NEEDS AND GAP ANALYSIS

DELIVERABLE 1.1

CIRCPLASTX

A DATA SPACE TO INCREASE CIRCULARITY THROUGH DATA FOR THE PLASTICS INDUSTRY

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CircPlastX

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Abbreviations

ABBREVIATION	MEANING
AGEC	Anti-Waste for a Circular Economy Law (France)
CEAP	Circular Economy Action Plan
CRM	Critical Raw Materials
CSRD	Corporate Sustainability Reporting Directive
DPP	Digital Product Passport
EC	European Commission
ECHA	European Chemicals Agency
EPR	Extended Producer Responsibility
ISO	International Organization for Standardization
JRC	Joint Research Centre
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
PPWR	Packaging and Packaging Waste Regulation
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals

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Executive summary

CircPlastX is a project funded under the Digital Europe Programme (DEP) that aims to create a data space to support circularity in the plastics and composites manufacturing sector. The data space will enable data access and acquisition among participants across the value chain, fostering trusted, interoperable, and secure data exchange. Three digital services will be developed, each addressing a specific data-related challenge for circularity:

1. Recycled Material Certification – improving traceability, quality and validation of recycled content.
2. LCA Data Quality Checker – enhancing the reliability and comparability of life cycle assessment datasets.
3. Substance Compliance Checker – automating verification of data on hazardous substances.

Within this framework, Task T1.1 (Needs and Gaps Analysis) provides the foundation for aligning technical developments with real industrial needs. The deliverable examines the current state of digitalisation in the plastics and composites sector, identifies key gaps in data practices, and gathers feedback from stakeholders to guide the design of the data space and its services. The purpose of the report is to establish a strong evidence base for the subsequent design and technical development of the CircPlastX data space and three digital services for circularity. The scope of the report is therefore both analytical and preparatory: it identifies the current state of play in the industry, highlights barriers and opportunities, and translates these into requirements that guide the project's next steps. We aim to report on the following goals:

- Assess the current digital maturity of companies in the plastics and composites industry.
- Fine-tune the proposed services through industry feedback.
- Formulate requirements for the technical development of the data space and its services.

The analysis is based on a multi-step methodology combining desk research, expert interviews, surveys, and a stakeholder workshop. This approach enabled a robust mapping of industry needs and challenges related to data exchange for circularity, while ensuring that the proposed services are aligned with real-world priorities.

The document is structured as follows: a brief introduction to the data space concept, followed by an overview of industry needs and regulatory drivers; a presentation of data space architectures and governance frameworks; and a detailed discussion of the three digital services, including insights from desk research and stakeholder feedback. The report concludes with next steps for refining technical requirements and engaging stakeholders in the further development of the CircPlastX data space.

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Introduction

CircPlastX – a Data Space for circularity

The CircPlastX project is part of Digital Europe Programme (DIGITAL). It officially launched on March 1st, 2025, and will run for 36 months.
The project aims to unlock the value of data sharing across the plastics value chain to accelerate circular economy practices, to support regulatory compliance (for example: Digital Product Passports, Corporate Sustainability Reporting Directive or REACH), to enable trusted, interoperable data exchange, to promote reuse, recycling, and design-for-circularity and to foster innovation and new data-driven services.
CircPlastX gathers a multidisciplinary consortium of partners from across Europe from 5 different EU-countries. The consortium is composed of industrial players, digital solution providers, Research and Technology Organisations (RTOs), Standards bodies, regulatory experts and competitiveness cluster, in order to ensure both technical feasibility and industry relevance in developing the data space.

Data sharing plays a vital role in driving both circularity and regulatory compliance in the plastics sector. By enabling traceability, organisations can track the origin, composition and life cycle of materials and products, laying the groundwork for recyclability and eco-design. Access to detailed information on material properties and performance allows stakeholders to design products that are easier to reuse, recycle or recover. Furthermore, data sharing can help different actors work together to close the loop and reduce waste. On the regulatory side, structured and trustworthy data enables the implementation of Digital Product Passports (DPPs), supports Environmental-, Social and/or governance (ESG) reporting under frameworks such as CSRD[1] and the EU Taxonomy. Having access to the right data can ensure compliance with safety regulations concerning substances as for instance laid down in the REACH guidelines[2]. The Data Governance Act provides a framework for data exchange based on principles of data sovereignty, meaning that data holders retain control over who can access their data, for which purpose, under which conditions and for how long, while ensuring that data sharing takes place in a secure, transparent and legally compliant manner.

CircPlastX first supports circularity by enabling traceability across the plastics value chain, allowing stakeholders to identify the origin, composition, and life cycle of materials and products. It improves recyclability by making information on reuse, recycling processes, and material compatibility accessible and shareable among actors. The project promotes eco-design by integrating data on Life Cycle Assessment (LCA), emissions, and product usage to foster the creation of more sustainable and circular products. Finally, it enhances collaboration by facilitating data exchange between manufacturers, recyclers, and suppliers to support end-to-end circular processes within the value chain.

[1] Corporate Social Responsibility Directive, see Directive - 2022/2464 - EN - CSRD Directive - EUR-Lex
[2] See Guidance documents - ECHA

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Scope and objectives of the report

This deliverable reports on the work carried out in Task 1.1: Needs and Gaps Analysis of the CircPlastX project. The purpose of the report is to establish a strong evidence base for the subsequent design and technical development of the CircPlastX data space and three digital services for circularity. The scope of the report is therefore both analytical and preparatory: it identifies the current state of play in the industry, highlights barriers and opportunities, and translates these into requirements that guide the project's next steps.

The specific objectives of this deliverable are threefold. A first objective is to assess how far companies, in particular SMEs, have progressed in terms of digitalisation, data management, and data sharing practices. Mapping the current level of digital maturity provides insight into the readiness of stakeholders to engage with data spaces and related services. It also helps identify capability gaps that may limit uptake and points to areas where additional support, standardisation or capacity building may be required.

A second objective is to gather structured input from industry actors on the three proposed digital services: Recycled Material Certification, LCA Data Quality Checker and Substance Compliance Checker. By consulting stakeholders through surveys, interviews and workshops, the report refines the scope, functionality, and expected benefits of each service. This ensures that the services are not only technically feasible but also aligned with real-world priorities, addressing urgent needs such as material quality assurance, environmental reporting, and regulatory compliance.

The third objective is to translate the identified needs and gaps into concrete requirements that will guide the technical work of CircPlastX. These requirements concern both the generic data space architecture and the specific services built on top of it. By doing so, the report bridges the gap between industry needs and technical specifications, laying the groundwork for subsequent design, implementation, and validation activities.

In the next sections, the approach to data collection, the state of the art of current data spaces and of cicurlarity in places will be discussed, followed by an explanationof the envisioned services and stakeholder feedback, to close with insights and next steps for the project.

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I. Methodology

Capturing feedback from industries and organisations within plastics manufacturing was done via desk research, interviews and an online survey. Desk research covered scientific literature, grey literature, company reports and policy papers. It provided a broad overview of current principles, blueprints and architectures of data spaces, as well as sector-specific challenges related to manufacturing and circularity. The review informed subsequent data collection and analysis, ensuring that the study builds upon existing knowledge, identifies best practices and situates CircPlastX within the broader European regulatory and industrial context.

The CircplastX team in charge of interviews was composed by and toward LCA experts, polymer materials experts and digital tool experts. The interviewees targeted were industrial companies and stakeholders in the plastics industry via video conferencing tools such as Microsoft Teams and Zoom. The interviewees were selected from the networks of CT-IPC, Polymeris, and PCL, targeting SMEs and other companies actively engaged or interested in circularity across the entire plastics value chain. Interviews focused on stakeholder practices, expectations, barriers to data sharing and adoption of circular economy approaches. This allowed us to obtain initial qualitative feedback on the specific needs of the industry. The interviewer documented responses using a structured template, ensuring consistency across interviews and alignment with the predefined question framework.

An online survey, distributed via LimeSurvey in English, French and Dutch, enabled the project to reach a wider set of participants across the consortium's target regions. The survey collected both quantitative and qualitative data on stakeholders' current approaches. Targeted outreach through partner networks, mailing lists, and professional contacts ensured broad participation. Data from the survey were analysed using LimeSurvey's statistical modules, while structured templates supported consistent documentation and analysis of responses.

Several topics were addressed within each activity. Participants reviewed the fundamental concepts of data spaces (governance models, interoperability requirements and technical architectures) to ensure a common understanding and alignment with European frameworks such as GAIA-X and IDSA. Participants also discussed specific requirements and barriers encountered in industrial contexts, such as fragmented data formats, limited digital maturity and operational constraints in SMEs. Stakeholders assessed the relevance of the proposed services for their own operations and for the sector, providing insights into priority functionalities, expected benefits and potential challenges related to their adoption.

Using this methodology, CircPlastX was able to further detail the sector's needs concerning circularity and the role of data for circularity and validate the service concepts that will be offered. The aim of this approach is to ensure that the project's digital services are both technically feasible and relevant, thereby creating a solid foundation for the development of a reliable, interoperable and secure circular data space.

An overview of interviews held and the interview guide can be found in Appendix A and B.

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II. Circularity challenges for plastics in Europe

Plastics sit at the centre of Europe's industrial system, but circularity still lags behind ambition. Around 32 million tonnes of plastic waste are generated in the EU every year (source), yet only a fraction returns as high-quality secondary material. Most companies still struggle to balance technical performance requirements with recycled content targets, and the supply of consistent, traceable recycled plastics remains nowhere near demand. Regulations like the EU Packaging and Packaging Waste Regulation (PPWR) and upcoming product-specific recycled content mandates push the market forward, but they also expose fragmentation in collection systems, inconsistent quality standards and gaps in data sharing along the value chain[3].

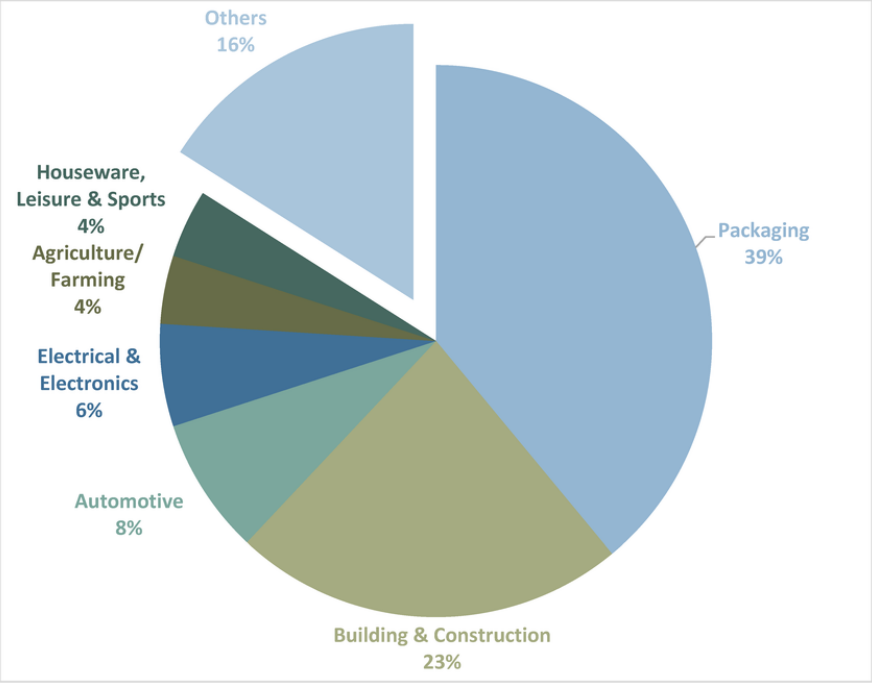

Figure 1: Plastics in Europe per sector. Source: Pie-chart-showing-the-percentage-use-of-plastics-in-different-sectors-of-the-European.tif (850×665)

European plastics consumption (see figure 1) is dominated by a few major sectors. Packaging is by far the largest, accounting for roughly 40% of total demand[4]. Building and construction follows, driven by long-life applications like pipes, insulation and window profiles. The automotive industry is another major user, relying on lightweight polymers to meet energy-efficiency and safety targets. Then come electrical and electronics, agriculture and a wide range of consumer goods. Each of these sectors has its own regulatory pressures and quality requirements.

[3] See also Statistics_2025_Final.pdf

[4] See https://plasticseurope.org/wp-content/uploads/2022/12/PE-PLASTICS-THE-FACTS_FINAL_DIGITAL.pdf See also See PE_TheFacts_25_digital-1pager-scrollable.pdf and also Beena Unni, Aparna & Muringayil Joseph, Tomy. (2024). Enhancing Polymer Sustainability: Eco-Conscious Strategies. *Polymers*. 16. 1769. 10.3390/polym16131769.

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1. The plastics production process

Most conventional plastics in Europe are produced through a sequence of steps that begins with the use of fossil-based feedstocks. These feedstocks are transformed into monomers through cracking or similar processes. The monomers are then polymerised to form various types of polymers, which are subsequently processed into granules. These granules are supplied to converters and molders.

At the conversion stage, technologies such as thermoforming, extrusion, and injection moulding are used to shape the granules into finished or semi-finished plastic parts. Throughout these stages, additives like stabilisers, flame retardants, fillers and colourants may be incorporated to obtain mechanical, chemical or aesthetic properties required for specific applications.

When plastic products reach the end of their use phase, they follow different waste-management routes. A proportion enters recycling systems, where materials are collected, sorted, processed and reintroduced into manufacturing cycles. Other fractions are managed through incineration with or without energy recovery, exported to treatment facilities outside the country of origin or disposed of in landfills or in rivers and oceans, depending on local infrastructure, regulatory frameworks and waste-management practices.

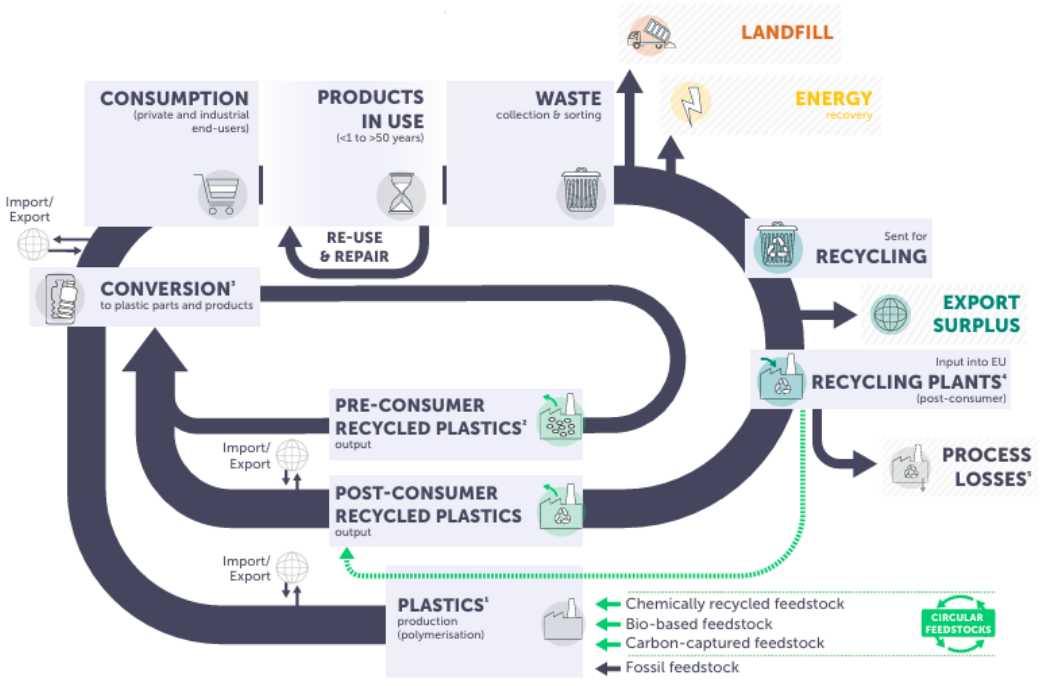

Figure 2: plastic life cycle. Source PE-PLASTICS-THE-FACTS_FINAL_DIGITAL.pdf

Plastics used in European industry fall into a few main families:

- Polyolefins (PE, PP) dominate packaging and many consumer applications because they are versatile and relatively easy to recycle mechanically.
- PVC is widely used in construction thanks to its durability and stability.
- Styrenics (PS, ABS) are common in electronics, automotive interiors and appliances.

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- Engineering plastics like PA, PBT, PC, or PET serve in higher-performance applications, from car components to medical devices.

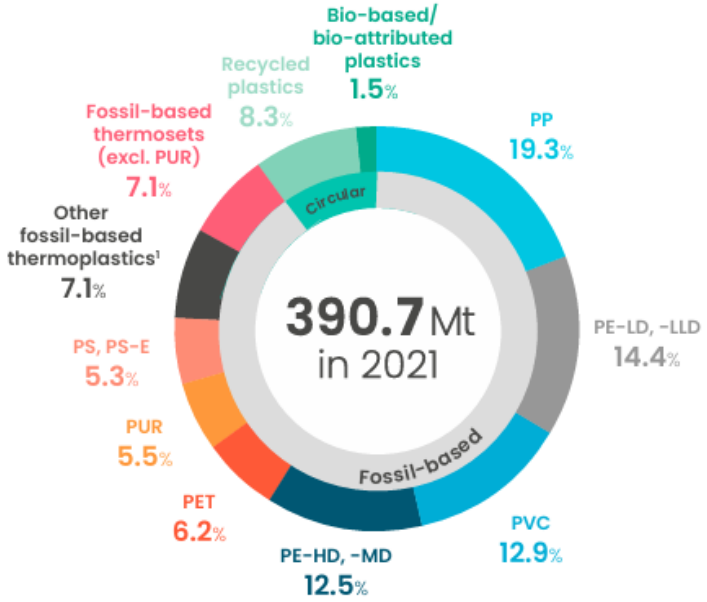

Figure 3: Distribution of the global plastics production by type

Each family behaves differently during processing and recycling. One of the challenges is to understand the quality of recycled material. Quality expectations differ dramatically between markets. Packaging often requires optical purity and food-contact compliance. Automotive, electric and electronic sectors demand strict mechanical strength, impact resistance, and long-term durability. Construction applications focus on weathering, stability, and safety standards that can span decades. These differences explain why a recycled PP suitable for a flowerpot might fail every requirement for a car's interior trim. Circularity only works if recycled materials can reliably meet the property thresholds defined by each sector.

In Europe, the term "R-cycles" (recycle, reuse, repair, refurbish, recover) is used to describe the different pathways through which plastics can be recovered and brought back into material circulation. These pathways cover several distinct processes.

