluded that even if the DPP instruments are not fully developed, it could be an advantage for companies to prepare their organization for the implementation of the DPP. Future research should investigate if DPP can contribute to a faster transition by being able to identify possible sustainability challenges in the value chain in the early product design phases. In addition, it should be investigated if it may be easier to place clear sustainability requirements on suppliers and other actors in the value chain with support from DPP.
The final roadmap and the proposed action plan to address critical knowledge and capacity gaps to reach a desired vision and common vision of how manufacturers can benefit from the DPP and develop more sustainable products are presented. It is recommended to launch activities to launch critical activities and further detail proposed actions on several levels of readiness from a deployment perspective.

The recommendations from the DIPP prestudy project can be formulated as below.
1) a first short project is conducted to compile and document a Circular Economy Design model, capable of utilizing richer data availability expected to be the consequence of Digital Product Passport and similar incentives. As a second step,
2) thereafter, three parallel initiatives are recommended.
a) On most mature and wide ranging nature is a standards and educational initiative. Here, industry have several initiatives ongoing that can be strengthen with knowledge in the consequences of increased data transparency and availability. Collaboration with standardization bodies, ongoing and planned, are necessary.
b) Demonstration of data enriched circular economy vehicle concepts. Here, the purpose is to de-risk circular concepts, to demonstrate the consequences and opportunities of data informed design, and to unveil risks and consequences that need to be addressed in advance of business investments.
c) This pre-study project has identified a prioritized set of actions, several of which require knowledge development (research). Hence, long term (3-5 years) initiatives are recommended to develop knowledge, methods and tools for data driven sustainable and circular design. The focus of these are on the applicability on design and new businesses as data becomes more available. Collaboration and complementary initiatives to e.g. Computer Science oriented research is needed to bridge into vehicle systems and engineering context.
3) Finally, its recommended that this roadmap is revisited and refined as the results and learnings from activities give new results. Also, the intense development of technology, market and legislation require that the roadmap needs to be revised, suggestively every 2 years.

3 Background

Automotive manufacturing industry represents large volumes vehicles where each vehicle is a rather advanced compilation of technologies and materials, used globally with a high impact on services for business and people globally. Automotive business is furthermore competitive and currently undergoing a rather radical transformation in core technologies, predominately through electrification and hybridization. The business if further rather exposed to regional and national legislation that evolves and changes constantly. In addition,

the complexity in the industrial ecosystem of companies engaged to realize automotive products is both extensive and complex.
In Europe, the Green Deal and the Circular Economy Action Plan (CEAP) have a clear impact on the future for manufactures. The Digital Product Passport mechanism is being implemented for the first prioritized areas (e.g. batteries) already, and discussions are ongoing for how to expand. Automotive industry already follow instruments such as the End Of Life Vehicles (ELV) Regulation, that proposed updates in July 2023. The ELV partly address similar aspects as the Digital Product Passport, where the EU council1 recently adopted new regulations for batteries and battery waste, that clarifies targets and expect increase in circular economy solutions.
Aside from enforcing clearer traceability and transparency of sustainability information for products, down to the individual products and components and along their life, there are important openings also for the future generations of automotive solutions. Circular Business models require also more control of the product data and its evolution of their individual lifecycles. Knowledge and ownership of product information that impact the sustainability performance of the solution is an asset for manufactures. The ability to design products to both enable transparency, traceability and also support Circular Economy models is an area that raise significant interest.
Suppliers may also gain from offering clear and transparent information to stakeholder downstream in the value chain. In the context of Circular Economy, specific and detailed information, such as: type of materials, chemical contents, life lengths, and, social conditions in the production, is likely to be needed to develop and provide increasingly sustainable and circular offers. What can manufacturers do to benefit from the transformation that is ongoing in the business, and enabled by new means to capture and trace information?

DIPP contributes to clarify how Swedish automotive industry proactively can take advantage of the increased market expectations and legislative requirements on transparency and traceability of sustainability related product data. This directly comply with FFI vision on Sweden leading the transition to sustainable road transport.
DIPP and the completion of activities prepared in DIPP contribute to FFI impact goal 3, by outlining the innovative skills and capabilities for transparency and traceability necessary to include in design of circular and sustainable vehicles and transport solutions. This is done together with value chain partners.
As DIPP direct further actions to address the gaps and realize potential through the roadmap created, and proposals formed, this address common needs in automotive industries in general and form a firm based recommending the Volvo's ambition and commitments to deliver circular solutions and a fossil free vehicle fleet by 2040.
In the pre-study the potential, and associated risks and actions is clarified. The roadmap and action plan proposed is targeted to realize the potential by pilot applications and closing knowledge gaps.