Mechanical recycling is widely applied and involves steps such as collection, sorting, washing, shredding and reprocessing into pellets. It is used for a broad range of polymers, including PET, PE and PP and relies on the quality and consistency of incoming waste streams.

Chemical recycling refers to technologies that convert plastic waste into chemical intermediates, monomers or hydrocarbon feedstocks. These technologies include depolymerisation (used for polymers like PET or PA), pyrolysis (which converts mixed polyolefin waste into oils or gases) and gasification. The outputs can enter existing chemical production routes or be used as inputs for new polymer production. Several pilot and commercial-scale facilities operate in Europe, with ongoing developments across multiple countries.

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In addition to recycling processes, re-use, repair and repurposing are part of the R-cycle framework. Re-use systems keep plastic products in service without altering the material. Repurposing refers to using components or products in new applications that differ from their original design. These approaches reduce the volume of material entering waste streams and extend the functional life of products.

Each R-cycle pathway operates with its own collection requirements, processing steps and traceability needs. Depending on the polymer type, product design and end-use constraints, materials may follow different routes within this framework before being reintroduced into manufacturing value chains.

2. Challenges of integrating recycled plastics into new products

Using recycled plastics in new products is still difficult for many manufacturers. Variability in batches, impurities, legacy additives, and inconsistent colour or smell can disrupt production or fail compliance checks. Recycled polymers also tend to have slightly reduced mechanical performance compared to virgin materials, which is a problem in regulated sectors like automotive or electrical & electronics (E&E). Even when the material works technically, supply volumes fluctuate, making long-term sourcing strategies complicated. These issues slow down adoption despite strong environmental and regulatory incentives. (see also chapter 1.3). Some mitigating measures to this adoption challenge have been proposed[5], but much more needs to be done, both on the side of market creation for recycled plastics and protection of that market, and on the level of transparency and data sharing.

a) Traceability and geographical scope

Traceability is one of the biggest bottlenecks in plastic circularity. Manufacturers often do not know the exact origin, composition or additive history of the recycled plastics they buy. Waste streams may mix materials from different countries or collection systems, making it difficult to document compliance with quality-and safety standards in plastics. Several European initiatives such as Digital Product Passports and certification schemes like EuCertPlast[6] aim to solve this, but the system is far from seamless. Without reliable traceability, companies struggle to guarantee safety, performance, or regulatory conformity.

b) Cleaning, mixing reusing

Before plastics can be recycled, they must be cleaned, sorted and sometimes separated into compatible polymer types. Contamination (food residue, inks, adhesives, metals) reduces output

[5] See for instance frsus-06-1531428-t001.jpg (1375×1058) and frsus-06-1531428-g002.jpg (1325×767)

[6] EuCertPlast is a European certification scheme for plastics recyclers. It is designed to improve transparency and traceability in recycled plastic supply chains by setting common requirements for how plastic waste is processed, documented and sold as recycled material. Based on the EN 15343 standard, the certification helps ensure that recycled plastics are produced under controlled conditions and that key information about origin, processing and material quality is properly recorded, making it easier for downstream users to assess compliance and reliability.

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quality and increases processing costs. Mixing different plastics is rarely an option because blends often produce low-performance materials unless specifically engineered. Reuse strategies, when possible, avoid these issues entirely, but they only work for certain product categories. The technical limits of cleaning and separation explain why some waste streams remain difficult to recycle at scale.

c) Quality assurance (mechanical properties, substances/toxicity, other properties)

Quality assurance is critical in both mechanical and chemical recycling. Manufacturers need predictable mechanical properties (tensile strength, impact resistance, melt flow) but also assurances about chemical safety: absence of restricted substances, low VOC emissions, and stable additive content. Toxicity risks come from legacy additives like phthalates, brominated flame retardants, or heavy metals that may remain in recycled waste. Standards exist, but they're unevenly applied and testing adds cost and time. Without robust QA, high-value applications simply won't incorporate recycled content.

3. Circularity in plastics policy in Europe and national level

Compliance with environmental regulations is a critical driver for circularity in the plastics sector. Companies must navigate an evolving landscape of European Union legislation that sets requirements for chemical safety, packaging sustainability, product design, and material reuse. Meeting these obligations is essential not only for legal conformity but also for protecting human health, reducing environmental impacts, and maintaining market competitiveness.

Key regulations shaping industry practices include REACH, which governs the safe use of chemical substances; the Packaging and Packaging Waste Regulation (PPWR), which establishes recycled content targets and promotes reuse and recycling of plastics; and the forthcoming Circular Economy Act, which is expected to harmonize rules for secondary raw materials, enhance recycling, and strengthen circular business models across sectors. Understanding these regulatory frameworks is essential for identifying industry needs, existing gaps, and opportunities for data-driven solutions that support circularity, compliance, and sustainability objectives.

a) REACH

REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) is a cornerstone regulation of the European Union that ensures the safe production, use, and management of chemical substances across all member states. It requires companies that manufacture or import chemicals in quantities of one tonne or more per year to register these substances with the European Chemicals Agency (ECHA), providing comprehensive information on their chemical properties, intended uses, potential hazards, and risk management measures.

The regulation serves multiple objectives: protecting human health and the environment, encouraging the development and use of safer alternatives to hazardous substances, and fostering innovation and competitiveness within the EU chemicals sector. REACH also promotes data sharing

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across the value chain, enabling manufacturers, downstream users, and recyclers to access verified information about substance content and compliance requirements.

For the plastics industry, REACH compliance is particularly critical because materials often contain complex mixtures of polymers, additives, and colorants, some of which may be classified as hazardous. Ensuring accurate, up-to-date data on chemical composition is essential for regulatory reporting, safe handling, and integration into circularity strategies such as recycling, reuse, and eco-design. Within the CircPlastX data space, structured and interoperable REACH data supports traceability, risk management, and automated compliance checks, reducing manual effort and enhancing reliability across the value chain.

b) PPWR

Packaging and Packaging Waste Regulation (PPWR), initially adopted at the end of 2022 and finalized between 2024 and 2025, is a key EU legislative framework aimed at reducing packaging waste and promoting circularity across member states. Unlike the previous directive, PPWR is a directly applicable regulation, ensuring uniform implementation without the need for transposition into national law.

The regulation sets binding targets for recycled content in packaging materials, with particular focus on plastics, and introduces measures to minimize unnecessary packaging. It encourages the design of packaging for reuse, recycling, and recovery, including stricter requirements for compostable and biodegradable plastics. By harmonizing rules across the EU, PPWR seeks to create a level playing field for producers and recyclers, reduce environmental impacts, and facilitate cross-border circular practices.

For companies in the plastics and composites sector, PPWR imposes both challenges and opportunities. Compliance requires accurate tracking of material composition, recycled content, and recyclability, as well as adaptation of production processes and product design. At the same time, the regulation incentivizes innovation, such as the development of recyclable packaging solutions, sustainable materials, and circular business models. In this context, the CircPlastX data space can provide reliable, interoperable, and traceable data to support reporting, certification of recycled content, and alignment with PPWR objectives, enabling stakeholders to enhance compliance and accelerate circularity throughout the value chain.

c) Circular Economy Act

On 1 August, the European Commission launched a public consultation and Call for Evidence for the upcoming Circular Economy Act, expected to be adopted by the end of 2026. The Act will succeed the Circular Economy Action Plan (CEAP) and aims to accelerate the EU's transition to a circular economy by establishing a Single Market for secondary raw materials, increasing the supply and demand for high-quality recycled materials, and enhancing economic security, resilience, competitiveness, and decarbonisation.

The initiative seeks to update existing EU rules to foster circular competitiveness across multiple sectors, including construction, textiles, automotive, and electronics. It will revise key legislation such as the Waste Framework Directive, the WEEE Directive for e-waste, and the Critical Raw Materials Act, aiming to increase recycling rates, reduce reliance on virgin materials, and recover critical raw materials vital for the green and digital transitions. In addition, the Act will promote a

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right to repair, extend product lifetimes, and harmonize Extended Producer Responsibility (EPR) systems to create a more integrated and competitive EU waste market.

The Circular Economy Act aligns with broader EU strategies, including the Competitiveness Compass, the Clean Industrial Deal, the Single Market Strategy, the Steel and Metals Action Plan, the Eco-design for Sustainable Products Regulation, and the Packaging and Packaging Waste

Regulation. It is designed to make the EU a global leader in circularity by 2030, double the EU circularity rate, and shift the perception of waste as a valuable resource while promoting sustainable consumption and production practices.

4. National level: implementation practices and reporting diversity

At national level, circularity policies provide concrete regulatory signals that directly shape data needs across the plastics value chain. In France, the Anti-Waste for a Circular Economy law (AGEC) illustrates this clearly. It introduces binding obligations such as mandatory consumer sorting information (Triman and Info-tri), extended producer responsibility (EPR) reporting, progressive bans on non-recyclable plastic packaging, and objectives for recycled content incorporation.

While EU regulations establish a common legal framework, national authorities play a key role in implementation, enforcement and reporting. Member States differ in waste management systems, Extended Producer Responsibility schemes, data collection practices and verification procedures. These requirements force companies to maintain reliable and auditable data on material composition, recyclability, volumes placed on the market, and end-of-life management. Similar national measures exist across EU Member States, often with country-specific implementation rules layered on top of European legislation, but this fragmentation increases the complexity of compliance for companies operating across borders.

In practice, this regulatory environment affects multiple stakeholders in plastics manufacturing, from polymer producers to converters, brand owners, recyclers and certification bodies. Each actor generates and requires different types of data. Understanding who produces, shares and consumes these data points is essential for implementing circularity measures effectively. The next section examines the types of stakeholders involved in plastics production and highlights how data flows, or fails to flow, between them, illustrating the connections between regulatory requirements and operational practices in the value chain.

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5. Types of stakeholders in plastics manufacturing

a) Who is involved in plastics production? Breakdown of different stakeholders

The plastics value chain in Europe is long and crowded. It starts with feedstock suppliers: refineries and chemical companies that produce monomers and polymers. Then come compounders and master-batch producers, who fine-tune materials with additives and colours. Converters and molders turn granules into actual products through processes like injection

moulding, extrusion, or thermoforming. Downstream, brand owners and original equipment manufacturers set performance specs and push recycled-content targets. At end-of-life, waste collectors, sorters, and recyclers take over, trying to recover as much value as possible. Regulatory bodies, certification organisations and logistics providers sit around this system, influencing how it operates (but not always coordinating with each other).

Digital connections between stakeholders in the plastics value chain take different forms depending on the sector and the size of the company. Many exchanges rely on standard documents such as technical data sheets, compliance certificates, batch reports or quality tests, usually shared via email or through company-specific portals. Some industries use structured systems for materials information. For example, automotive suppliers rely on the IMDS platform to report substance information along the supply chain. However, these systems are not uniformly adopted across all segments of plastics manufacturing or recycling.

For circularity, several categories of data are relevant for movement between actors. Material producers hold information on polymer composition, additives and processing parameters. Compounders can document formulations, masterbatch content and stabilisers introduced at their stage. Converters generate data related to production conditions and part geometry, which can influence recyclability. Recyclers collect information on incoming waste characteristics, contamination levels, sorting results, mechanical properties of recyclates and recycled content measurements. Certification bodies provide documents related to food-contact compliance, REACH conformity or recycling process audits such as EuCertPlast[7].

Data may need to flow in multiple directions:

- recyclers often require upstream composition and additive information,
- manufacturers using recyclates need documentation on material performance and test results,
- brand owners collect consolidated data to meet regulatory reporting requirements. The extent and format of these exchanges vary depending on contractual relationships, industry norms and available digital tools.

[7] European Certification of Plastics Recyclers | EuCertPlast

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b) Missing links in the network and ecosystem of plastics recycling

The plastics value chain involves multiple actors that often maintain separate information systems. These systems range from enterprise resource planning tools to local databases,

spreadsheets or paper documentation. When materials move from polymer production to compounding, then to conversion, assembly, use and end-of-life handling, the information associated with each step is typically recorded at the company level and does not systematically accompany the material to the next stage. As a result, data on additives, pigments, fillers and formulation details may not be available to downstream actors, including recyclers.

Digital interfaces between original equipment manufacturers (OEM) and recyclers vary widely. OEMs define specifications relating to substances, performance or circularity targets whereas recyclers generate data on incoming waste composition, sorting outcomes, and recyclate properties. These datasets are not always exchanged directly because they follow different formats, reporting frameworks, or documentation practices. In many cases, the two groups share information through intermediaries (converters, compounders or waste-management companies) rather than through direct data channels.

The structure of the sector contributes to this fragmentation. A significant portion of European plastics processors and recyclers are small or medium-sized enterprises with heterogeneous levels of digitalisation. Some companies rely on paper-based traceability, while others use dedicated digital tools. This diversity creates variations in the type of data generated, how it is stored, and how easily it can be transferred along the chain.

Taken together, these factors create points in the network where information does not move from one actor to another. The resulting gaps concern material composition, processing conditions, waste characteristics and recyclate specifications. These gaps influence how data circulates in the overall ecosystem and determine which actors receive, or not, information relevant to their activities.

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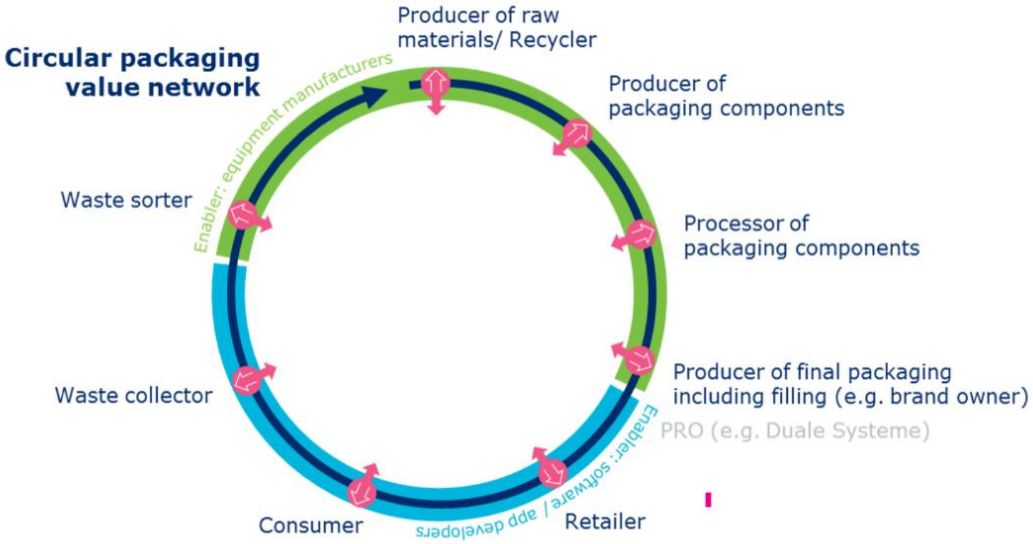

Figure 4: An example of circular plastics actors in the context of packaging. Source: GS1

6. Data needs for enhancing and accelerating circularity in manufacturing

Data plays a central role in enabling circularity across the plastics and composites value chain. Accurate, comprehensive, and interoperable data allows stakeholders to track materials, optimise processes and make informed decisions that reduce waste, enhance recyclability, and improve environmental performance. In the context of CircPlastX, understanding the different levels, types and quality requirements of data is crucial to designing an effective circularity data space. Concerning data needs,

Recent research on circularity underlines that effective data sharing across value chains is a key condition for enabling circular practices in operational contexts. Studies show that limited access to shared information on product composition and material origin generates uncertainty for value chain actors, particularly when decisions must be made on recycling or reuse options[8]. This lack of transparency reduces confidence in secondary materials and constrains coordination between production and end-of-life activities. Further analysis points to structural weaknesses in how data and information flows are organised, notably the absence of consistent standards and interoperable systems, which slows the diffusion of circular economy practices and weakens their integration into policy and market frameworks[9]. Overall, the literature emphasises the need for data-sharing mechanisms that balance confidentiality with transparency, while clearly defining the

[8] 1-s2.0-S2352550922002251-gr3_lrg.jpg (3153×1882)

[9] 1-s2.0-S2352550922002251-gr4_lrg.jpg (1779×1004)

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information required by different actors to support circular design choices and downstream management[10].

III. The role of data exchange to improve circularity

1. Types of data for circularity, from technical data to environmental data

Data relevant to circularity can be described across several levels, reflecting both the scope of analysis and the degree of detail, from individual materials to broader societal systems. Research on plastics circularity in Europe shows that material flows, recycling rates and system performance vary significantly across these levels, indicating distinct data needs for different parts of the value chain.

At the material level, data relates to chemical composition, physical and mechanical properties, recyclability potential and compliance with substance regulations such as REACH. Material flow analyses conducted at EU scale demonstrate that detailed polymer and recyclate flow data is essential for understanding the distribution of plastics from production to end-of-life and the volume of recyclates actually consumed in converters and manufacturers, with an average recycling rate of around 19% in the EU27 for all plastics in 2022 according to material flow studies[11] .This type of data enables traceability of virgin and recycled materials and supports identification of hazardous substances. Material-level information is also a basis for design-for-circularity tools such as digital product passports.

At the product level, data covers product design, bills of materials, material composition, environmental performance and end-of-life options. These data support assessments of circularity potential for products and feed into life cycle assessment (LCA) frameworks and environmental performance metrics. EU data on circular material use rates show that secondary material contributions (recycled plastics) to overall material use in the EU reached about 12.1% in 2022, indicating both the current scale of product-level circularity and the potential need for improved data coverage[12]. Product-level data linking composition and performance across the lifecycle supports verification of recycled content and compliance documentation.

At the factory level, data focuses on production processes, energy and water use, emissions, waste streams and operational efficiency. Detailed production and process data enable monitoring of

[10] https://discovery.ucl.ac.uk/id/eprint/10154153/1/1-s2.0-S2352550922002251-main.pdf
[11] Modelling plastic flows in the European Union value chain)
[12] European environnement agency

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material flows and recycling or recovery rates within industrial sites. Environmental data collected at plant level, such as resource input and waste output, contributes to understanding the efficiency of manufacturing systems and benchmarking across companies. The European Circular Economy Metrics Lab has identified gaps in environmental data that limit comprehensive monitoring of plastics circularity, reinforcing the need for consistent environmental performance data at this level[13].

At the sector level, data aggregates information from multiple companies and value chains, providing a view of material flows, recycling performance and regulatory compliance across industries. Sector-level analyses such as Plastics Europe's circular economy reports provide aggregated data on plastics consumption, recycling technologies and secondary plastics production, revealing mixed progress in uptake of circular feedstocks and differences in performance among sectors[14]. This aggregated data supports benchmarking and strategic analysis of sector performance relative to policy targets.