4 Project objective and method

The DIPP pre-study seeks to clarify implications (gaps, opportunities) of DPP in product development and proposes a roadmap and action plan for addressing these.
The problems addressed are that
(i) it is unclear what sustainability criteria are needed, and how
these can be represented,
(ii) insufficient technology and methods in place to transparently trace
Such data,
(iii) the ability to assess sustainability impact of alternatives is too limited, and

[1] *Council adopts new regulation on batteries and waste batteries - Consilium (europa.eu)*

(iv) design methodology does address sufficiently factors decisive for circular solutions, such as how to benefit and integrate supplier solutions for circularity,
These problems may result in legislative risks, missed business and/or extensive manual resources to meet requirements. Manually tracing the requested data will quickly consume labor that amounts to 100'reds of MSEK per year for a typical automotive manufacturer.

This DIPP pre-study project aims to build a strong consortium by involving partners within the automotive eco-system of companies, specialists in data traceability, experts and researchers in
sustainable product development and value driven systems engineering. The roadmap and action
plan clarifies how to accelerate the transformation in the form of a proposal for a full-scale FFI,
and/or EC project. Cases and partners are expected to be formed through the pre-study activities.
Chalmers, BTH and VOLVO worked tightly together to manage the project. Volvo provided industrial expertise and access to experts and relevant insight in industrial activities, such as the international imitative Catena X.
BTH and Chalmers organized the project activities to conduct both a state of art and a state of practice knowledge base for the project.
A literature review was conducted to summarize the state of art in the field of DPP. In parallel, three focus studies were conducted, targeting automotive manufacturing companies and other stakeholders, to collect insights with the purpose to understand how different stakeholders in a value chain prepare for and work with DPP. In addition, information from on-going and recent project initiatives in relation to DPP was summarized. All together this provides a good base of information and contribution to the Vision and Roadmap were formulated based on State of the Art and State of Practice workshops and interviews. The roadmap also comprised a set of proposed activities to provide capabilities for innovation and for more circular and sustainable products.
The vision, roadmap and suggested action plan is included in this report, whereas more comprehensive state of art and analysis is the basis for scientific dissemination after the project.

5 Goals

The Ideas, objectives and goals of the DIPP pre-study is to clarify both the current gaps and upcoming opportunities with the increased requirements of transparent and traceable sustainability data and formulate an action plan in a specific roadmap. During DIPP, consortia
and proposals for how to address critical gaps and realization of identified potential will be formed
.
The successor projects expected from DIPP will focus on developing and establishing necessary and effective work-methods and tools for Product Develoment of circular and sustainable solutions using DPPs in automotive manufacturing ecosystems.
The goal is to enable development of circular and sustainable solutons meeting market and legislative requirements such as the DPP. In particular, (i) define sustainability criteria necessary, to be traced in the value chain for automotive companies, (ii) understand how to ensure trustful, transparent and traceable data sharing between actors in the value chain throughout the life cycle of a product (iii) ensure that the value and sustainablity impact of candidate circular solutions can already be assessed and evaluated during early phase design and (iv) support the transition and establishment of work practices that complies with DPP and enable value chain collaboration.

6 Results and Goals fulfilment

Below the results and goal fulfilments are summarized. The underlying analysis is subject for scientific publications, a work that is ongoing at the time of writing. A bibliography of most important references used in the project is provided.

6.1 State of the Art

The literature review gives an introduction of Green Deal initiatives and Digital Product Passports (DPPs), as part of efforts in the European Union (EU) to promote sustainability and circularity. The EU has implemented new policy instruments to encourage companies to align with sustainable practices. The Green Deal aims to decouple economic growth from resource use and improve circularity. The New Circular Economy Action Plan (NCEAP) includes launching legislative initiatives to incentivize resource-efficient and climate-neutral product designs. The EcoDesign Directive is being updated, and DPPs are being investigated to store product information.

DPPs are intended to trace and store data about a product throughout its entire lifecycle, providing transparency and reliability on green claims. The proposed requirements for DPPs include product durability, reusability, upgradeability, presence of substances of concern, energy and resource efficiency, recycled content, remanufacturing and recycling, carbon and environmental footprints, and waste generation. However, the specific information to be stored in DPPs is yet to be determined.

This review also highlights the challenges and opportunities associated with DPPs. These include the need to make DPPs attractive and user-friendly for stakeholders, the difficulty of collecting and updating data during different lifecycle stages, and the importance of ensuring that consumers can interpret and understand DPPs. Access to DPP information raises concerns about protecting intellectual property while facilitating collaboration and improving traceability.

This review further discusses sustainable product development in relation to circular design. It emphasizes the challenge of defining and communicating sustainability, as well as the variety of indicators used to assess sustainability performance. Standardized sets of impact assessment indicators and assessment methods are being developed to enable product comparisons and support sustainability evaluation. Different types of indicators are applicable at different design phases, with "ex-ante" indicators suggested for guiding early design decisions. However, reliance on standardized criteria or indicators can lead to sub-optimizations and may not address all sustainability dimensions.

Lastly, the literature review addresses the measurement of sustainability-related product performance. Sustainability impacts are modeled as impacts on ecological, social, and economic systems triggered by lifecycle activities. Sustainability performance can be described using "lagging" or "leading" indicators, with the former assessing actual impacts retrospectively and the latter guiding design decisions. Complete traceability of sustainability-related information across a product or system lifecycle is currently lacking.

6.2 State of Practice

The introduction of Digital Product Passport (DPP) is being increasingly recognized and attended to by industry stakeholders. The attention towards DPP stems from the uncertainties surrounding its consequences and the clear indication of a heightened demand for producer responsibility and traceability of sustainability data throughout the product life cycle. Interviews conducted with representatives from various companies within Sweden's product development sector revealed a range of perspectives on the potential impact of DPP.

Although the level of awareness varied among the interviewees, with some having only brief knowledge while others were actively involved in internal investigations, the majority believed that DPP would have a positive impact on their businesses and sustainability efforts. This optimism stemmed from expectations that management would prioritize sustainability-related work to meet legislative requirements, leading to increased resources allocated to sustainability in product development. Furthermore, the legislation would drive companies to enhance their capabilities, skills, and knowledge in sustainability, ultimately fostering the implementation of sustainable design strategies. The ability to compare products based on information stored in the DPP was also seen as advantageous.

However, there were uncertainties regarding the coverage of companies, products, and solutions under the legislation, making it difficult to assess the magnitude of the impact on businesses. Concerns were raised regarding the adaptation of operations to deliver DPPs, particularly in terms of IT and data management systems. Questions were also raised about the storage of DPP data, the existence of a central EU database, and the specific requirements for each company's product information. Clarity was lacking regarding the timing and extent of the DPP implementation.

A survey targeting stakeholders in the automobile industry highlighted challenges related to tracking and sharing sustainability information throughout the product life cycle. The respondents expressed difficulty in obtaining data on social aspects and the limited knowledge of the extent to which ecological information is available within their supply chains. They emphasized that data easily shared today primarily pertained to internal networks, while sustainability data posed more significant challenges. Identified risks and uncertainties included data reliability from the supply chain, linking information to specific products, the absence of clear standards, data security, excessive administration, suboptimization, and ambiguity surrounding inclusion and information sharing.

Despite these challenges, stakeholders recognized opportunities presented by DPP. These included communicating commitments to transparency, enhancing transparency and informed decision-making for sustainability improvements, gaining better control over sustainability data along the value chain, facilitating simplified customer communication, promoting circular product solutions and material recycling, and avoiding greenwashing to enhance credibility.