At the societal level, data reflects large-scale patterns related to consumption, product lifetimes, waste generation and recycling systems across regions or countries. Broad indicators such as the circular material use rate published by Eurostat provide a high-level measure of material circularity across the entire economy and help monitor progress towards EU circular economy goals at national and regional scales[15]. In 2022, recycled materials accounted for approximately 12% of total material use in the EU. Such data informs public policy and long-term planning by highlighting trends in material use and recycling performance.

2. Data gaps across the plastics value chain

Research on plastics circularity in Europe indicates that available data often remain fragmented or incomplete across the value chain and that this limitation affects the monitoring of circular outcomes and the management of materials. The European Environment Agency notes that current monitoring frameworks provide only partial coverage of plastics circularity and that additional data and metrics are needed to assess the state of the circular plastics economy, in part because available evidence is not comprehensive or harmonised across sectors and material types[16]. Analyses of material flows by the European Commission's Joint Research Centre show that, in 2019, approximately 4.46 Mt of plastic recyclates were consumed in the EU27, with an average recycling rate of about 19 %, and highlight that a majority of plastics waste remains outside effective recycling loops, partly because detailed information on material composition and end-of-life outcomes is not consistently available[17]. Other assessments, including the OECD *Global Plastics Outlook*, underline that only a small fraction of global plastic waste reaches recycling and that data on plastics use and waste management are insufficiently integrated to give a complete picture of flows and losses through the lifecycle[18].

Below an overview of existing data standards or principles (such as FAIR, Findable, Accessible, Interoperable and Reusable) that will be part of the data spaces development process:

[13] European Environment Agency
[14] Plastics Europe
[15] European Commission
[16] Agence Européenne de l'Environnement
[17] JRC Publications
[18] OECD

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Table 1: Overview of data quality principles and illustrative examples

Principle	*Example*
Accuracy and completeness	Material certificates, laboratory analyses and supplier declarations can provide reference points to verify technical and environmental data
Consistency / comparability	Harmonised formats, units of measurement
Traceability / provenance	Metadata and logging data
Interoperability	Standardized metadata, semantic frameworks and common data formats
Timeliness and relevance	Timestamped data, 'freshness' of data

In terms of standards related to such principles, we will need to bridge ISO standards relating to life cycle assessment (ISO 14040/44) and carbon footprint (ISO 14067), as well as the European standard EN 15343 on the traceability of recycled plastics. New European Union initiatives are being added to these frameworks, such as the digital product passport (DPP).

We will come back to the types, levels and standards related to data for circularity in plastics as reported from the survey and interviews in section VI.

Taken together, these observations show that current data practices in plastics manufacturing and recycling are characterised by fragmentation across organisational boundaries, inconsistent data formats and limited reuse of information beyond its original purpose. While relevant data exists at material, product, factory and sector levels, it is rarely structured in a way that allows it to circulate reliably between actors or to be combined for cross-value-chain analysis. As a result, assessments related to circularity performance and regulatory obligations are often based on partial or proxy information rather than on verified and traceable datasets that can be reused across contexts. Addressing these limitations requires more than incremental improvements to existing reporting tools. It points to the need for shared data infrastructures that enable data to be exchanged between actors under defined access conditions and to be interpreted consistently across heterogeneous systems. In this context, data spaces and associated services provide a technical and organisational framework to allow existing datasets to be connected while maintaining control over how data is shared and used for circularity-related purposes use cases such as traceability or compliance verification, as further developed in the following chapters.

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3. Data spaces to accelerate data exchange and use for circularity

a) Definition

According to DSSC Glossary a Data Space is an " *Interoperable framework, based on common governance principles, standards, practices and enabling services, that enables trusted data transactions between participants*. ".

According to DSSC Glossary a Data Space is an "A distributed system defined by a **governance framework** that enables secure and trustworthy **data transactions** between **participants** while supporting trust and **data sovereignty**. A Data Space is implemented by one or more **infrastructures** and enables one or more **use cases**".[1]
The DSSC rely on the definition of a Data Space, which borrowed from the recently published CEN CENELEC workshop agreement on Trusted Data Transactions:
This definition includes several elements
Interoperability. To share data, participants in a Data Space need to ensure they're technically, semantically, legally, etc., interoperable. The Data Space provides common governance principles, standards, practices, and enabling services. As you will see later, these are bundled into what is often called a 'rulebook' or 'governance framework'.
Services. All kinds of services are needed to form these frameworks, such as identifying and onboarding participants or making data findable. Each participant also needs services to connect their own data sources with the Data Space and vice versa.
Trust. Trust enables participants to make informed decisions about how, when, and with whom to share data.
Note that there currently is no formal/legal definition of a Data Space; in different context the term is defined slightly differently. In the definition above for example the term 'framework' is used, but of course Data Spaces have instances as well.

Data Spaces aim to achieve:

- **Data Sovereignty**: Ensuring that data providers retain control over their data, including who can access it and under what conditions.
- **Interoperability**: Enabling seamless integration and use of data from various sources by supporting different data formats and systems
- **Innovation and Collaboration**: Promoting data-driven innovation and collaboration across sectors, leading to new business models and services.
- **Security and Privacy:** Providing robust security measures and compliance with data protection regulations to maintain the confidentiality and integrity of data.
- **Economic Growth**: Enhancing the value derived from data, which can drive economic growth and competitiveness.
- **Public and Private Sector Collaboration**: Facilitating cooperation between public and private entities to address common challenges and leverage shared data for the public good.

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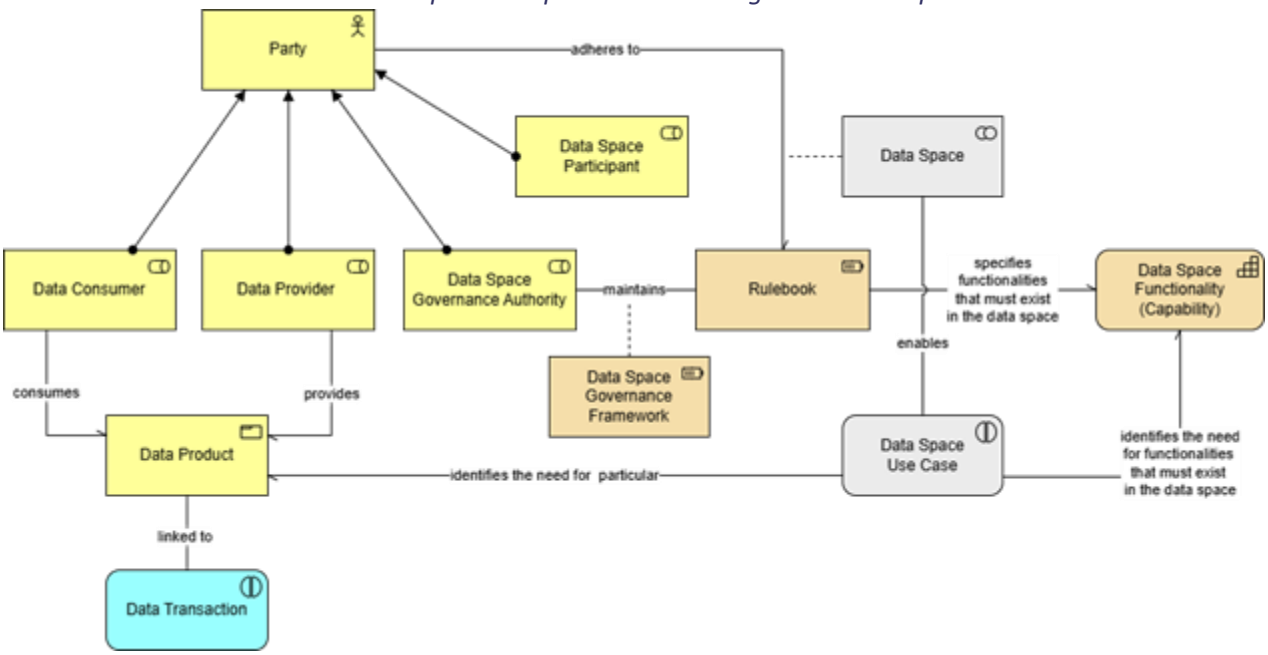
b) Data Spaces conceptual model

Data spaces are built around key concepts. The DSSC considers the Participants, Data Products, Services, and Rulebooks as the core concepts of every Data Space[2].

Table 2: Data Space components according to DSSC Blueprint V2.



To achieve a relevant a clear definition of all data spaces components, we can consider the following definition that relies on the work of *Gaia-X*; *DSSC*, and *Trusted Data Transaction* standardization initiative:

Table 3: Data space glossary in standards

Term	Definition	Source - Version
Data user	A natural person or organization authorized to exploit data	CEN/CENELEC - July 2024
Data producer	A natural person, legal person, device, or any software that generates data	CEN/CENELEC - July 2024
Data provider	A legal person who has the right or duty to make data available to data users through data offerings. The data provider performs several activities, namely: • Non-technical activities (on behalf of a data right holder), including description of data products, data licensing conditions, publication of data products in a data product catalog, negotiation with data users, and contract conclusion. • Technical activities, including the provision of data products to data users	CEN/CENELEC - July 2024

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Data right holder	A natural or legal person who has legal rights or obligations to use, give access to, or share certain data, or to transfer these rights to third parties. Note: The data right holder and the data provider represent different roles, which can be assumed by the same entity (natural or legal person) or by different entities	CEN/CENELEC - July 2024
Data space	An interoperable framework, based on common governance principles, standards, practices, and enabling services, which allows reliable data transactions between participants. Notes: • Data space services are implemented by one or more infrastructures. • Data spaces enable one or more use cases	CEN/CENELEC - July 2024
Data transaction	The result of an agreement between a data provider and a data user to exchange, access, and use data, in exchange for monetary or non-monetary compensation. Notes: • The terms "data exchange" and "data access" are used to describe different mechanisms, such as the actual transfer of data or situations where data is not transferred but access is provided to different stakeholders. • Data transactions do not necessarily imply a commercial relationship. • Each data transaction is unique and must be treated independently of other data transactions	CEN/CENELEC - July 2024
Gaia-X Trust Anchor	Gaia-X Trust Anchors are conformity assessment bodies or technical means accredited by the Gaia-X association, empowered to issue attestations regarding specific declarations. It is a trusted starting point for validating a trust chain. It is an entity, such as a Certificate Authority (CA), a certificate, or a public key, that is considered inherently trustworthy by the user or system	Gaia-X Glossary 25.05 Release
Trust Service Provider	A trust service provider is an entity (which is not necessarily a participant!) approved by the governance authority to officially issue Verifiable Credentials (VCs) for a given scope and purpose. Note: By default, for statements to have legal value, they must all be signed using one or more cryptographic elements that can be traced back to a Trust Anchor, which is in most cases a trust service provider (TSP)	Gaia-X Glossary 25.05 Release
Participant	A legal or natural person who has committed to respecting the governance framework of a particular data space and who may play one or more roles within it.	Gaia-X Glossary 25.05 Release

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	Note: A participant is integrated into the data space and has a Gaia-X participant identifier. A participant can assume one or more of the following roles: provider, consumer, and operator	
Governance authority	A governance authority (GA) of an ecosystem or data space is the body of a particular data space or ecosystem, composed of participants, which commits to respecting the governance framework of the data space or ecosystem, and which is responsible for developing, maintaining, operating, and enforcing this governance framework	Gaia-X Glossary 25.05 Release
Issuer	A decentralized identity issuer is an entity that creates and signs verifiable identity information, called "Verifiable Credentials" (VCs), on behalf of an individual or organization	
Data space federated services	Federated services support interaction between participants in a data space. They operate in accordance with the policies and rules specified in the rulebook by the governance authority	
Data space governance framework	A set of principles, standards, policies (rules/regulations), agreements, and practices that apply to the governance, management, and operation (including business and technological aspects) of a data space, as well as their implementation and the resolution of any conflicts	DSSC Glossary Version 2.0
Data space rulebook	Documentation of the data space governance framework for operational purposes. The rulebook may be expressed in human-readable and machine-readable formats	DSSC Glossary Version 2.0
Data	Any digital representation of acts, facts, or information, as well as any compilation of these acts, facts, or information	CEN/CENELEC - July 2024
Data catalog	A data catalog presents a set of available data and data products that can be queried	Gaia-X Glossary 25.05 Release
Data exchange services	A set of services offering functionalities allowing data exchange, including: policy negotiation for access control and usage control, traceability of exchanges, service protocol negotiation, data access, data prioritization, access enforcement, usage enforcement. Note: The data connector and the data exchange platform are two different architectural implementations of potentially similar data exchange service functionalities	Gaia-X Glossary 25.05 Release
Data product	A set of one or more data items that are grouped by the data product provider and prepared for data exchange	CEN/CENELEC - July 2024
Data product usage agreement	A legally binding agreement concluded between a data product provider and a data consumer, which specifies the terms and conditions of a data exchange	CEN/CENELEC - July 2024
Metadata	Data relating to data or data elements, which may include their descriptions, as well as data relating to data ownership, access paths, access rights, and data volatility	CEN/CENELEC - July 2024

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c) Core concepts of all data spaces: Data Products and data transactions

Data Product

Data Products and Data Transactions constitute the operational backbone of any functional Data Space. While the Data Space itself provides the infrastructure for sovereign data exchange, it is specifically through well-defined **Products** and governed **Transactions** that tangible value is actually generated, exchanged, and tracked. These concepts are crucial because they are the universal prerequisites for interoperability: understanding how data is packaged for consumption and how its transfer is executed is essential for navigating, building, or leveraging any Data Space ecosystem effectively.

The European Commission has recently published in its final form a *Standardization Request for a harmonized European Standard on Trusted Data Transaction*[3], under the umbrella of a European Trusted Data Framework, which also includes requests for other European standards and European standardisation deliverables.
A *harmonised European Standard* (hEN) is developed by a European Standardization Organization upon a mandate from the EU Commission to support the implementation of EU legislation. In the case of Trusted Data Transaction, it's the Article 33 of the Data Act, which addresses "Essential requirements regarding interoperability of data, of data sharing mechanisms and services, as well as of common European Data Spaces. Complying with such hEN provides a presumption of conformity with the referenced regulation or relevant parts thereof.

The *Trusted Data Transaction* initiatives, co-created by TNO, Fraunhofer and Dawex, will thus become a harmonized European standard linked to the Article 33 of the EU Data Act and **will create a presumption of conformity to the regulation.**

According to the Trusted Data Transaction future standard, data products should include, without being limited to, metadata describing the asset and, in the context of trusted data transactions, data licence terms as defined by the data provider.

Descriptive information included in and/or associated to the data product, such as the

- specific purposes the data product is intended for,
- terms of usage,
- legal terms,
- commercial terms,
- price, if any,
- consent and authorizations

facilitate discoverability, understandability and ability to transact the data product

Data Transaction

The concept of a **data transaction** can be understood under the general remarks below:

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A data transaction can be related to a broad set of scenarios, including but not limited to: one-time data exchanges, data subscriptions, API-based data exchanges (pull or push), data streaming, "code2data", "data2code", among other scenarios.

A data transaction, in order to materialize, requires a data provider, a data user and the data product being transacted.

- Traceability of the data transaction contributes to enhancing transparency, providing accountability, improving security and meeting compliance requirements.
- The technical transfer of - or access to - the data, takes place as a result of the data transaction.
- In some cases, the data is transferred from the data provider to the data user. In other cases, the data does not move while access to the data is given to the data user.
- Data transactions do not necessarily imply a commercial relationship between the data provider and the data user, and does not necessarily imply the payment of a fee by the data user to the data provider in order to access and use the data.
- Each data transaction is "unique" indicating that it must be treated independently of other data transactions.
- Data transactions and data spaces are interconnected concepts. Data spaces provide a foundation for managing and facilitating trusted data transactions, enabling stakeholders to leverage data effectively while ensuring governance and compliance.

The concept of data transaction can be described with the conceptual model hereafter:

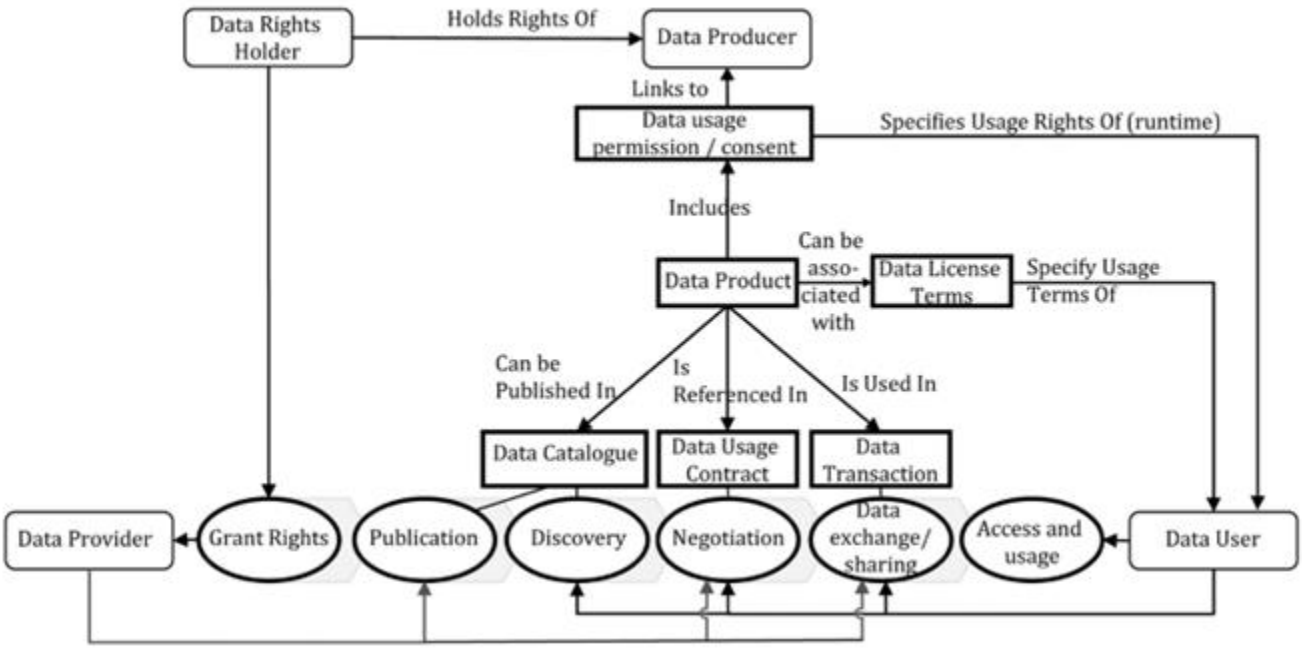

Figure 5: Scope of a Data Transaction, CEN/CENELEC4

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The concept of data transaction relates to the following three phases:

- Granting rights and publication of the data product which is a provisioning phase leading to the publication of metadata and data policies.
- Discovery and negotiation which is the phase leading to an agreement (data usage contract) between a data provider and a data user regarding a data product
- The data exchange or sharing phase operationalizing the data usage contract through a data transaction which includes also the access and usage of the data product by the data user

d) The EU normative Data Space Ecosystem

Data Spaces function as a core component of a broader strategic vision aimed at realizing fully data-driven ecosystems. This vision is underpinned by major initiatives designed to build a federated data infrastructure capable of supporting Data Spaces across diverse sectors. Key initiatives including specific ones to the manufacturing domains, as **Gaia-X, DSSC, and Manufacturing-X,** are central to Europe's strategy for Data Space development. Together, they play a decisive role in guaranteeing digital sovereignty, ensuring data interoperability, and fostering innovation across the continent.

e) Gaia-X

Gaia-X, a not-for-profit Association that was established in 2021, unites a variety of organisations (such as large companies and SMEs, developers and users of technology, industrial players, and academic members) to achieve one common goal: to enhance the European data economy by enabling the creation of common Data Spaces, in full alignment with the EU's data strategy. Gaia-X is committed to the development of a common standard for a digital ecosystem that is open, transparent, and secure. This standard will serve as the foundation for a new data infrastructure that ensures the safe and trustworthy exchange of data.