There are numerous initiatives, both in Sweden and other EU countries, focused on the development of Digital Product Passports (DPPs). These initiatives aim to address challenges related to data, transparency, and traceability. Projects like the Global Battery Alliance (GBA) are working towards establishing criteria and benchmarks for sustainable and transparent battery markets. The CIRPASS project is developing a roadmap for DPP prototypes in electronic, battery, and textile value chains. Other initiatives, such as PROPARE and Trace4Value, are building open infrastructures and facilitating data sharing for credible sustainability information. The Onto-DESIDE project aims to improve data sharing and usability in the circular economy. CATENA X focuses on creating end-to-end digital traceability in the automotive industry. These initiatives signify ongoing efforts to enhance sustainability and circularity through the implementation of DPPs. Only a few projects, e.g. GBA Battery Passport and CIRPASS, focus on what data that should be traced in order to make an impact towards more circular and sustainable solutions. Only GBA Battery clearly present inclusion of the social dimension. This group also plan to develop a sustainability indicator framework, which is open to contribute to.

To mitigate risks and maximize opportunities, measures such as internal control and external follow-up, extended industry dialogue, clearer standardization, simple and adaptive IT solutions, and cross-functional collaboration were recommended. The interviews conducted with key representatives from various industrial sectors underscored the importance of understanding supply chains, technological solutions, and the need for realistic expectations regarding the capabilities of DPP. Maintaining corporate confidentiality and addressing the specific challenges faced by small and medium-sized enterprises were also crucial considerations.

It was emphasized that proper implementation of DPP could lead to improved customer communication, enhanced understanding of circularity, and the need for standardization and international collaboration. Companies were advised to familiarize themselves with DPP implications, prioritize the development of digital infrastructure, manage sustainability aspects effectively, and adapt to circular economy laws and regulations.
In conclusion, the challenges and opportunities surrounding DPP have been identified through multiple studies and interviews. By addressing these challenges and capitalizing on the opportunities, companies can navigate the implementation of DPP successfully, striking a balance between transparency and corporate confidentiality while contributing to sustainability and circularity goals. Standardization, collaboration, and proper data management are vital for realizing the benefits of DPP and driving positive change across industries.
This study was conducted in a limited time period, targeting stakeholders only in Sweden, and had a limited set of answers. To cover the full picture of the state of practice it should be complemented with more companies, and more interviewees.

6.3 Vision

A condensed vision is based on the increased information being clearly linked to products by legislation, and enabled by sensing and digital traceability technologies. This will strengthen the interaction between the integrators (OEM's) and their suppliers. The ability to benefit from this tightened dependency open for "smart" innovation in the sustainable and circular dimension.
The vision, formulated and validated with the participants of the physical workshops, what that at a future state
"**Smart use of available product life cycle information that enable sustainable and circular designs in collaborative ecosystems**", see figure 1.

Figure 1 A common vision expressed by workshop participants representing an ideal state where sustainable and circular products are developed based on enriched information from the value chain.

Based on the state of art and state of practice, presented in chapter 2, and the DIPP workshops a set of prioritized areas were derived, each of which represent areas where knowledge and practice need to advance to realize the vision.

6.4 Roadmaps and suggested actions

At the workshops and together with partners from Volvo, Chaintraced, Eurostep, SSAB, Chalmers and BTH , seven critical areas were formulated wherein knowledge and solutions need to be formulated were defined.

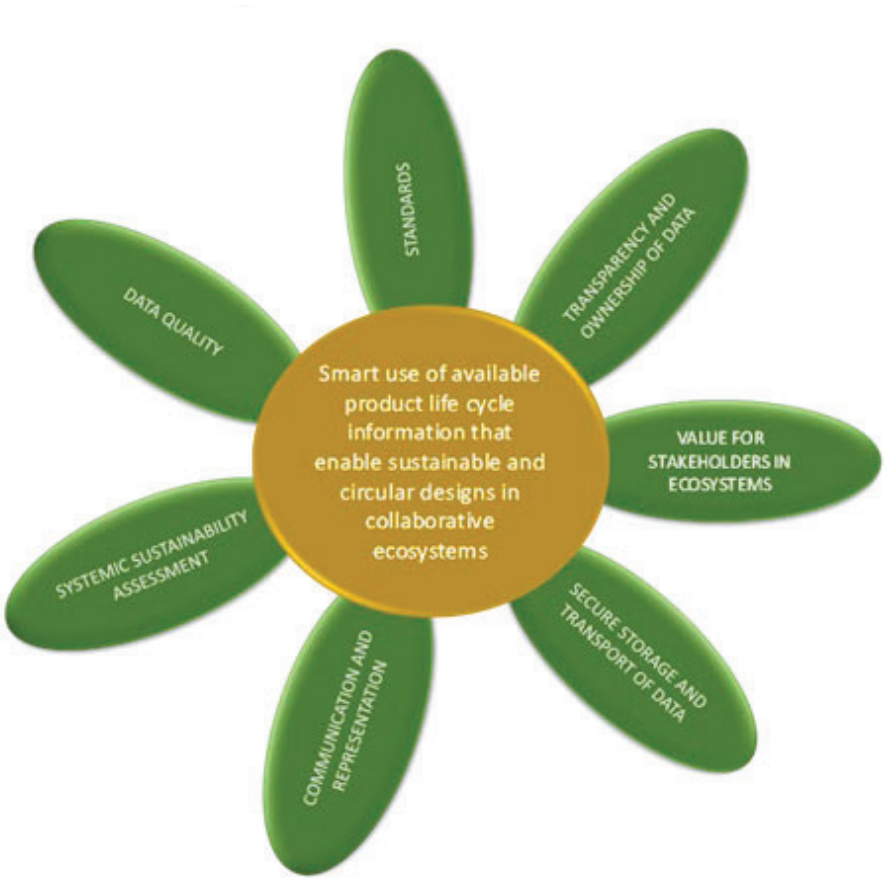

Figure 2 Critical areas that needs to be addressed for the vision

The meaning of the areas and suggested actions to close knowledge gaps are listed in the table below.

Critical Area	Explanation and rationale	Proposal
Systemic Sustainability Assessment	Sustainability is a systemic concept, typically requiring extensive and data rich information to assess. In early phases of Product Development neither time nor extensive data of the forthcoming product exists.	Develop Knowledge and Models to Formulate Sustainable Criteria, Design Methodology and Evaluation Methodology covering Value Chain and Life Cycle dimensions (modelling, simulating, optimising, Exploring, Decision making)

Data Quality	Data captured and stored have different quality. Understandig what quality level exists vs what is required for decision making is critical.	Raise knowledge on data quality perspectives, risk and value that build in credibility, accessability, completeness, actuality, effectivity etc of data. Exploring how e.g. ISO8000 can be used to build practices and methods to assess and classify data quality. Link Data Quality to Decision quality,
Standards	Standards are decisive for scale up in industrial ecosystems and to enable integration of DPP data in information management systems. Relevant standards exist (e.g. ISO 10303-239/242) but not demonstrated in DPP contexts.	Activities to Benefit from existing standards, develop scaleability scenarios and strategies, analyse and formulate recommendations and proposals for deployment of standards, and for launching standards in critical areas.
Secure storage and transport of data	Increased IT requirements for DPP data handling, transport, and accessibility are being addressed, including the use of blockchain technology. These solutions must align with data types, actors, and complexity. IT service providers are actively developing technical solutions, with a primary focus on legislative compliance. However, their role in next-gen products and solutions is less clear. The intersection of Product Lifecycle Management (PLM) with material and sourcing dataflows, like Enterprise Resource Planning (ERP), may lead to increased complexity and involve new stakeholders, potentially affecting transparency and reporting. Ethical, privacy, and legal concerns (e.g., GDPR) could pose challenges to implementation and deployment.	Develop criteria and auditing criteria and tools for DPP, compile and gather state of art solutions, map standards and defacto standards vs. Commercial solutions.
Communication and representation	In contrast to physical vehicles, machines and even materials, the characteristics of DPP is largely “tacit” and also highly contextual in nature. This means that there are outstanding knowledge gaps for decision makers to judge forthcoming solutions. Means to define, visualize and explain impact of circular solutions using DPP data is lacking. The direct impact also on business, supply chain and legal aspects	Develop and demonstrate means to define, model, represent and visualise circular driven services, develop requirements and criteria communication and aggregation. Techniques to filer, navigate and explore data in different application contexts.