Gaia-X aims is to provide the European Single Market with unparalleled opportunities for innovative data-driven business models, thereby reducing the reliance on non-controllable technologies and reflecting Europe's need for data and cloud sovereignty. The association is open to everyone and aligns with the European values of human-centricity, transparency, openness, and sovereignty. Gaia-X mission is to design and implement a data sharing architecture that includes common data sharing standards, best practices, tools, and governance mechanisms. Additionally, it represents a federation of cloud infrastructure and data services that is firmly established in the European Union, with the commitment of all 27 EU Member States. This overarching mission serves as the driving force behind the Gaia-X architecture.

Based on the principles of European data and cloud sovereignty, Gaia-X intends to build a federated open data infrastructure. Gaia-X seeks to create a digital governance system that can be implemented on any existing cloud or edge technology platform, thereby enabling data and service transparency, controllability, portability, and interoperability.

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The Gaia-X vision is expressed through the creation of two ecosystems: data and infrastructure, which are interconnected by federations. The three conceptual pillars for the achievement of this vision are[5]:

- Gaia-X Compliance: Decentralized services that foster objective and measurable trust.
- Data Spaces / Federations: Interoperable and portable cross-sector datasets and services
- Data Exchange: Established contract rules for access and data usage

The objective of this framework aims to enable the portability, exchange, and sovereignty of services and data among providers, thereby opening the European Data Market to enhance competitiveness and ultimately foster growth and social equality. This vision will only become a reality if all three pillars are fully realized.

The initiative publishes technical specifications to allow constructions of European Data Spaces

- Gaia-X **Architecture Document**
- Gaia-X **Data Exchange Document**
- Gaia-X **Policy Rules Conformity Document**

The Gaia-X Architecture document describes the essential concepts for building the Gaia-X data and infrastructure ecosystem. It integrates the necessary Providers, Consumers and Services to facilitate this interaction. These services include securing identities, implementing trust mechanisms, and controlling the data use, exchange and compliance, all without the need for individual agreements.

Architecture Document 24.04[6]
A new milestone was reached with the publication of the Gaia-X Architecture Document 24.04

A particular element to highlight in the document is the section mapping the Gaia-X Architecture, the Gaia-X Digital Clearing Houses components, specifications on Federated Catalogues, and enhancements to Identity, Credential, & Access Management, as well as major updates for Data Exchange Conceptual and Operational Models.

Data Exchange document 23.11[7]
The release of the Gaia-X Data Exchange Document 23.11 is a major update to the Data Exchange Services specifications and paves the way for a secure and trustworthy data economy.

Major updates to the Data Exchange Conceptual and Operational Models were released and technical ontologies for Data Product, Data Transaction, Policies & Data Product Usage Contracts, and Data Usage Descriptions have been introduced, based on open standards like DCAT-V3 and ODRL.

This document serves as guiding principles to all organizations looking at creating data ecosystems and Data Spaces which have become a fundamental component of business competitiveness and economic sovereignty.

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The Gaia-X Compliance document consolidates the previous deliverables “Policy Rules & Labelling Document” and the “Gaia-X Trust Framework”, and introduces the new criteria for Data Exchange services within the Gaia-X framework among other significant advancements.

By encompassing in the document Data Exchange services criteria, this defines what it means to be compliant to Gaia-X when conducting data exchanges.

The Gaia-X Trust Framework is a comprehensive set of rules that define the minimum requirements for participation in the Gaia-X ecosystem. These rules offer a common governance structure and ensure basic interoperability among the individual ecosystems, thereby allowing control over decisions to be maintained.

The Gaia-X Trust Framework implements the requirements defined by Gaia-X, as described in the Policy and Labelling Document and the Architecture Document. The Architecture Document specifies the standards and protocols that ensure seamless interoperability among various systems, facilitating the exchange of information and enabling the utilization of that information in mutually beneficial ways.

The Trust Framework defines verifiable credentials and linked data representations as fundamental components of its future operations. Trusted information will be retrieved in machine-readable formats, and where such formats are unavailable, Gaia-X will implement procedures to convert trusted information into machine-readable formats. This conversion is essential for the federation of trusted assertions within the Gaia-X ecosystem and for the development of mechanisms to re-evaluate the validity of claims within the trust framework.

The GXDCH (Gaia-X Digital Clearing House) serves as a node of verification of the Gaia-X rules, and it is an essential part for the operationalisation of Gaia-X in the market. It acts as the entry point for achieving Gaia-X compliance and becoming part of the Gaia-X ecosystem. GXDCHs are non-exclusive, interchangeable nodes operated by market participants, functioning as Gaia-X federators. They operate and execute the mandatory and optional Gaia-X Framework services necessary for compliance and facilitate the onboarding of any Gaia-X adopter. The Gaia-X framework outlines the software assets, technical requirements, and functional specifications necessary for compliance with Gaia-X standards. This framework guarantees the distributed and decentralised characteristics of Gaia-X compliance, which is not centralised by the Gaia-X Association.[9]

The Gaia-X concept of sovereignty includes the autonomy and self-determination necessary for users to make informed technological decisions. All providers in Gaia-X are obligated to provide **Gaia-X Credentials**, formerly known as Self-Descriptions, which are standardised, machine-understandable metadata that describe their service offerings and themselves. Gaia-X Credentials are the common language used by participants in a Gaia-X ecosystem to communicate with one another.[10] The Gaia-X Conceptual Model, as published in the Gaia-X Architecture Document, outlines the relationships between all entities in the Gaia-X ecosystem. "Provider," "Service Offering," and "Resource" are the most critical entities. A Provider is defined by Gaia-X as a participant who "operates resources and creates service offerings." A Service Offering is a digital service that can be ordered. Services may be derived from resources or may be dependent upon

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other service offerings from third parties. Providers use metadata to describe themselves, their service offerings, and the resources that comprise them. The Self-Descriptions are comprehensible to the Federation Services that oversee the Self-Descriptions throughout their lifecycle, as well as by consumers, including humans and the automated machine agents that support them.[11]

A federated technical architecture is not possible without an essential network infrastructure. Interconnection and networking are fundamental components for connecting and federating all of the different entities inside the ecosystem. Gaia-X creates an infrastructure ecosystem by establishing portability and interoperability between network and interconnection providers, Cloud Solution Providers (CSP), High Performance Computing (HPC), sector-specific clouds and edge systems. Mechanisms are developed to find, combine and connect services from participating providers in order to enable a user-friendly infrastructure ecosystem. Gaia-X supports distributed use cases, spanning from on-premises set-ups, cloud hosted infrastructure through to facility to edge cases.

Circplastx objective -> the ambition of **CircPlastX** lies on a crucial prerequisite: acting as a digital trusted third party. Therefore, the project will firmly anchor itself in the principles and standards of **Gaia-X**. This strategic alignment enables us to offer a platform where participant identities are verified and exchange rules are transparent and sovereign.

f) DSSC

The Data Spaces Support Centre (DSSC) is a key implementation initiative of the European Data Strategy delivered through the Digital Europe Program. One of the objectives of the DSSC is to accelerate the deployment, scaling and adoption of Data Spaces in Europe. In attaining that objective, the DSSC aims to fully respect European values, and supporting the European economy and society.
The DSSC is fostering the development of Common European Data Spaces through exploring the needs of Data Space initiatives. Additionally, it defines common requirements and establishes best practices to accelerate the formation of sovereign Data Spaces. Herewith, the DSSC contributes to realizing the vision of a genuine European single market for data.

The DSSC has several offerings they provide to Data Spaces and Data Space initiatives[28]. The main ones we focus on in this report are the Building Blocks part of the DSSC blueprint. The building blocks are meant to break down the Data Space into smaller manageable pieces. The building blocks are the "*basic units or components that can be implemented and combined with other building blocks to achieve the functionality of a Data Space*". Figure 6 provides the latest rendition of the DSSC Building Blocks, which comes out of Blueprint version 2.

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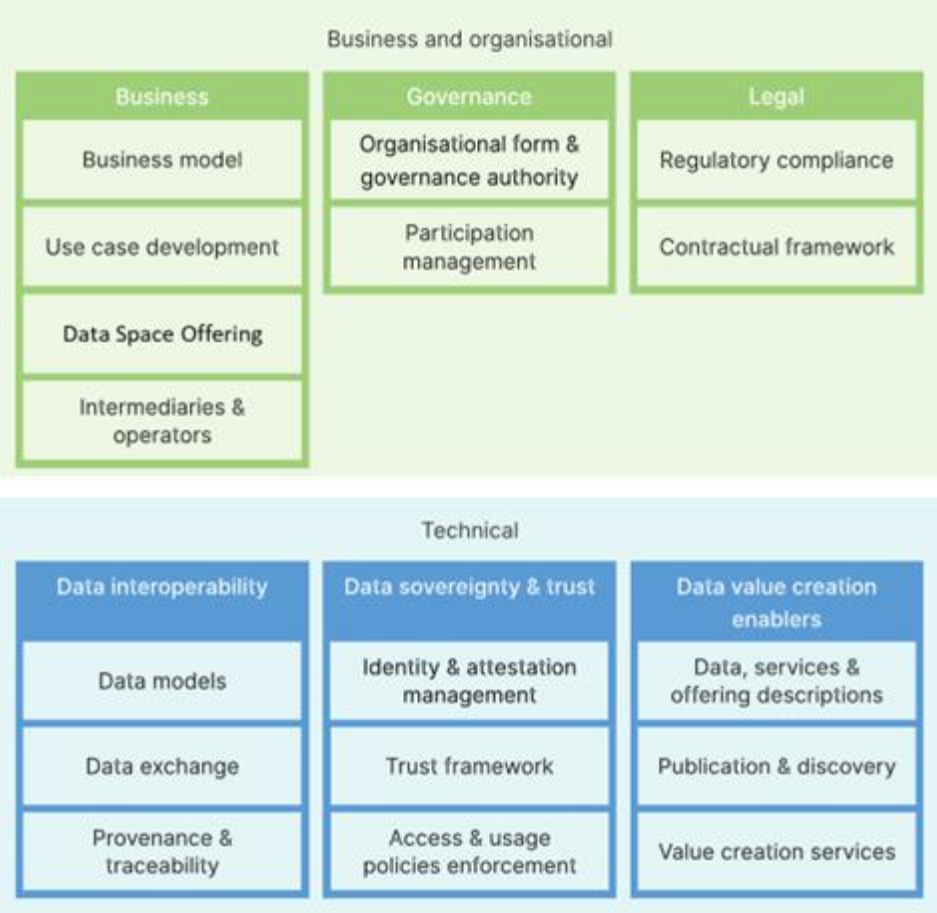

Figure 6: DSSC data space building blocks, blueprint v212

Circplastx objective -> CIRCPLASTX future architecture will be aligned with the DSSC blueprint and will cover all the Data space building blocks required to build a future-proof and compliant data space.

g) Manufacturing-X

Manufacturing-X represents a collaborative effort across the economic, political, and scientific sectors designed to establish a global, interoperable data ecosystem. Its primary goal is to foster digital innovations that enhance industrial resilience, sustainability, and competitiveness. Additionally, Manufacturing-X operates as a German government funding program running from 2024 to 2026.

- Building upon the established "Industrie 4.0" brand and the foundational achievements of the Plattform Industrie 4.0 network, the initiative tackles critical challenges such as secure data interfaces, trustworthy infrastructure, data governance, and the development of new business models.

Key characteristics of Manufacturing-X include:

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- **Cross-border connectivity:** Facilitating data-driven networking throughout industrial value chains, spanning various sectors and nations.
- **Innovation hub:** Providing a foundation for production methods that are competitive, resilient, and climate-neutral.
- **Holistic lifecycle management:** Tracking products and production assets from raw material extraction through to recycling.
- **Business transformation:** Enabling the creation of novel, data-centric business models and applications.
- **Scalability:** Promoting industry-standard solutions applicable to both large enterprises and SMEs.
- **Sovereignty:** Utilizing Gaia-X standards to ensure open, secure, and sovereign data exchange.

The Manufacturing-X initiative aims to create cross-industry data ecosystems with maximum interoperability. These should help to enable effective and efficient value creation for a resilient, sustainable and competitive industry. The following tasks are planned for this:

- definition of common standards for the implementation of Manufacturing-X for industry
- establishing technologies to enable data to be shared securely and confidently along entire value chains
- defining which technical, legal and organizational requirements must be created for this,
- making the initiative known to economic actors in particular through accompanying communication
- promoting concrete use cases, such as process improvements through data fusion from different sources or quality improvement through the use of machine, material and processing data.

The focus is on the implementation of practice-relevant added value, e.g.:

- efficient and fast traceability of supplied parts
- ESG reporting in complex supply chains
- decarbonization across various processing stages
- circular economy from design to disposal
- product passport management
- capacity management within and across sectors
- complex quality assurance and damage analysis

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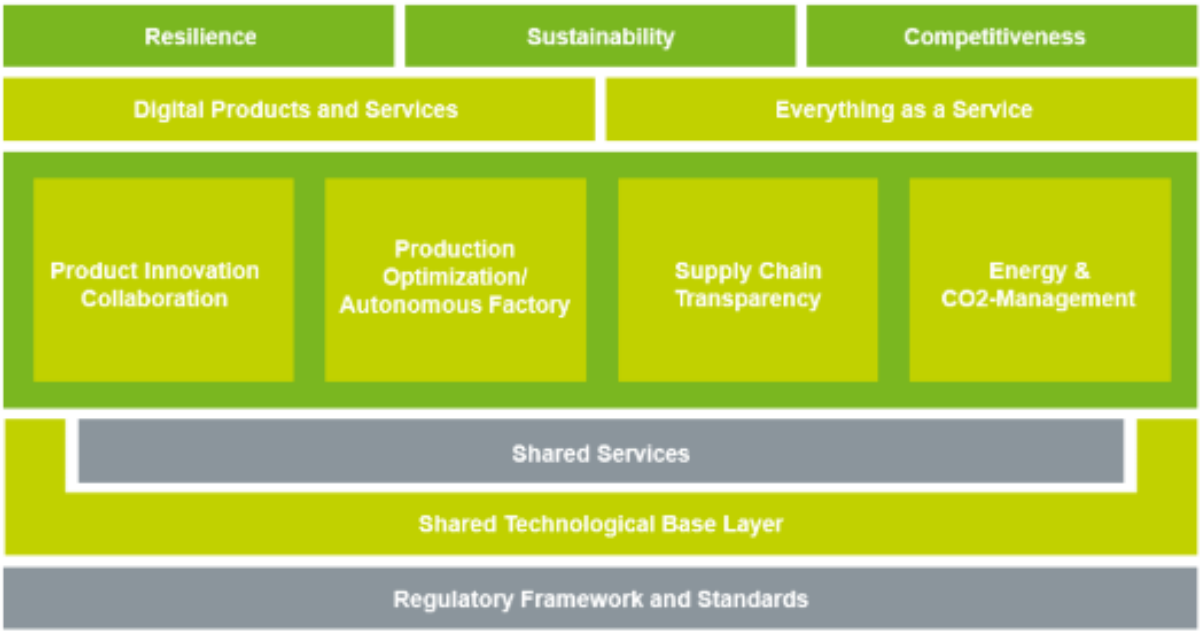

Figure 7: Manufacturing-X approach[13]

To ensure true interoperability, Manufacturing-X is building an overarching architecture capable of bridging different industries. By identifying common requirements across various use cases, the initiative has defined four universal "building blocks" that integrate existing and future systems into production Data Spaces.

The Four Pillars:

- **Identity & Trust:** Focuses on secure data exchange. It ensures that information flows only between identified, trusted entities.
- **Visibility & Access:** Maximizes efficiency by using standardized interfaces and mechanisms to enable seamless multilateral sharing.
- **Service & Sharing:** Offers central tools for implementing data processes, such as a unified registry for discovering decentralized data.
- **Agreements:** Provides the framework for contract management, ensuring legal security and defining how data flows are monetized.

Manufacturing-X also promotes the transfer of project results to industry at large and supports internationalization. The first projects under the funding framework started at the beginning of 2024 and will run until 2026. Current Manufacturing-X projects include:[41]

- Factory-X
- Aerospace-X
- DAVID
- Decide4ECO
- HealthTrack-X
- Robot-X
- Semiconductor-X
- Scale-MX

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Manufacturing-X is vital for the future of industrial data spaces because it provides the necessary infrastructure to support a value chain that is becoming increasingly integrated and digitalized. Since the scale of this transformation is too vast for any single country, initiative, or company to manage alone, Manufacturing-X serves as the essential connector. This connectivity is the prerequisite for achieving greater resilience, sustainability, and global competitiveness in smart manufacturing.

Beyond technical connectivity, Manufacturing-X is crucial because it provides the governance framework needed to build trust and alignment among diverse stakeholders. Through the International Manufacturing-X Council (IMXC), the initiative unites partners from science, politics, and industry to jointly define agendas, roadmaps, and responsibilities. By anchoring this ecosystem in core values of open collaboration, inclusion, transparency, and equal treatment, Manufacturing-X ensures a level playing field for all participants.

Circplastx objective -> Embracing this spirit of global collaboration, **CircPlastX** intends to positions itself as a proactive node within the International Manufacturing-X landscape. CircplastX goal is to ensure that our specific solutions for the circular economy are perfectly synchronized with the broader Manufacturing-X vision.

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IV. Data space services for circularity

1. Introduction: digital services on top of the data space to accelerate circularity

The Data Space Support Centre blueprint distinguishes different types of services connected to data spaces, being federation services, Participant Agent Services and Value creation services

- Participant Agent Services are services required for an individual participant to join a data space
- Federation Services: These are services that facilitate the interplay of participants for all kinds of data sharing.
- Value-Creation Services: These are services operating within the governance framework of a data space that support value creation.

Services are provided by a service provider (see also the different roles in a data space – the service provider can be the data space governing body or can be an external entity).
Whereas in CircPlastX the participant agent services and the federation services will be provided by the technical partners in the project, mainly based on existing standards and building blocks, the value creation services will be aimed at accelerating circularity in the plastics sector, mainly by helping them to comply to regulation or to help improve analysis and know-how. The business models for each of these services will differ, but each will have a clear connection to the data space. Below a schematic overview of the logic of a data space service as develop by the DSSC. They identify a service provider that provides a service to a party. This service provider ensures the implementation of the services, including a technical infrastructure and certain specific functionalities. For the data space this can be services around AAI (authentication, authorisation and identification), or around data offerings (managing datasets, access, payments etc.), whereas for the value-added services these are content-related functionalities, such as data quality, certification, analysis.

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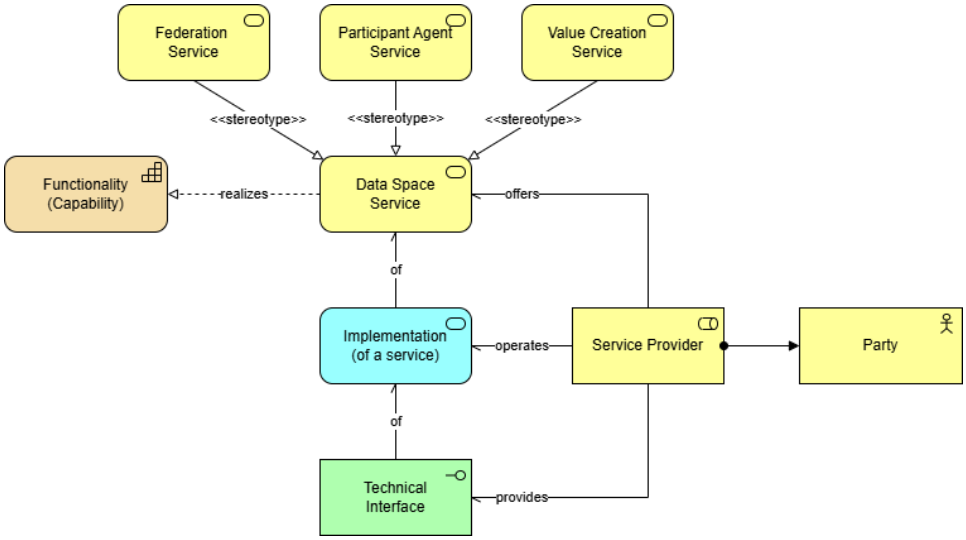

Figure 8: Data spaces services. Source: DSSC

2. Participant Agent Services

These services are related to account management, including identification- authentication- and authorisation services, which will be treated in WP 3 and in consequent deliverables.

3. Federation Services

These services are related to day-to-day data space operations, including the development and management of connectors, payment services and data space management services, which will be part of WP2 and WP3 developments and described in consequent deliverables.

4. Value-Creation Services

Service 1: Online testing and certification of percentage of recycled material

Driven by the need to reduce their environmental footprint and align with circular economy objectives, industries investigate the incorporation of post-consumer and post-industrial recycled plastics. The PPWR[19], the EU 2019/904 Directive[20] and the EPR schemes[21] set targets of recycled plastic incorporation in new products, not mentioning the national laws that can also apply. If the PPWR targets the Packaging industry, the EPR schemes concern diverse industries, and a new European Directive for end-of-life vehicles and waste of electric and electronic equipment (WEEE)

[19] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202500040
[20] https://eur-lex.europa.eu/legal-content/FR/TXT/?uri=celex%3A32019L0904
[21] https://circulareconomy.europa.eu/platform/sites/default/files/2025-06/EPR_Schemes_White_Paper_2025.pdf

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should be ready soon[22]. Therefore, transparency, traceability and credibility related to recycled content are key building blocks for legal compliance.

Description of service

This service enables real-time calculation and certification of the recycled content in plastic compounds. It connects to the compounder's dosing system to automatically collect data, calculate the percentage of recycled material, and integrate it into the CIRCPLASTX dataspace. Data can be shared with manufacturers, consumers, or selectively with other stakeholders (e.g., restricted data like compound rheology). The service addresses EU directives mandating minimum recycled content under Extended Producer Responsibility (EPR) schemes and supports compliance and product circularity.

State of the art from desk research

The need for reliable certification around the incorporation of recycled materials is especially critical since there is no standard method as of today to determine the recycled content of a product already processed. Some methods are under investigation (markers or tracers), and some plastics can leave a signature when they are reprocessed (see figure below). The calculation then needs to be made before the product enters the market.

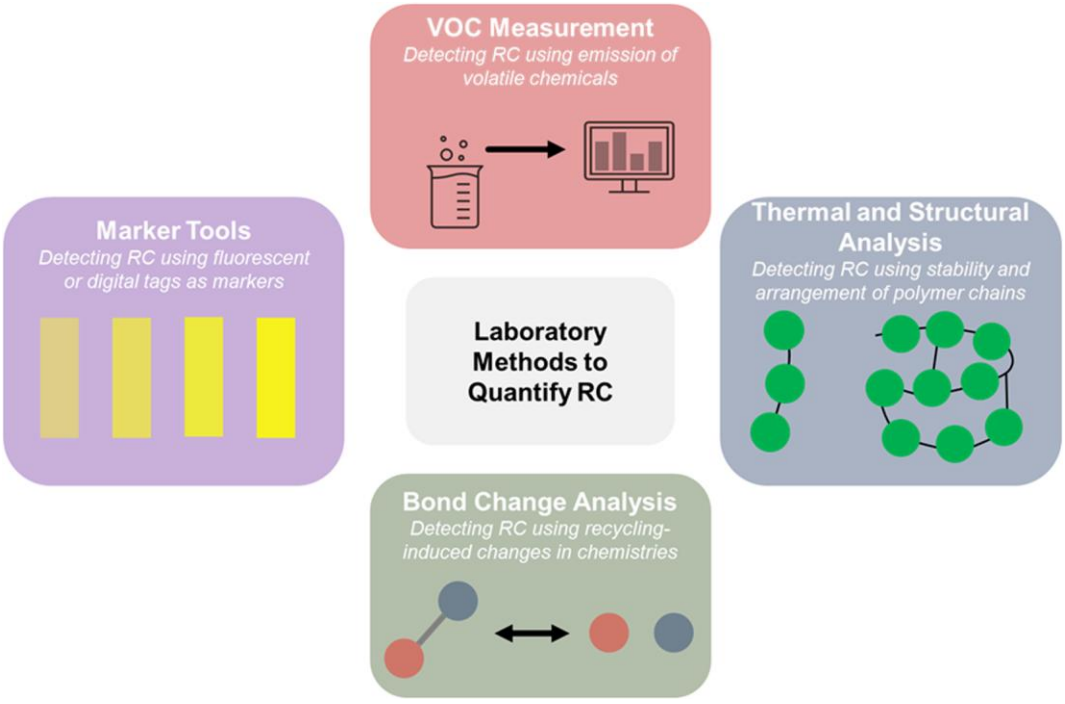

Figure 9: Summary of laboratory methods to quantify recycled content

[22]https://www.etui.org/topics/health-safety-working-conditions/hesamag/waste-and-recycling-workers-at-risk/eu-waste-legislation-current-situation-and-future-developments

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As there are several certifications available, this State-of-the-Art will present the most common, presenting their differences and similarities[23] . They typically assess criteria such as the percentage of recycled content, the origin and type of recycled material and the compliance with environmental standards. They usually differ in the scope and applicability, depending on the industry and the product type. With the multiplication of certifications, a number of methods for the calculation arise: batch-level, site-level, group-level, and one of the most contested, the mass-balance. These methods are framed by standards. The three more relevant are presented in the next parts.

Relevant standards

The **Standard ISO 14021:2016** – Environmental Labels and Declarations[24] sets some definitions:
Recycled Content: Proportion, by mass, of recycled material in a product or packaging. Only pre-consumer and post-consumer materials shall be considered as recycled content.

Recycled Material : Material that has been reprocessed from recovered [reclaimed] material by means of a manufacturing process and made into a final product or into a component for incorporation into a final product.

Pre-Consumer Material: Material diverted from the waste stream during the manufacturing process. Excluded is the reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.

Post-Consumer Material: Material generated by households or by commercial, industrial, and institutional facilities in their role as end-users of the product that can no longer be used for its intended purpose. This includes returns of materials from the distribution chain.

The **European standard EN 15343** [25] specifies the procedures for the traceability and the assessment of the conformity of mechanically recycled plastics. It provides the basis for the calculation procedure for the recycled content of a product. The procedures are needed to formulate or describe the traceability, while the traceability can be used as a basis for calculating the recycled content. For the purposes of this calculation:

- A recyclate or material containing recyclate is considered a product.
- Only pre-consumer and post-consumer materials shall count towards recycled content.
- Material that is recovered within the same manufacturing process that generated it, shall not count towards recycled content.

To ensure traceability of recycled plastics, the supplier of the recyclate must provide data for each of the following stages:

[23] https://eunomia.eco/reports/a-comparative-assessment-of-standards-and-certification-schemes-for-verifying-recycled-content-in-plastic-products/
[24] https://www.iso.org/obp/ui/#iso:std:iso:14021:ed-1:v1:en

[25] https://knowledge.bsigroup.com/products/plastics-recycled-plastics-plastics-recycling-traceability-and-assessment-of-conformity-and-recycled-content

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- Control of input material (e.g. proper design of collection and sorting schemes, batch identification)
- Control of the recyclate production process (e.g. recording the process variables, quality control testing of the products delivered by the process, batch identification of the output)
- Plastics recyclate characterization (information regarding characteristics of the batch of recyclate following the relevant standard, e.g. EN 15342)

The standard is used for a number of certifications that focus on mechanical recycling.

The **international standard ISO 22095**[26] as referenced earlier in the report defines the notion of Chain of Custody:

Process by which inputs and outputs and associated information are transferred, monitored and controlled as they move through each step of the relevant supply chain

Around the recycled content, five key Chain of Custody models are used. From the identity model, where the recycled input can be physically traceable in the output, to the mass balance model, where the recycled input can be split in several output as long as what goes in is equal to what goes out, the ability of physically follow the recycled material reduces. The measures within ISO 22095 aim to provide transparency and consistency in terms of accounting Chain of Custody that can be used across different product and material supply chains.

The principles and requirements for all Chain of Custody models are that the organization shall:

- Establish and implement one or more Chain of Custody models for all materials or products with specified characteristics and shall be transparent about that model;
- Use the same Chain of Custody model as its supplier.

Global certifications

ISCC PLUS[27]

The International Sustainability and Carbon Certification (ISCC) is a global certification developed in 2006. It certifies sustainable, deforestation-free and traceable supply chains. It treats recycled and biobased materials over the entire supply chain and is based on a traceable mass balance or segregation approach. It I to be noted that it accepts the pre-consumer waste in the recycled content calculation. It is not in compliance with EN 15343 and ISO 22095 but follows the ISO 14021.

ISCC PLUS also offers a certification scheme to ensure sustainable practices in the food and feed market, fuels, electricity, etc.

UL 2809[28]**:**

The UL 2809 is a standard developed by UL solution and authenticates the post-consumer, pre-consumer, closed-loop or total recycled content of products. It provides a third-party validation. It is the only one that includes the Ocean Bound Plastic and Ocean Plastic in the source material. It

[26] https://www.iso.org/standard/72532.html
[27] https://www.iscc-system.org/certification/iscc-certification-schemes/iscc-plus/
[28] https://www.ul.com/services/ul-2809-recycled-content-validation

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is not limited to plastic and can treat metals, batteries, jewelry and electronics. It is more used for mechanical than chemical recycling. It is in compliance with EN 15434 and ISO 14021.

It is to be noted that UL in general provides a wide number of standards for bio-based content, paper-based products and recyclability rate for example.

SCS[29]:
The SCS Recycled Content is also a standard focused on measuring the plastic recycled composition. It takes into account pre- and post-consumer recyclates. Up until the Version 7, it treated only the mechanical recycling, but the 8th version should include non-mechanical and mass balance calculations. It complies with EN 15343 and ISO 14021.

In addition to the Recycled Content Certification, it proposes a specific certification for Recycled Content Certification for Electronical and Electronics Equipment and a Recycling Program Certification for recyclers and reclamation facilities.

RCS[30]:
The Recycled Claim Standard applies to any product containing at least 5% of recycled materials. It was first developed by Textile Exchange but broader its field. It only complies with ISO 14021. It sets requirement for third-party certifications of both recycled content and Chain of Custody. It is based on an affiliated standard CCS (Content Claim Standard) to ensure the accuracy of the claims. It includes the pre-consumer waste as recycled content. It is linked to the GRS certification, which add a social and environmental impact to the RCS.

RSB[31]:
The Roundtable on Sustainable Biomaterials allows certifying non-energy products such as plastics, but also textiles, pharmaceuticals, cosmetic, food… It proposes one uniform standard for bio-based, recycled content and attributed systems. It is based on mass balance calculations. The scheme complies with ISO 14021 and imposes at least 25% of substitution over a 3-months period

European certification : RECYCLASS[32]
Recyclass is an initiative from Plastic Recyclers Europe (PRE). They developed several audit schemes to verify traceability of recycled material and, from their association with EuCertPlast[1], a scheme to certify recycling processes.

All the schemes are aligned with ISO22095 and EN 15343.

- The “Recycled Plastics Traceability Certification” focuses on product containing recycled material. It is based on a mass-balance approach and ensures the origin, the process and the incorporation of pre- and post-consumer waste through Chain of Custody transparency. It aligns with EU/UK plastic tax incentives.
- The “Recycling Process Certification” ensures the environmental performances and the conformity and quality of the recycling processes. It certifies that recycled plastics are physically traceable and reports the share of pre- and post-consumer content at

[29] https://www.scsglobalservices.com/services/recycled-content-certification
[30] https://textileexchange.org/recycled-claim-global-recycled-standard/
[31] https://rsb.org/certification/certification-schemes/rsb-global-advanced-products-certification/
[32] https://recyclass.eu/

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converters, producers and compounders. It involves annual audits and physical inspections of recyclers' facilities.

Furthermore, Recyclass proposes Recyclability certifications, labelling and list of best practices.

National certifications recognized by POLYCERT Europe

POLYCERT Europe was created to harmonize existing certification schemes by converters of polymeric materials in Europe. PolyCert Europe does not certify itself, but validates the mutual recognition of existing certification schemes. The objective of PolyCert Europe is to provide quality certification and verification of recycled content in converted products, following EN 15343 and in accordance with ISO14021.

- **QA-CER**: this certification is based on the Belgian Quality Association expertise, and is already available in several countries. The recycled content and the quality of the final product can be assessed.
- **AENOR**: This certification is based in Spain and complies with the EN 15343. It offers 2 types of certificates : recycled plastic content certification and traceability of recycled plastic.
- **CERTILOOP**: Authorized by the Operation Clean Sweep Turkey, this certification body can deliver Recycling Process Traceability Certificate, as well as Recycled Content and recycling process Certificate complying with EN 15343, and a Recyclability Certificate.
- **PLASTICA SECONDA VITA**: This certification was founded by IPPR and the representatives of the Italia plastic value chain. To get the PSV label, the product must comply with the minimums content of recycled plastics and guarantee traceability of the recycling material
- **TZÚ-PQA**: this certification ensures the recycled content and quality systems of the recycling processes
- **DIN CERTCO**: it is the certification body of TÜV Rheinland Group. It offers the DIN-Geprüft and flustix Recycled ranges of services. They are both in compliance with ISO14021 and EN 15343
- **LNE/IPC**: this certification is based in France and proposes the incorporation of recycled plastic materials certification. This certification treats two levels : the overall tonnage of recycled material incorporated in a site, or the specific quantity of recycled material contained in a product or a product range.
- **RETRAY** is a certification specialized in the thermoformed PET recycling. It can certified the incorporation of recycled material in a tray-to-tray circuit as well as the recyclability of the final tray.
- **MOORE Label** is a French certification for Circular economy and recycled content certification for packaging and consumer goods. It is based on ISO 14021 principles, includes traceability and environmental impact scoring, and offers consumer-facing labeling for transparency (https://www.polyvia.fr/fr/label-More-Polyvia)

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- **EcoLabel / Nordic Swan33** is an environmental performance including recycled content for packaging, consumer goods, and industrial products. (https://www.nordic-swan-ecolabel.org/nordic-ecolabelling/environmental-aspects/circular-economy-and-resource-efficiency/recycled-plastics/)
- **Blue Angel (Der Blaue Engel)** is a German certification for products with reduced environmental impact, including recycled plastics. (https://www.blauer-engel.de/en/certification.https://recyclass.eu/news/recyclass-recycling-process-certification-recognised-by-the-blue-angel-ecolabel/)

This state-of-the-art of existing certifications regarding recycled content was strongly based on the very detailed Eunomia report[34]. It is very difficult to compare the different certifications, since often, only details differ from one to another.

Today, a very strong will of harmonization between the certifications is seen, like the reunion of APR, EuCertPlast and Recyclass and the Polycert Europe umbrella, in order to ensure that whatever certification is chosen, the results will be consistent with another one. However, the calculus methods from PPWR (Packaging and Packaging Waste regulation) are pending, and should strongly influence these certifications and harmonization.