	further add to the task to gain a sufficiently clear understanding of new, potentially innovative, DPP based solutions. Furthermore, the data treated will need to be presented in different ways to different stakeholders. End users of a consumer product may need a simple labeling system to be informed.	
Value for Stakeholders in Ecosystems	AS data will be provided in more traceable and transparent ways, the incentives and cost for all stakeholders in the value chain is impacted. Established business relations may be impacted.	Generally, its adviced to develop means to analyse the cost, risk and value consequences for all stakeholders. Such should cover dimensions such as richer data availability, sensitivity and resilience studies for alternative Data Management strategies (Capture, Store, Report, Share, Maintain, Retrieve.)
Transparency and ownership of data	Consequences of transparency and traceability of product data open new questions. IP analysis for multiple stakeholder, Explore Level of Resolution in DPP data transparency, Complexíty and Digital Define and explore Scenarios for Risk, Value and Consequence of Ownership and Transparency questions are some of the uncertainties that need to be addressed.	A set of proposed actions are listed below. Develop realistic examples that clarify implications for different stakeholders. Create a stakeholder value mapping and analysis for alternative scenarios. Derive recommendations for LOR (Level of Resolution) for typical applications. Develop suggested practices for establishing DPP's to particular application fields. Communicate proposals and consequence analyses to ongoing DPP establishment forum. Make value and risk analyses for alternative scenarios. Create and organize knowledge sharing activities in the Swedish Automotive Network of actors, e.g. at "klusterdagarna" on the topic.

6.5 Contribution to FFI goals

DIPP results contribute to clarify how Swedish automotive industry proactively can take advantage of the increased market expectations and legislative requirements on

transparency and traceability of sustainability related product data. This directly comply with FFI vision on Sweden leading the transition to sustainable road transport. DIPP proposed actions suggest to strategically take action to prepare automotive industry to develop novel products and innovations that benefit from the successively increased availability and transparency of sustainable related product data.

DIPP and the completion of activities prepared in DIPP contribute to FFI impact goal 3, by outlining the innovative skills and capabilities for transparency and traceability necessary to include in design of circular and sustainable vehicles and transport solutions. This have been met as results have together with value chain partners.
As DIPP direct further actions to address the gaps and realise potential through the roadmap created, and proposals formed, this address common needs in automotive industries in general and form a firm based recommending the Volvo's ambition and commitments to deliver circular solutions and a fossil free vehicle fleet by 2040.

The prestudy have provided a vision and a list of seven critical areas to address. Actions are proposed and a roadmap has been issued with recommendations. A proposal for first actions have been formulated and submitted to FFI

7 Dissemination and publication

7.1 Knowledge and results dissemination

Hur har/planeras projektresultatet att användas och spridas?	Markera med X	Kommentar
Öka kunskapen inom området	X	More than 15 organisations have been inwited to, and participated in surveys and workshops, discussion the knowledge gaps collectively from different perspecties. A joint vision and formulation of critical areas to reach the vision have been formed together with partners also outside the project members.
Föras vidare till andra avancerade tekniska utvecklingsprojekt	x	A small study to form a design approach that include the data transparency and traceability that follow upcoming legislation has ben formed into an FFI application (CADCOD). Partial results have partially been presented internatiolly with candidate partners to coordinate international activities and potential projects and standardization intiitiatives.
Föras vidare till produktutvecklingsprojekt	x	Volvo has used the results in their planning towards circular truck demonstrators, and direct discussion together with material suppliers on how to contribute to circular demonstrators,
Introduceras på marknaden		DIPP is a prestudy, and market introduction is not applicable.
Användas i utredningar/regelverk/ tillståndsärenden/ politiska beslut	(x)	Svenskt Näringsliv and Naturvårdsverket participated in the survey to provide input. The intent is for the roadmap and action plan to be available for a wide range of authorities . Follow up activities suggest to develoo knowledge and evidence, partially for such reasons. Also for input to standardization.

7.2 Publication strategy

Results from the short pre-study has been compiled after the summer of 2023, and journal publications are being prepared for submission at present.
The results would be highly relevant to present at FFI klusterdagar (2024).

8 Conclusions and further research

This Roadmap section suggest the logic of organizing the necessary activities that build up design and development capabilities for sustainable and circular economy solutions in manufacturing industry eco-systems. The capabilities are divided in four strands, and their relations are displayed in the “Capability development roadmap” in Figure 4. By capabilities we refer to complex bundles of skills and accumulated knowledge, exercised through organizational processes that enable firms to coordinate activities and make use of their assets.