The table below gathers some of the most important criteria to be taken into consideration:

Table 4: overview of relevant methods and standards on recycled plastics

	Name	Type	Alignment with EN 15343, ISO 22095 and ISO 14021	Recycling	Post-Industrial Material (PIM) Post-Consumer Material (PCM)	Coc model type
Global	ISCC PLUS	Certification	ISO 14021	Mechanical and Chemical	PIM/PCM	Segregation Mass balance
	UL2809	Standard	EN 15343 and ISO 14021	Mechanical and Chemical	PIM/PCM	Mass balance
	SCS	Standard	EN 15343 and ISO 14021	Mechanical and Chemical	PIM/PCM	Mass balance
	RCS	Standard	ISO 14021	Mechanical and Chemical	PIM/PCM	Segregation and controled blending
	RSB	Standard	ISO 14021	Mechanical and Chemical	PIM/PCM	Mass balance
European	Recyclass	Certification	EN 15343, ISO 22095 and ISO 14021	Mechanical only	PIM/PCM	Mass balance
American	APR	Certification	ISO 14021	Mechanical only	PCM	Mass balance
	Greenblue RMS	Standard	ISO 14021	Mechanical and Chemical	PIM/PCM	Mass balance
	Cradle-to-Cradle	Certification	None	Mechanical only	PIM/PCM	Unclear
National	QA-CER	Certification	EN 15343, ISO 22095 and ISO 14021	Mechanical and Chemical	PIM/PCM	Segregation Mass balance
	AENOR	Certification	EN 15343	Mechanical only	PCM	Mass balance
	CERTILOOP	Certification	EN 15343	Mechanical and Chemical	PIM/PCM	Mass balance
	PLASTICA SECONDA VITA	Certification	ISO 14021	Mechanical only	PIM/PCM	Mass balance
	TZU-PQA	Certification	Unclear	Mechanical only	PIM/PCM	Mass balance
	DIN CERTCO	Certification	EN 15343 and ISO 14021	Mechanical and Chemical	PIM/PCM	Mass balance
	LNE/IPC	Certification	Unclear	Mechanical and Chemical	PIM/PCM	Segregation Mass balance
	RETRAY	Certification	EN 15343	Mechanical and Chemical	PCM	Mass balance

Other factors be impactful to choose a certification:

[33] https://www.nordic-swan-ecolabel.org/nordic-ecolabelling/environmental-aspects/circular-economy-and-resource-efficiency/recycled-plastics/

[34] https://eunomia.eco/reports/a-comparative-assessment-of-standards-and-certification-schemes-for-verifying-recycled-content-in-plastic-products/

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- The duration of the certificate;
- The mass balance system boundary: some certification allows the transfer of recycled content within companies in the same or different countries (sharing a border for example);
- The mean: the third party can just conduct an audit, or request a visit of the site;
- The claims and labelling: most brand owners want to display the recycled content of the product.

Service 2: Improving life cycle assessment data quality

Life Cycle Analysis (LCA) is nowadays based on well-established methods, standards and regulations, as well as numerous databases. However, these databases remain largely 'generic', despite their structured architecture and a certain degree of traceability. Their diversity and the heterogeneity of the information they contain make it difficult to assess data quality, particularly when it comes to data created by manufacturers. The real challenge for LCA experts is not to obtain the most accurate data possible, but to have sufficient traceability to understand how the data was constructed and determine to what extent it represents.

Description service

Data relating to environmental assessment and life cycle analysis can vary in terms of format, quality and completeness. The data space consolidates and harmonises LCA datasets, providing consistent, comparable and verifiable environmental information, technical, industrial, and environmental data to produce a reliable LCA quality rating, considering:

- Proximity of LCI datasets to the actual material/product.
- Weighting and importance of different environmental impact categories.
- Missing key elements or gaps in practitioner inputs.

This service supports eco-design, regulatory reporting and corporate sustainability commitments. It helps identify elements reducing LCA quality, prioritize improvements, and ensure compliance with LCA standards and Product Category Rules.

State of the art from desk research

LCA Tools most mentioned and used by LCA experts (besides companies internal LCA Tools):

Figure 10: Key software tools used for LCA

Main LCA databases used or mentioned:

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Figure 11: main data sources and sets for LCA

For example, main LCA databases like EcoInvent use different steps to create a data:
Primary data collection: ecoinvent gathers data from industry partners, research institutions, and expert contributors, based on real measurements, reports, and technical studies.

- **Use of secondary sources:** when primary data are missing, the database integrates information from scientific literature, national statistics, and public reports.
- **Consistent modeling framework:** all datasets are structured using standardized system definitions, allocation rules, and supply-chain modeling approaches to ensure coherence across sectors.
- **Quality review:** each dataset undergoes internal checks for mass/energy balance, comparison with external references, and validation of assumptions and sources.
- **Detailed documentation:** every dataset includes transparent information such as data sources, geographical and temporal representativeness, uncertainties, modeling choices, and limitations.
- **Continuous updates:** ecoinvent is regularly revised to add new processes, update outdated data, and improve methodological consistency.

These steps ensure reliable, transparent, and traceable data for LCA practitioners. A more elaborate state-of-the-art overview of LCA data, describing the structure of LCA data and needs is available and ready upon request. The main issues surrounding LCA data concern the content of the data itself:

- How detailed should the data be? (Materials, additives, processes, etc.)
- What environmental data should be included? Which indicators are relevant for which data? (Climate change, resource use)
- What life cycle data should be included? (Recycling cycle, recyclability, etc.)

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Service 3: Helping SMEs improve management and compliance related to substances

Description of service

The substance compliance checker service automates the treatment, verification, and updating of safety data related to regulated substances. It enables routine checks of data provided by suppliers and recyclers, automatically verifying information against the latest lists (such as ECHA), which are updated every six months. The service assesses the completeness and accuracy of reported substance levels, helping companies ensure that all relevant substances are properly accounted for. By streamlining these processes, the service facilitates regulatory compliance, reduces manual effort, and allows industrial users to manage safety data more efficiently and reliably.

State of the art from desk research

All plastics are made of chemicals, including polymers and solvents, stabilizers, flame retardants or pigments to deliver the right functionalities, as well as unintentional chemical residues resulting from the processing. While the adverse physical impacts of plastics in the environment are often visible, less apparent are the health risks associated with the chemicals used to produce or found in plastics and subsequently released into the environment. Latest research has identified over 13,000 chemicals associated with plastics across a wide range of applications such as packaging, building and construction, consumer products, automotive and transportation, electrical... Amongst these, 7,000 chemicals have been screened for their hazardous properties, of which more than 3,200 plastic monomers, additives, processing aids, and non-intentionally added substances have been identified as chemicals of potential concern based on their hazardous properties.
Plastics can contain a range of persistent organic pollutants (POPs), including short-chain chlorinated paraffins (SCCPs), polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), polychlorinated naphthalenes (PCNs), perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), and other related hazardous substances. Additionally, plastics are often associated with chemicals flagged as emerging policy concerns under the Strategic Approach to International Chemicals Management (SAICM). These include endocrine-disrupting chemicals (EDCs), toxic substances found throughout the lifecycle of electrical and electronic products, and per- and polyfluoroalkyl substances (PFASs). Further concerns highlighted in the Global Chemicals Outlook II (UNEP 2019a) involve compounds such as bisphenol A (BPA), cadmium, lead, microbeads used in cosmetics and personal care items, polycyclic aromatic hydrocarbons (PAHs), phthalates, and triclosan, all of which have been linked to potential risks for human health and environmental safety.

A significant number of these concerning chemicals are released at various stages of the plastic life cycle, beginning with the extraction of oil and gas, followed by the synthesis of polymers and chemicals, and through the manufacturing, use, and disposal of plastic products. These substances have been linked to numerous toxic effects, both immediate and long-term, spanning across generations. Documented impacts include damage to specific organs, multiple forms of cancer, genetic alterations, reproductive and developmental harm, disruption of hormonal systems, and ecological toxicity.

Plastic products are engineered based on their intended use by combining one or more polymers with various additives, such as plasticizers, flame retardants, UV stabilizers, and pigments, that

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provide essential functional characteristics like flexibility, thermal and UV resistance, and coloration. On average, additives make up about 4% of a plastic's total weight, though the proportion can vary depending on the type of polymer used.

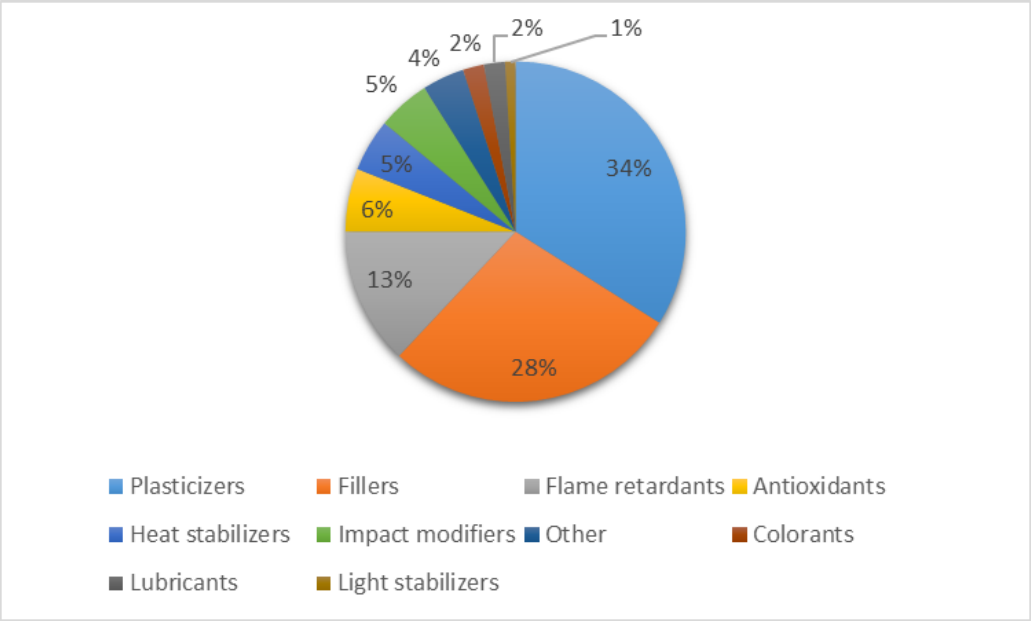

Figure 12: Main additive types in global plastics production (United Nations Environment Program, 2023)

Beyond polymers, fillers, and additives, plastics may contain a variety of other chemicals. These include intentionally added substances such as solvents, unreacted monomers, precursor materials, and processing aids. Additionally, plastics often contain non-intentionally added substances (NIAS), which encompass impurities, reaction by-products, and degradation products. NIAS alone can represent more than half of the total chemical content in plastics. As a result, from a chemical standpoint, plastic products are intricate blends comprising one or more polymers, fillers, multiple additives, and numerous, often unidentified, NIAS.
Non-intentionally added substances (NIAS) are explicitly addressed in the EU's Regulation (EC) No 10/2011 on plastic food contact materials (FCM). As a result, evaluating NIAS has gained growing attention, although it continues to pose significant analytical challenges. These substances can arise from multiple sources, including polymer degradation, impurities in raw materials, unintended reaction by-products, and contaminants introduced during recycling processes.

In this context, regulations have been put in place to frame the use of the intentionally added compounds in plastics. Next, the main European regulations concerning substances in plastics are gathered in the following table:

Table 5: Overview of relevant circularity policies and regulations

Short description / Title	Reference	Objectives
CLP (Classification, Labelling and Packaging of	n°1272/2008	Identify hazardous chemicals and to inform users about these hazards.

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substances and mixtures)		Signal words and pictograms on labels and safety data sheets. Mandatory for the suppliers to apply this harmonised classification and labelling.
POP (Persistent Organic Pollutants)	n°850/2004	Safeguard human health and the environment by prohibiting and limiting the production, marketing, and use of substances covered under the Stockholm Convention on Persistent Organic Pollutants and the 1998 Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution.
Food Contact Plastics Regulation	n°10/2011	Sets out safety requirements for plastic materials and articles intended to enter into contact with food
Regulation on recycled plastic materials and articles intended to enter into contact with food	n°1616/2022	Sets specific requirements to produce recycled plastics, aiming to ensure that decontamination processes achieve both chemical and microbiological safety. Outlines standards for quality control of recycled plastics and mandates their enforcement by public authorities. Introduces a procedure to determine the suitability of new recycling technologies for food-contact applications and encourages the advancement of innovative recycling solutions.
REACH (Regulation for Registration, Evaluation, Authorisation and Restriction of Chemicals)	n°1907/2006	Requires companies or individuals who use chemical substances, either individually or in mixtures, as part of their industrial or professional activities to provide information about the risks these substances pose and the appropriate handling procedures. This information must be communicated throughout the supply chain, including to manufacturers, suppliers, or the European Chemicals Agency (ECHA).
ROHS (Restriction of Hazardous Substances Directive)	n°2015/863	Establishes EU-wide restrictions on the use of hazardous substances in electrical and electronic equipment (EEE) to safeguard public health and the environment. Bans or restricts ten substances: lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE), bis(2-ethylhexyl) phthalate (DEHP), butyl benzyl phthalate (BBP), dibutyl phthalate (DBP), and diisobutyl phthalate (DIBP).
Toy safety directive	2009/48/EC	Sets out the safety standards that toys must meet before being placed on the EU market and requires compliance with all other relevant EU legislation.

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		Outlines essential safety requirements addressing both general risks—such as the health and safety of children, parents, and caregivers—and specific hazards, including physical and mechanical risks, flammability, chemical exposure, electrical safety, hygiene, and radioactivity.
Global Automotive Declarable Substance List (GADSL)		Facilitates communication and exchange of information regarding the use of certain substances in automotive products throughout the supply chain. Substances listed in GADSL are categorized as either prohibited (P) or declarable (D). A declarable (D) classification does not imply that the substance is banned or must be eliminated from use in vehicle parts.

Analytical techniques for evaluating substances in plastics include spectroscopic, chromatographic, thermal, and microscopic methods, each tailored to identify, quantify, and characterize both intentionally and non-intentionally added substances (NIAS). The table summarized the main analytical approaches used in plastic substances evaluation:

Table 6: Overview of substance-related regulatory frameworks

Type of Analysis	Substances Addressed
FTIR (Fourier-Transform Infrared Spectroscopy)	Polymers, additives (e.g., plasticizers, stabilizers), functional groups
Raman Spectroscopy	Pigments, polymers, additives (especially in colored or opaque samples)
UV-Vis Spectroscopy	Dyes, pigments, UV stabilizers
NMR (Nuclear Magnetic Resonance)	Complex organic compounds, additives, monomers
GC (Gas Chromatography)	Volatile organic compounds (VOCs), residual solvents, degradation products
LC (Liquid Chromatography)	Non-volatile additives (e.g., plasticizers, antioxidants), NIAS
GC-MS / LC-MS (Chromatography-Mass Spectrometry)	Unknown substances, NIAS, trace contaminants, legacy additives
TGA (Thermogravimetric Analysis)	Thermal stability, filler content, degradation behavior
DSC (Differential Scanning Calorimetry)	Polymer transitions (melting, glass transition), crystallinity
Pyrolysis-GC/MS	Breakdown products of polymers, NIAS
SEM/TEM (Electron Microscopy)	Microplastics, surface morphology, contaminants
Optical Microscopy	Visual identification of microplastics, structural defects
XRF (X-ray Fluorescence)	Heavy metals (e.g., lead, cadmium), elemental composition

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TOF-SIMS (Time-of-Flight Secondary Ion MS)	Surface-level trace substances, NIAS
Headspace Analysis	VOCs, residual solvents, off-gassing compounds

These techniques are often used in combination to ensure comprehensive chemical characterization, especially for regulatory compliance and safety assessments.

Beyond the state of the art of existing standards and regulations concerning chemical substances in plastics, it appears valuable to develop a digital tool such as a dataspace designed to monitor the risks associated with the use of plastic materials, while also ensuring that new formulations remain compliant with regulatory requirements. Such a tool could provide proactive risk assessment, facilitate traceability, and support innovation by aligning material development with evolving legal frameworks.

Other potential services

Other potential services can be developed as part of the CircPlastX data space offerings. One of the emerging topics for the plastics-sector in relation to recycling or reuse, is the digital product passport. CircPlastX partners are exploring and following closely the developments of DPP standards, both on content and form. The so-called DPP-as-a-service-model [35] could be an interesting development to which our data space can connect and provide data. More on this in WP3.

5. Summary

The three services foreseen in the project are corresponding to social-and legal needs regarding recycling and reuse of plastics in Europe. The industry is facing challenges mainly in regulation to global competition and the flooding of EU markets with either cheaper virgin plastics or fake recycled plastics (virgin material sold at the price of recycled), which in turn also creates opportunities for digital services and data exchange for administrative burden relief related to regulatory compliance and quality control (thus increased single-market protection). We have described the current challenges form desk research and have shown the current standards and requirements. In the next chapter, we report on stakeholder views on the role of data, data spaces and digital services for circularity in plastics.

[35] See https://cirpassproject.eu/wp-content/uploads/2024/03/D3-DPP-as-a-Service-Minh-Le.pdf

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VI. Stakeholder views on data space and services for circularity

1. Gathering insights from industry to sharper our data space proposition and services

Next to the desk research, one approach to specifying the digital service foreseen in the CircPlastX data space is to gather views and feedback from the sector. We have conducted a series of interviews and have launched a survey among a variety of stakeholders.

Survey
The survey was collectively developed among WP1 partners. It was put on a European and open source survey provider (LimeSurvey). The survey was translated in French and English, and sent around via the project internal list of stakeholders, via LinkedIn, and via interview contacts. We have had 41 responses, of which 7 completed the survey.

Interviews
We have interviewed 28 people in total, representing various stakeholders across the value chain of plastics manufacturing and recycling. The interview guide (appendix B) consists of a semi-structured list of questions per theme, with the liberty for the interviewer to focalise on certain themes more than others, depending on the expertise of the interviewee and type of organisation. Interview notes were taken and are available upon request. Interviewees were asked for consent to use the interviews for analytical purposes and were asked if they wanted to remain anonymous or mentioned by name. In this report we have chosen for anonymity (the names of the interviewees are known and recorded by each partner responsible for their part of the interviews). We have taken the approach of saturation in qualitative and explorative research, meaning that a minimal target was set (6 per partner between IPC, POL and PCL) and additional interviews serving for clarification, new information or confirmation, with a stopping point at reaching saturation (repetition of points, no new information provided)[36].
Via several internal workshops, data from interviews, the survey results and desk research were used in analysis. Below we provide summaries of finding per 'thematic block', the blocks being:

- Digital maturity and knowledge of data sharing
- Data value and data space for circularity
- Digital services for circularity

[36] See SAUNDERS, Benjamin, SIM, Julius, KINGSTONE, Tom, *et al.* Saturation in qualitative research: exploring its conceptualization and operationalization. *Quality & quantity*, 2018, vol. 52, no 4, p. 1893-1907.

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2. Section 1: digital maturity and knowledge of data sharing

In the first part of both the survey and the interview, we are interested in a generic level of digital maturity. Following roughly questions that are also posed in the Digital Maturity Assessment for SMEs[37], we can report on the questions and replies concerning the role of data and any data governance approaches in place at the organisation or company interviewed.

a) Survey results summary

Out of the 41 respondents, a wide variety of roles is represented, such as Manager of the LCA business unit, COOs and business development, Stagiaires and students; R&D Directors, CEOs, R&D managers, Commercial Managers, a Director & owner, Data and data security personnel, Environmental coordinators and Finance and IT personnel. In general, the level of data expertise varies widely among interviewees, with a high level of expertise and adequate digital maturity on the one side, and hardly any expertise not data governance or data management structures in place.

Responses to the question: *How would you describe your level of digital maturity compared to peers (in several keywords)?*

- I'd say I have some level of comprehension of digital stuff and data-related topics but I'm mostly clueless.
- Average
- Beginner
- Compared to other SME's i think we are (very) advanced, especially related to data security.
- Compared to large & multinational companies i think we are on similar level.
- Above average

Responses to the question: *Who would you list as the main data user or data consumer within your company (these can be roles or departments)*

- Admin and especially accountants
- HSE
- MDM (Master Data Management)
- CEO
- All operational processes
- Sales
- Managers
- Development
- Customer Service (CRM system)
- Admin
- R&D

[37] See Open DMAT - Digital Maturity Assessment tool | European Digital Innovation Hubs Network

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- Finance

Responses to the question: *Which of the following systems do you have or use within your company (ERP or MES)?*

- SAP
- EXACT

Other systems mentioned for data sharing internally or with external partners were Sharepoint, Google Drive or internally developed systems. IN terms of databases only one mentioned GrantA. Only one respondent states there is a specific role appointed within the organisation for the management of data access and data sharing.

b) Interview summary

Table 7: summary of responses on part 1: digital maturity

Subject addressed	***Summary of answers from the different interview teams***
Level of expertise	*(interview team 1)* Among the five persons interviewed, three of them had a confident expertise in data-related topics. Indeed, most of the interviewed industrial stakeholders do not have a position directly linked to data but to circularity.
	(interview team 2) Eight interviews bring together twelve LCA experts, all of whom are involved in some way with LCA data, all of them handle data to carry out environmental analyses. Some work more directly with data created by research consultancies or manufacturers to feed into simplified LCA software or internal tools.
	(interview team 3) The interviews reveal varied levels of expertise among stakeholders. Some respondents feel confident with data topics due to their involvement in R&D or traceability activities. Others consider their expertise low, especially when their role does not require managing technical datasets. In general, expertise is higher in organisations that handle materials analysis, LCA work or regulatory compliance.
	(interview team 4) Among the six persons interviewed, only two of them had a confident expertise in data-related topics. Indeed, most of the interviewed industrial stakeholders do not have a position directly linked to data.
Role of data in your company	At the scale of a group, data is generated and used internally.
	LCA data is mainly used to carry out environmental analyses for products or projects, eco-design. Some expert can create to feed internal or even external databases for software: creation of internal primary data, for clients, for simplified LCA software (Askor, C3'R Impact). Secondary Data from databases are used when the primary data are missing Life Cycle Inventory (LCI) data are mainly used by all of the stakeholders for modelling, exchanges and impact results are used for internal and external communication and for reports to the customers

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	The data quality is the most important aspect of the data, the Data Quality Rating (DQR) of EcoInvent is a good reference used by a lot of experts to rate the quality in different
	At the scale of a group, data can be shared with the different subsidiaries. Data generation is mainly linked to production processes. In some cases, industrial can put in place measuring devices to collect data during production and optimize processes. For all the interviewed stakeholders buying data is not among their practices, except for marketing data. Another specific case is to access Ecoinvent for LCA data. Besides, the exchanges of data outside their companies mainly take place in the framework of collaborative projects (always under confidentiality agreements). Another case is for the furniture of legal data to their clients. In the two cases, the data are not sold. All the industrial stakeholders interviewed agree on the criticality of their data for their business, especially regarding formulations.
	Data plays an essential role in day-to-day operations. Several companies generate large internal datasets through production monitoring, optical measurements or chemical and material characterisation. External data is used when necessary for regulatory purposes, particularly through eco organisations or LCA databases. Most stakeholders consider data highly sensitive and critical for their business, which explains their cautious approach to external sharing. A few companies occasionally share data through technical collaborations or R&D partnerships.
Data governance and data sharing	Data governance practices are generally limited and often informal. Some organisations rely on security procedures or ISO9001 requirements to manage access rights and storage. Internal training on data management is rare, although a few companies receive guidance from IT teams or data security managers. Concerns focus on confidentiality, trust and the need for secure storage. Data is shared mainly under NDAs or within collaborative R&D frameworks. External access is granted only when strictly required, and legal constraints remain a major barrier to broader data exchange.
	LCA data management varies greatly from one company to another. Some use secure SharePoint sites, servers hosted by LCA software (Simapro) or even internal hard drive storage. This data management still presents risks of data deletion, IT risks, or cyberattacks. In most cases, stakeholders do not share data with external parties, except in the case of data management for software such as Askor or C3'R Impact. This software is managed internally and allows manufacturers to carry out their own simplified LCAs. Some data are created with the help of other manufacturers, or a manufacturer may request the creation of its own confidential data.
	Not a lot of training on data management. CITEO has put in place a “data referee” in each team to structure internally. Data exchanges have not been monetized. Projects are being set-up to automatize data sharing internally.

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	Generally speaking, industrial stakeholders have an IT charter. It has been observed that only groups have put in place specific and frequent training on data management, related to confidentiality.

c) First insights

It is important to note the high variability of expertise in either circularity- and materials-expertise and data-related expertise between interviewees. Many note that they still work mainly in excel when it comes to data processing, while only some mention the presence of a digital roadmap within the company. The interviews indicate that, in many organisations, the implementation of circularity policies remains closely linked to data practices that are largely operational rather than strategic. While internal policies may formally address material traceability or waste reduction, data collection is often driven by production needs, regulatory obligations or LCA work, rather than by a structured data governance approach. Several stakeholders report that data related to formulations or material flows is considered highly sensitive, which limits internal circulation beyond strictly defined teams and reinforces siloed practices across departments or sites.

It was also highlighted that technical data is among the most critical and confidential assets for industrial actors, especially when it relates to formulations or proprietary processes. As a result, sharing of technical data outside the organisation is generally limited to collaborative R&D projects and governed by strict confidentiality agreements. Even internally, access to detailed technical datasets is often restricted, which can constrain broader reuse for circularity analyses or cross-site optimisation.

Insights from industrial and LCA practitioners confirm that data quality is generally considered more critical than data volume. Stakeholders emphasise the need for clear documentation of data sources, assumptions and uncertainty levels to ensure that datasets are fit for modelling and comparison purposes. At the same time, the lack of harmonised practices for data storage and governance increases risks related to data loss, inconsistency or limited reuse, particularly in organisations with low digital maturity or decentralised IT systems. Rather than a lack of data, the main issue lies in the transparency and representativeness of available datasets, particularly for materials and processes specific to the plastics sector. Several practitioners rely on recognised references such as EcoInvent and its data quality indicators, while noting that primary data collection remains resource-intensive and uneven across organisations.

Several interviewees note that access to reliable end-of-life data remains uneven, particularly beyond aggregated figures provided by eco-organisations. While such data is essential to assess real recycling performance, detailed information is often difficult to obtain and rarely feeds back into design decisions in a systematic way, limiting the effectiveness of circular feedback loops.

Regulatory data is mentioned as a key driver for data collection and structuring within companies. Compliance requirements related to substances, reporting or product certification often justify investments in data generation and documentation, even when similar efforts are more difficult to justify for purely voluntary circularity objectives. In this context, regulatory pressure is frequently perceived as a lever for improving traceability and internal data consistency.

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3. Section 2: Data value and data space for circularity

In the second part, we try to understand the current use of platforms or services used for data sharing or data exchange for circularity among different actors in the value chain of plastics. We also inquire into data buying-or selling or other value identified-and connected to their data, as well as knowledge (or at least awareness) of the concept of data spaces.

a) Survey results summary

On the many questions posed in the survey on potential acquisition or selling of data, or other added value sought externally with data, none of the respondents replied. On the questions of the need for-and relevance of data for circularity, only 5 respondents replied that they are actively generating or collecting data on circularity-related topics or processes. None of the respondents had heard of the concept of data spaces before.

b) Interview summary

Table 8: summary of responses to part 2: data management and data value

Subject addressed	***Summary of answers***
Current use of platforms and tools	Companies use a wide range of tools depending on their digital maturity. ERP systems such as SAP or AXELOR are common for managing traceability and inventories. Other daily tools include internal CRM systems, Excel files, material analysis software such as MASS or SharePoint folders. Some companies develop in-house solutions to streamline data access while others optimise existing software platforms. Procurement processes for new tools are often informal and driven by management or compliance needs.
	The main LCA software used by the experts interviewed is Simapro using the Ecoinvent Database. This software and database are the most used in the industrial sector by LCA experts. Other softwares are used to complete Simapro: Brightway, Askor, C3R Impact, One Click LCA... A variety of software programs specific to specific requests. Microsoft Excel is sometime used as a simplified LCA tool. The software GrantA is also used for the data management for LCA or all type of data in companies.
	Most of the industrial stakeholders interviewed have an ERP (Enterprise Resource Planning) to follow their orders, flows and business data. In one case, it has been reported the use of Business Object to objectify the Business objectives and data. In another case, CRM (Customer Relationship Management) for marketing data and LIMS (Laboratory information management system) for R&D data are also used. Some of the stakeholders also use additional modules, for example to HR management. However, it must be noted that smaller entities, such as SMEs, do not have access to such tools and are working mainly with Excel files.

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	In the context of collaborative projects, SharePoint, Teams, Zenodo and cloud tools are mainly used.
Data value, data buying and selling	Globally, data exchanges have not been monetized, going outside or coming inside.
	Companies identify clear economic value in improved traceability, better compliance and the possibility to justify higher product value through accurate documentation. Some stakeholders already pay for services such as EcoInvent or RECYCLASS, and they could consider paying for a dataspace if the quality of data and services is high. Non-economic value includes time savings, improved coordination, support for innovation and better understanding of material flows. Several organisations note that generating reliable data is costly, which reinforces the need for structured and trustworthy datasets.
	Data quality is the main problematic in LCA, not about the high-quality data but to have the most transparent information about quality to have the most representative data for the modelling. Today those materials quality data aren't strong enough. Other main issue about data is the confidentiality but that can be solved by the type of LCA data shared on the dataspace (impact results are confidential enough for some type of inventory)
	Some of the interviewed stakeholders interviewed already pay for the access to platform such as Ecoinvent. In this context, paying to access to the dataspace could be possible depending on the price and time to spend. The regulatory context could be a lever to attract industrials as the dataspace could facilitate their compliance with different regulations, especially regarding substances. All the data collected could be used for eco-conception later on.
	For all the interviewed stakeholders buying data is not among their practices, except Ecoinvent for LCA data. For eco-organism or associations, data is collected externally and used. Data is generated internally but confidential: only agglomerated data can be published. In both cases, the data are not sold. All the industrial stakeholders interviewed agree on the criticality of their data for their business and some would be interested to sell data.
Concept of Dataspaces	Familiarity with dataspaces varies significantly. Some companies know the concept through collaborative projects or platforms such as SharePoint while others have never worked with a dataspace before. Most organisations express interest in using a dataspace if it provides secure and well-governed access to data while protecting confidentiality. Barriers include technical complexity, legal concerns, lack of trust and the need for clarity on usage rules. Several stakeholders highlight the importance of interoperability and a clear governance structure to ensure balanced value for participants.
	For the majority, never heard of the term "dataspace" but some have thought about the idea of it. Few companies have this kind of data sharing system but internally, using Viva Engage or GrantA

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	Stakeholders show a strong interest in this kind of service to help quality, transparency and confidentiality among LCA data. Dataspace could help to retrace details of a data, the data construction while maintaining a security and a confidentiality of the data provider/seller. Data can be updated regularly automatically and keep the information of the previous versions.
	Eco-organism and association are keen on using a dataspace decentralized and secure, but with a clear governance on data. They also point out the risk of multiplication of initiatives and the necessity of interoperability. It can be hard to obtain the data so some kind of obligation could be necessary. For industrial stakeholders it is more difficult to work with a dataspace, especially regarding confidentiality.
	Industrial stakeholders can consider working with a dataspace but only in very strictly delimited conditions, especially regarding confidentiality of their data which is clearly pointed as the main challenge. Indeed, this can be seen as a brake on competitiveness. Besides, such dataspace must prove their real utility. Economic data must not be concerned by such system. Another technical barrier that has been reported is the interoperability of the system. It has also been mentioned that industrial should chose who can access their data, mainly due to competition. At this stage of the interviews, the value of the data has also come up as a subject that could condition membership of such dataspace. The example of TÜV Austria has been cited as a reference. Indeed, industrial must communicate to TÜV their formulations to certify their products as compostable but all the data stay confidential.

c) First insights

Recyclers: The effort of recyclers is mainly focussed on sorting different types of plastics coming from a very divers background. The starting point can vary from disposed electrical appliances coming from consumers to waste from landfills and large streams of similar items coming from businesses. The origin of the waste and its homogeneity determines its value. Human perception on what we think and know about the waste play a big role here. The more information is available about the batch of waste the higher it's value. When materials arrive at the recyclers the decision on re-use or recycling already has been made.

The recycling process is aimed at increasing the homogeneity of the materials, shredding them first and sorting them by physical properties. As soon as batches of homogeneous materials appear from the process they start to become more valuable. This value is still very brittle, by appearance the batch of sorted material still looks like junk. So, it is very important to safeguard the data belonging to that specific batch. Currently, data is stored mostly manual although ERP system become increasingly applied. It is generally recognized that a dataspace will bring improvement in capturing the value of the recycled material.

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Virgin material suppliers: For virgin material manufacturers the value of their materials is determined differently. Because in a lot of occasions the material is made to a customer specific compound of which is negotiated upfront. The production process is more about registering additives and generating data to prove the quality of the production batch.
These production processes are more mature and already have a great deal of data collection in them. Data is collected according to a company policy and work processes are in place to ensure the data quality. Although data is available within the company, sharing is not so obvious. Because when shared, the data can reveal IP sensitive information to the outside world. In general, publicly available information is shared via the company website. On request, the supplier can share extra information to their customers, but this is not something that is done frequently on batch level.
For the moment, when it comes to LCA data, data for such processes are not strong enough - more data needs are there that go beyond recycled material only. Currently in LCA and other circularity-data, often we only have proxy-indicators. One main issue that comes to the fore is that of confidentiality of LCA data. One idea is to offer via CircPlastX a protected way to show and share LCA results – we can protect these results depending on type of LCA data following the data construction – we could introduce a data scheduler or a data-freshness-label so that they can know when data is coming (LCA data planner), for example.

4. Section 3: Feedback on the services for circularity

In the third section, we delve into the digital services connected to the data space that respond to particular legal- or business challenges when it comes to circularity in plastics.

a) Survey results summary

The survey did not delve very deep into business challenges or legal needs, as we used the interviews to gather more in-depth views here. Most survey respondents state they would be interested in the circularity services we foresee.

b) Interview summary

Table 9: summary of responses on part 3; digital services for circularity

Subject addressed	*Summary of answers*
Digital services	The digital service about recycling is the one generating the most interest at first sight. Indeed, there is a huge need for industrial to obtain more information about the recycled materials. Nowadays, there is a lack of communication regarding recycled material from manufacturers. Also, this service could be useful apprehend chemical recycling to simplify the understanding of the regulation (ISCC PLUS). Regarding LCA, some companies, especially groups, seem to be autonomous on this subject. Thus, this service does not generate a lot of interest from them compared to SMEs that need LCA data to establish environmental arguments

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	about their products. However, stakeholders agree on the difficulty to follow the different European methods for LCA (PEF, SsbD). Facilitate the access to these methodologies could be of interest. It has also been mentioned the interest in data on LCC. The third service on substance generate a lot of interest. Indeed, it is difficult for companies to obtain information on this topic from manufacturers and producers. However, this subject is highly critical in terms of confidentiality. It has been suggested to give access to the data without entering in the details of a formulation for instance. Besides, it seems to be relevant to make reliable the substances data on virgin materials, including not only plastics but also inks and labels. There is also an interest to access to developed methods to measure substances in a reproducible and repeatable manner. One additional service suggested could be the automatic calculation of biobased content in materials as well as the capacity of be auto certified on the end of life (compost ability). Once again, the main issue identified by the interviewed stakeholders regarding the three services is confidentiality. Moreover, some of them are doubtful about the contribution of all stakeholders, especially manufacturers.
	The services are considered of interest and worth to be explored. However, for industrials it mainly depends on the European legislation. For eco-organisms, having a dataspace service harmonized for data collection, administrative reporting to public authorities would be useful. The digital service about recycling is interesting if it brings commercial value. ISCC+ should be integrated. An interesting proposal was to add the quality of the recycled material in the database as it is the main barrier towards its incorporation into products. The digital service on substances could gather all legislation linked to substances in one place which would be useful. However, sharing data on substances is very tricky as most suppliers are very secretive on that topic. To help sharing, a suggestion was to certify a “white substances list” instead of a blacklist. Therefore, you do not need to share the full composition, it is just shared that all substances are recognized in the whitelist. For LCA, the data is internal or via EVA/ECOINVENT, no need for more, but should harmonized at the European level. Sometimes, it can be interesting to know where the data actually come from, to ensure its reliability. The balance between sharing and what you get is to take into account.
	Strong connection with DPP, LCA dataspace could help with the subject of DPP regulation planned in 2027. The service of LCA is very interesting if it not only focusses on recycled plastics but at all kinds of plastics, material, processes and end of life: Bio-based, recycled, chemical recycling. Could be interesting to have information about on-going projects about data creation in specific inventory. Major obstacle is the price and business model of the dataspace
	Stakeholders show strong interest in services related to certification of recycled materials, LCA data quality and harmonization of testing protocols for

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	hazardous substances. Additional services mentioned include access to material formulations, directories of accredited laboratories and tools for supply and demand matching. Challenges to adoption include limited maturity of current tools, the need for European standardization, concerns about data sensitivity and the risk of overly complex systems. The most convincing elements for adoption are ease of use, transparency and the ability to facilitate networking and access to the right partners.

c) First insights

Feedback service 1: Certification of recycling

Industry feedback shows a strong interest in certification services that provide transparency and benchmarking, such as Recyclass. Companies highlighted the need for a European-wide directory of certified recycled materials, complete with technical data sheets, to facilitate informed decision-making. Stakeholders also expressed a demand for supply-demand tools that allow efficient identification of materials and suppliers. However, several challenges were identified for adopting such services, including the need for standardization, building trust, addressing legal uncertainties, and ensuring technical compatibility across systems. The most compelling factors for adoption were services recognized across the entire value chain, interoperability, and the provision of reliable, accurate data. To maximize effectiveness and adoption, the service should fully align with European standards and regulations. User interfaces should be intuitive, and the system should allow flexible data sharing options to meet different stakeholder needs. Integrating supply-demand functionalities and incorporating the concept of a 'material passport'—documenting technical characteristics, origin, and recycling history—would further enhance the service's value for manufacturers, recyclers, and end users.