The “KNOWLEDGE AND CAPABILITY DEVELOPMENT”, in figure 4, activities generate new methods, tools and suggested practices on a lower TRL level. Their criticality and potential impact should be high. Several of the long-term actions identified are recommended to be performed as research projects with academic lead and industry involvement for relevance, contexts, and strategic planning.
The “DEMONSTRATION AND VALIDATION” follow a logic of successively demonstrating more complete and complex capabilities in applied contexts. This means that industry actors need to be active and provide real and realistic environments, and often be in the lead of the initiatives. Capabilities and knowledge developed in parallel, or preceding, the demonstrators are validated and matured with a higher TRL level. The “UTILISATION AND TRANSFORMATION OF PRACTICE” path focus on introducing and establishing new practices, business and products. This is entirely driven by industrial actors, potentially supported by specialists’ actors, consultants, institutes and/or universities.
The “STANDARDS” strand is always present. The biggest challenge is the pace of change expected, where standards require time to mature, become accepted and foremost becoming adopted and made readily available. Demonstrations are recommended to provide examples and evidences for standardization, both how standards can be used, and to demonstrate areas and topics where standards need to support. Standards can also have direct relation to research studies, where knowledge important to advance standards can be generated and scientifically sound proposals can be included.

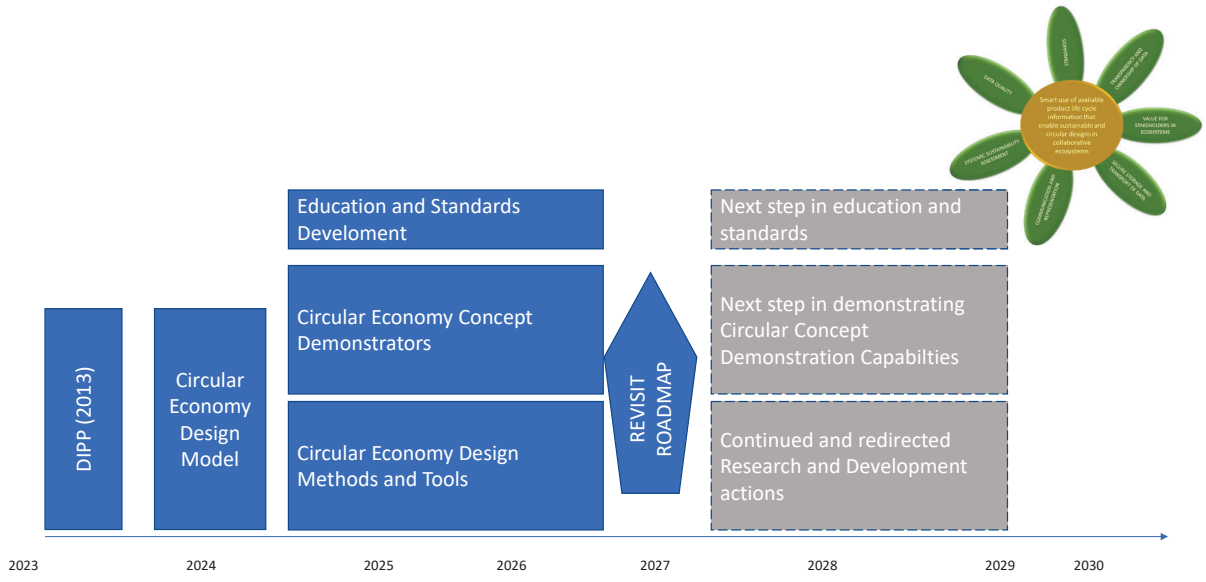

Figure 3 The Capability Development Roadmap addressing the knowledge gaps and proposed actions.

An example of how these four strands can be organized into a project roadmap is provided in Figure 5. It is difficult to prescribe exactly what projects that together will be formed to contribute to the path towards the vision.