Feedback service 2: LCA data quality rating

Industry stakeholders expressed strong interest in improving the reliability and comparability of Life Cycle Assessment (LCA) data. There is a clear need for flexible, easy-to-use services that can integrate seamlessly into existing workflows. Adoption challenges include limited user familiarity with digital LCA tools, inconsistent methodologies across practitioners, and partial uptake of available LCA solutions. Companies emphasized that the most valuable aspects of such a service would be improved data quality, greater comparability between assessments, and actionable insights to guide environmental performance improvements. Many stakeholders also expressed their need for security and confidentiality regarding such a service, particularly when exchanging and sharing data. Today, most of the experts interviewed store their data and modelling internally, via third-party servers or directly on hardware, increasing human and data security risks to address these needs, the service should provide clear guidance and a transparent scoring methodology for evaluating LCA data quality. Integration with existing LCA software and databases is crucial to ensure ease of use and compatibility. Additionally, the service should be flexible enough to accommodate sector-specific LCA practices, allowing companies to tailor the evaluation framework to their materials, products, and environmental contexts.

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Feedback service 3: improving management – and compliance of substances

Industry stakeholders expressed strong interest in a service that ensures the accuracy and reliability of safety data for regulated substances, as internal checks are often limited or inconsistent. Key adoption challenges include the lack of standardized procedures, limited staff resources, and the complexity of keeping up with frequently updated REACH lists. The main selling points highlighted by industrial users are ease of use, automated verification, and the ability to trust that their data meets regulatory requirements, thereby saving time and improving compliance efficiency.
To maximize adoption, the service should provide a user-friendly interface and clear guidance on interpreting verification results. Integration with existing data management systems and laboratory reports would facilitate seamless use in daily operations. Additionally, flexible configuration options to accommodate different industrial contexts and the ability to track updates automatically would enhance the overall utility and relevance of the service.

5. Other remarks from interviews

In the interviews, we left space for interviewees to share comments, ideas and suggestions. Below we share the most pertinent ones.

Table 10: summary of other remarks and suggestions from interviews

Subject addressed	***Summary of answers***
Other remarks	Stakeholders wish to be informed about the evolution of the project or maybe if they can participate for the first version of the dataspace
	Some of the stakeholders mentioned it is very difficult to involve petrochemical companies. A big chemist company, as a material producer, was contacted to discuss about the dataspace. At first glance, they do not see an interest for them as they are sufficiently known and the data they wish to share is already available on their website. They do not see the additional value of a dataspace. A circle/network of frontrunners should be set-up first to showcase the utility of such a dataspace as involving all stakeholders can be tricky. A business model should be defined to be interesting commercially. Maybe some obligations would be necessary to get data. The importance of harmonization and interoperability was emphasized, at least at the EU level.
	Several industrials warn about the occultation of data from materials manufacturers. The lack of transparency from manufacturers could be a killer for such a dataspace. It also seems important for several industrials to have the capacity to select who can access their data. Besides, industrials should be able to have traceability of their data and the different stakeholders accessing it. Another point raised by one of the stakeholders is the management of a European dataspace in a globalized system. How to avoid data leaks to other countries?

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	Lastly, the environmental impact of the use of the dataspace should be assessed as well.
	Some stakeholders point out the difficulty of involving large industrial actors who do not always perceive the benefit of participating in a dataspace. Interoperability, harmonization and the need for clear governance are seen as essential conditions for success. Several companies underline the importance of standards and certification to encourage the use of recycled materials. A few participants suggest engaging a first circle of frontrunners to demonstrate the value of the dataspace before scaling it more widely.
	Make sure your services connection to existing internal services of companies. If you can achieve time reduction or service convergence + added quality, then you get people interested.
	Trust in the data space in order to be used
	Circular materials (could also be a point of entry)
	Data quality as an additional to certifications
	Eco organisms interested in data spaces (there is already a project between the Benelux)
	We did not interview the big chemists yet – reason of failure – commercial interest + added value (Borealis) - batch to batch data interesting and certain parameter
	Cooperation of material producer – we need full cooperation otherwise less interest

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VII. Insights and next steps for data space and service development

From the desk research and stakeholder feedback-and analysis, we can have gathered insights into core areas of focus for our data spaces for circularity in plastics. A couple of contextual points are important to take into account in expectation management for the data space in the development work that follows.

In terms of data sharing needs, the desk research shows that transparency in plastics-value chains has been translated from societal needs and demands into a range of regulatory instruments that increase producer responsibility and transparency. On the level of products and materials, known instruments are being expanded, notably Lifecycle Assessment and producer responsibility, while novel regulatory development delve deeper into transparency and better management of toxic substances in plastics (such as REACH), while other focus on specific applications of plastics (such as the PPWR for packaging). Next to existing regulations on circularity, the following trends in policies and regulatory developments are on the horizon for European and will be key of importance for the project:

Table 11: trends in policy and regulation on circularity

Name of policy	Description	Benefits	Challenges	Expected timeline
Digital Product Passports (DPP), Benefits: Enhances transparency, supports compliance with PPWR and EPR schemes	Digtal product passports will be Mandatory under EU Circular Economy Action Plan starting 2026 for packaging and plastics. Their aim is to provides full traceability of material origin, recycled content, and environmental footprint. Relation to supply chain data space: economic operators gather data across the supply chain via the data space and present the DPP as an interface corresponding to the delegated act requirements	Enhances transparency, supports compliance with PPWR and EPR schemes.	Requires harmonized data standards, ~~and~~ interoperability across supply chains, and an additional B2B and B2A data sharing infrastructure.	There are different DPP developments, nonth for the content and the technical standards. See https://cirpass2.eu/ and Ecodesign for Sustainable Products Regulation - European Commission
PPWR Influence on Harmonization of recycled content	PPWR introduces standardized calculation methods for recycled content.	Reduces discrepancies between certifications and national schemes and will drive convergence of	Harmonisation of methods and data access+ exchange	Full enforcement expected by 2030 with interim guidelines by 2026.

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		mass balance and physical segregation models.		
Integration with EPR Schemes and Global Harmonization	EPR schemes will increasingly link recycled content certification to financial incentives.	Encourages brand owners to adopt certified recycled materials. ISO and UNEP initiatives aim to align regional standards.	Traceability, ensuring quality of material, provenance, costs	Progressive alignment expected between 2025 and 2032.

These regulations B2C, B2B and B2G connections and data exchange between various and sometimes even competing stakeholders in the value chain ranging from raw material supplier to recycler. Creating such a digital layer between the various parties is not just a nice-to-have, but rather a crucial element in achieving policy goals for circularity in plastics. A recent socio-technical analysis of circularity and recycling by Hofman et al. shows what happens in the case of weak data exchange:

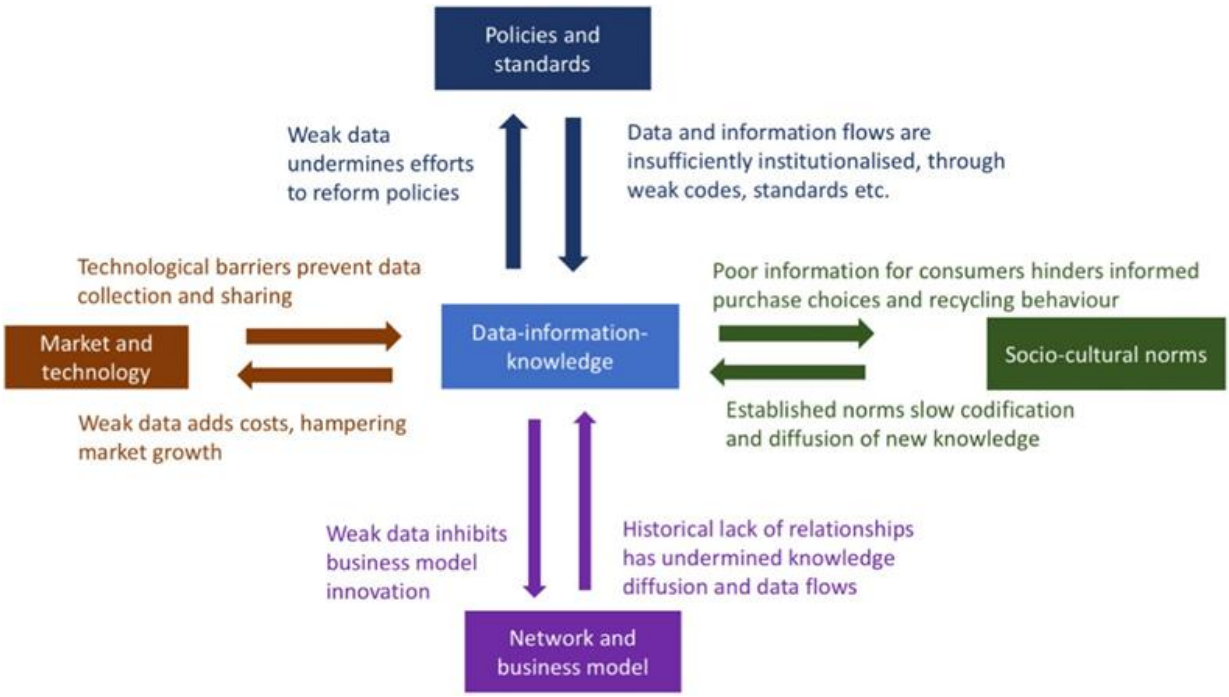

Figure 13: Consequences of weak data exchange for reaching circular economy goals. Source: Hofman et al. [38]

[38] Hofman, W., Rukanova, B., Tan, Y.H., Bharosa, N., Ubacht, J., Rietveld, E. (2024). Digital Infrastructures for Compliance Monitoring of Circular Economy: Requirements for Interoperable Data Spaces. In: Arai, K. (eds) *Advances in Information and Communication. FICC 2024. Lecture Notes in Networks and Systems*, vol 921. Springer, Cham.

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While this figure shows high-level implications of weak data connections and exchange for circularity, and suggesting a role for data spaces to improve this situation, the CircPlastX data space aims to contribute by connection data between stakeholders on a 'lower' level of data needs most notably on recycled plastics-certification, traceability and quality control, LCA data quality guidance and labelling, and self-assessment services and compliance guidance for substances of concern in plastics.

In this Deliverable, via desk research, an online survey and 28 interviews with various stakeholders, we have provided an overview of current regulatory-, technical- and business challenges and have explored these challenges and data spaces opportunities to respond to them.

Based on the summary of interviews some of the most important challenges for the Data Spaces Services are:

- Data confidentiality - technical data is considered IP-sensitive and there seems to be limited data sharing even internally
- Low digital maturity among (most of) the stakeholders - slows down adoption of DS services
- lack of harmonization and standardization - difficult to compare LCA practices, standardization is necessary for scalability
- Data quality and transparency is insufficient - especially for end-of-life and recycling streams, data quality is important (more than volume) but costly to achieve
- limited knowledge and trust in DS's - concerns about legal risks, interoperability. Unclear governance
- Economic and commercial barriers - uncertainty about the DS business model! Large chemical companies see little added value and are difficult to engage
- Regulatory pressure - compliance drives data collection but the complexity of regulations makes adoption difficult. Services must align with legal requirements.

The findings confirm that data sharing is both essential and challenging in relation to achieving both circularity and compliance. On the one hand, traceability and transparency across the plastics lifecycle are necessary to improve recyclability, support eco-design, and foster collaboration among manufacturers, recyclers, and suppliers. On the other, structured and trustworthy data is critical to enable compliance with key EU regulations, including the Digital Product Passport (DPP), the Packaging and Packaging Waste Regulation (PPWR), the Corporate Sustainability Reporting Directive (CSRD), the Ecodesign for Sustainable Products Regulation (ESPR), and REACH. Without harmonized, reliable, and secure data flows, companies—particularly SMEs—will continue to face barriers to meeting regulatory obligations and capitalizing on circular economy opportunities. Moving forward, the project will prioritize continuous stakeholder engagement to ensure that the CircPlastX data space and its digital services are firmly anchored in real-world industrial needs. SMEs, large companies, recyclers, regulators, and digital solution providers must all be involved in co-shaping both the technical architecture and the services to guarantee adoption and trust.

The next step is the detailing of technical requirements for both the data space infrastructure and the digital services built on top of it. On the infrastructure side, the focus will be on ensuring interoperability, security, and sovereignty through mechanisms such as Gaia-X-compatible connectors, compliance-as-code, and trusted consent and identity management. On the services side, the emphasis will be on refining and specifying the functionalities of the three priority services identified. Finally, the publication and dissemination of the findings contained in this

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deliverable represents a first milestone in positioning CircPlastX as a reference initiative within the Digital Europe Programme. By documenting the state of play, clarifying needs, and mapping opportunities, the project contributes to the broader European vision of federated manufacturing data spaces that are interoperable, trusted, and scalable.

In conclusion, CircPlastX is now better positioned to move from analysis to implementation. The coming phases will focus on co-designing the technical architecture, specifying and prototyping the three digital services, and validating them with stakeholders. Through these steps, the project will not only advance the digital and circular transformation of the plastics sector but also provide a blueprint for how data spaces can deliver tangible value for industry, society, and the environment.

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Appendices

Appendix A: Overview of Interviewees

Name of company or organisation	*Type of company or organisation*	*Role in plastic ecosystem*	*Date of interviews*	*Interviewed by*
Groupe Vacher	SME	Recycler	30/06/25	POL
PLAS'TRI	Startup	Recycler	19/06/25	POL
Idelam	Startup	Recycler	03/07/25	POL
Environnement recycling	SME	Recycler	20/06/25	POL
BARBIER	ISE	Recycler/Transformer	28/07/25	POL
SEDEM (ASPEN)	SME	Recycler	30/07/25	POL
Veolia		Recycler	5-11-2025	PCL/TNO
Mirec		Recycler	11-11-2025	PCL/TNO
Borealis		Virgin material supplier	12-11-2025	PCL/TNO
MGT		Recycler	5-11-2025	PCL/TNO
Philips IEN		LCA experts	28-11-2025	PCL/IPC
ALBEA Tubes	Large group	Converter	29-10-2025	IPC
CPA	Association	Comité de la Plasticulture et de l'Agroenvironnement	23-10-2025	IPC
SCHOELLERALLIBERT	Large group	Converter	3-11-2025	IPC
TORAY	Large group	Converter	30-10-2025	IPC
CITEO	Mid cap	French eco-organism for packaging	26-11-2025	IPC
WIPAK	Large group	Transformer	17-07-2025	IPC
ELKEM	Large group	Converter / transformer	31-07-2025	IPC
AIMEN	RTO	RTO	24-10-2025	IPC
VELFOR	Mid group	Transformer	04-11-2025	IPC
NATUREPLAST	SME	Converter	05-11-2025	IPC
EUROPLASTIQUES	SME	Transformer	13-11-2025	IPC

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Appendix B: Interview guide

CircPlastX

Interview - Guiding Questions.

Intro

1. Name, company, position in the company
2. Level of expertise /confidence in data related topics (self assessed)
3. Consent to use interview for research-and development purposes

Role of data in your company

4. D1 Could you explain the role of data in day to day operations in your organisation
5. D2 Can you provide a recent example of data-driven work or the need for, or generation of (large) datasets for an operational-or strategic action?
6. Do you buy or use data external to your company?
7. Are you generating and using internal data
8. Is that data also exported (sold, used) outside of your organisation and if so, can you provide a recent example?
9. How would you rate the business-criticality of data to your organisation, if at all?
10. Any other remarks on data in general for your organisation?

Data Governance and data sharing

11. Are there any specific data governance systems or frameworks in place in your organisation?
12. Does or organisation provide training or guidance on data management in any shape or form?
13. What would be the key concerns for your company when it comes to data governance?
14. Could you mention or do you know of any data governance frameworks or tools?
15. Do you share data with partners outside your company and if so what kind and how is this data shared?
16. Do you grant access to your data to outside entities or is access granted to you from external entities
17. Do you pay, or do you ask for payment when sharing or accessing data? If so, can you elaborate?

Platforms and Tools

18. Can you mention some typical day-to-day tools or platform used in your company for data sharing, data storage or data generation?
19. Is there a procurement process in place for novel data-related platforms or software tools and if so could you mention some of the criteria?
20. Are you developing any in-house solutions for data sharing and data access?
21. Any other points you wish to share when it comes to platforms or tools for data sharing?

Data Spaces

22. In this innovation project, one of the core elements is to create a safe and secure digital space where organisation in the plastics-and composites sector can take part to either

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share or grant access to each others' data related to circularity and production processes. Such a digital space where B2 data can be shared or accessed among partners, is called a data space.

23. Have you heard of data spaces before? If so, how / in which context?
24. Would you consider working in-or with a data space in the context of data for circularity?
25. What would be technical challenges or barriers for you to participate in a data space?
26. What would be legal challenges or barriers?
27. Any other points or remarks regarding data spaces?

Digital Services

28. In this innovation project, we are working on different digital services related to circularity on top of the data space as proposed and in development. We have foreseen three services to be developed, with potentially more in the future. All three are connected to European legislation and requirements related to circularity and safe-and sustainability by design in plastics.
29. *Data for certification of recycled material. Improving the data for recycled material, from recycler to manufacturer.*
30. *LCA data quality rating. Improving data used for lifecycle assessment*
31. *Data access improvement for harmonising testing protocols for hazardous subtances during production, recycling or end-of-life.*

32. Which of these services would be relevant and of interest for you and why?
33. Could you think of or mention other types of services related to circularity that would be of interest to you?
34. Can you say something about the maturity of digital services for circularity in your context or that you know of or use?
35. What are the most pertinent hurdles or challenges to adopt such services?
36. What are the key selling point that would convince you?
37. Any other points you wish to share on digital services for circularity?

Data value

38. The main idea of a data space and its related digital services is to create added value (economic and other) for the participants in that data space.
39. When thinking of data for circularity, what types of economic added value can you think of or mention?
40. Which other, non-economic value could be gained from increased data sharing and data access for circularity?
41. How would you rate your willingness-to-pay or the willingness-to-pay in the value chain for data and digital services for circularity?
42. Can you mention a successful service in this respect?
43. And a failed one?
44. Any other points you wish to share with us regarding data valuation and service pricing for circularity services?

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Other points

45. Do you wish to share any other points regarding data access, data sharing and/or data storage platforms?
46. Do you wish to share any other points with us regarding circularity, data, manufacturing or related topics?

End

47. Thank you for your time and for this conversation. Is there anyone you suggest we should talk to?
48. Do you wish to be kept informed about the project and its activities?

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