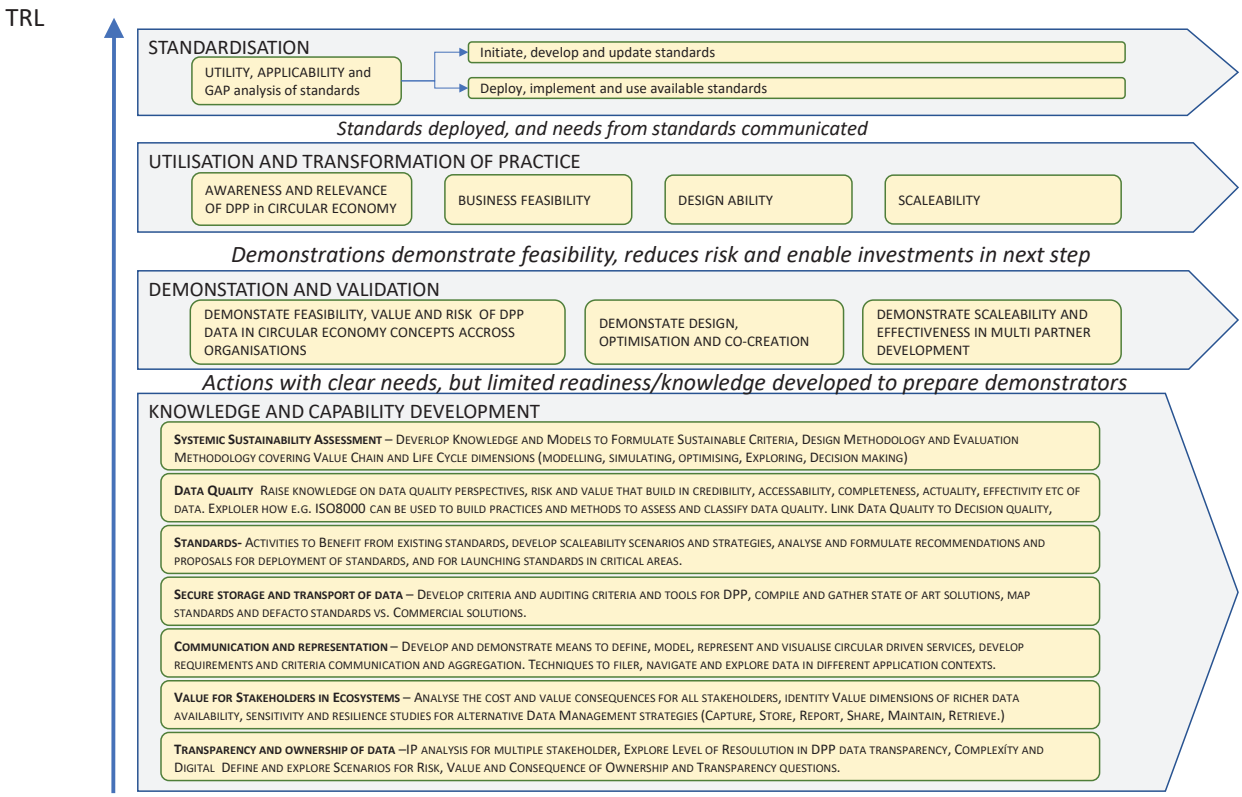

Figure 5. The project roadmap propose how projects of different nature are needed to accelerate the path towards the vision

As displayed in figure 5, the recommendations from the DIPP prestudy project can be formulated as below.

1) a first short project is conducted to compile and document a Circular Economy Design model, capable of utilizing richer data availability expected to be the consequence of Digital Product Passport and similar incentives. As a second step,

2) three parallel initiatives are recommended.

a) On most mature and wide ranging nature is a standards and educational initiative. Here, industry have several initiatives ongoing that can be strengthen with knowledge in the consequences of increased data transparency and availability. Collaboration with standardization bodies, ongoing and planned, are necessary.

b) Demonstration of data enriched circular economy vehicle concepts. Here, the purpose is to de-risk circular concepts, to demonstrate the consequences and opportunities of data informed design, and to unveil risks and consequences that need to be addressed in advance of business investments.

c) This pre-study project has identified a prioritized set of actions, several of which require knowledge development (research). Hence, long term (3-5 years) initiatives are recommended to develop knowledge, methods and tools for data driven sustainable and circular design. The focus of these are on the applicability on design and new businesses as data becomes more available. Collaboration and complementary initiatives to e.g. Computer Science oriented research is needed to bridge into vehicle systems and engineering context.

3) Finally, its recommended that this roadmap is revisited and refined as the results and learnings from activities give new results. Also, the intense development of technology, market and legislation require that the roadmap needs to be revised, suggestively every 2 years.

9 Participant and contacts

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