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ONTO-DESIDE

Use Case Needs Analysis and Circular Value Flow Mapping – Report v1

Deliverable number	D6.1
Deliverable name	Use case needs analysis and circular value flow mapping
Work package	WP6 – Industry use cases
Lead partner	Circularise BV
Contributing partners	+ImpaKT Luxembourg circular.fashion Concular GmbH Texon Lindner Group Ragn-Sells Recycling REIA
Deadline	2022-09-30
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Date	30/09/2022

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Project information

Project summary

Circular economy aims at maintaining and retaining the embedded value of products by creating continuous closed loops of materials or product parts and by phasing out waste. Today, lack of support for sharing data in a secure, quality assured, and automated way is one of the main obstacles that industry actors point to when creating new circular value networks. Together with using different terminologies and not having explicit definitions of the concepts that appear in data, this makes it very difficult to create new ecosystems of actors in Europe today. This project will address the core challenges of making decentralized data and information understandable and usable for humans as well as machines. The project will leverage open standards for semantic data interoperability in **establishing a shared vocabulary** (ontology network) for data documentation, as well as a **decentralized digital platform (i.e. Open Circularity Platform)** that enables collaboration in a secure and privacy-preserving manner.

The project addresses a number of open research problems, including the development of ontologies that need to model a wide range of different materials and products, not only providing **vertical interoperability** but also **horizontal interoperability**, **for cross-industry value networks**. As well as transdisciplinary research on methods to find, analyze and assess new circular value chain configurations opened up by considering resource, information, value and energy flows as an integral part of the same complex system. Three industry use cases, from radically different industry domains, act as drivers for the research and development activities, as well as test beds and demonstrators for the cross-industry applicability of the results. The developed solutions will allow for automation of planning, management, and execution of circular value networks, at a European scale, and beyond. The project thereby supports acceleration of the digital and green transitions, automating the discovery and formation of new collaborations in the circular economy.

Project start date and duration: 1st of June 2022, 36 months

Project consortium

No	Partner	Abbreviation	Country
1	Linköping University	LiU	Sweden
2	Interuniversitair Micro-Electronica Centrum	IMEC	Belgium
3	Concular Ug Haftungsbeschrankt	CON	Germany
4	+Impakt Luxembourg Sàrl	POS	Luxembourg
5	Circularise Bv	CIRC	The Netherlands
6	Universitaet Hamburg	UHAM	Germany
7	Circular.Fashion Ug (Haftungsbeschrankt)	FAS	Germany
8	Lindner Group Kg	LIN	Germany
9	Ragn-Sells Recycling Ab	RS	Sweden
10	Texon Italia Srl	TEXON	Italy
11	Rare Earths Industry Association	REIA	Belgium

Document reference

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Document approval

Version	Date	Name	Role in the project	Beneficiary
0.2	27.09.2022	Olaf Hartig	Internal reviewer, Deputy PC	LIU
1.0	29.09.2022	Eva Blomqvist	PC	LIU

Table of Contents

Abbreviations

B2B	Business to business relationship
B2C	Business to consumer relationship
CE	Circular Economy
EEA	European Environmental Agency
ID	Identifier
ISO	International Organization for Standardization
IT	Information Technology
EOSC	European Open Science Cloud
MFM	Multi-Flow Metabolism
OEM	Original Equipment Manufacturer
PCDS	Product Circularity Data Sheet
REACH	Registration, Evaluation, Authorisation and restriction of Chemicals
SMEs	Small and Medium-sized Enterprises
UNECE	United Nations Economic Commission for Europe
WP	Work Package

Terms and Definitions

Below are listed the definitions of specific terms used in the scope of this document:

Business requirements vs. Functional requirements	Business requirements relate to a business' objectives, vision and goals. Business requirements relate to a specific need that must be addressed to achieve an objective. Functional requirements break down the steps needed to meet the business requirement or requirements. Whereas a business requirement states the 'why' for a project, a functional requirement outlines the 'what'.
Product Circularity Data Sheet (PCDS)	Product declaration which presents standardized and trustworthy information on the circularity characteristics of a product. It is based on a template containing pre-set true/false statements which describe circular economy properties of the product (ex.: design for reuse and disassembly, recyclability, recycled content, hazardous materials thresholds, etc.). The PCDS is not intended to be a scoring mechanism, but it could be used partially or entirely by other stakeholders (e.g., databases, platforms, or consultants) to enable an evaluation of the product circularity.
Traceability	"The ability to identify and trace the history, distribution, location and application of products, parts and materials, to ensure the reliability of sustainability claims in the areas of human rights, labour (including health and safety), the environment and anti-corruption"[1] and "the process by which enterprises track materials and products and the conditions in which they were produced through the supply chain"[2].
Transparency	"Requires relevant information to be made available to all elements of the value chain"[3] in a standardized way, which allows for common understanding, accessibility, clarity, and comparison.

[1] United Nations Global Compact Office, A Guide to Traceability: A Practical Approach to Advance Sustainability in Global Supply Chains (New York, 2014).
[2] Organisation for Economic Co-operation and Development (OECD), Due Diligence Guidance for Responsible Supply Chains in the Garment and Footwear Sector (Paris, 2017).
[3] DAI Europe and the European Commission, A Background Analysis on Transparency and Traceability in the Garment Value Chain (2017).

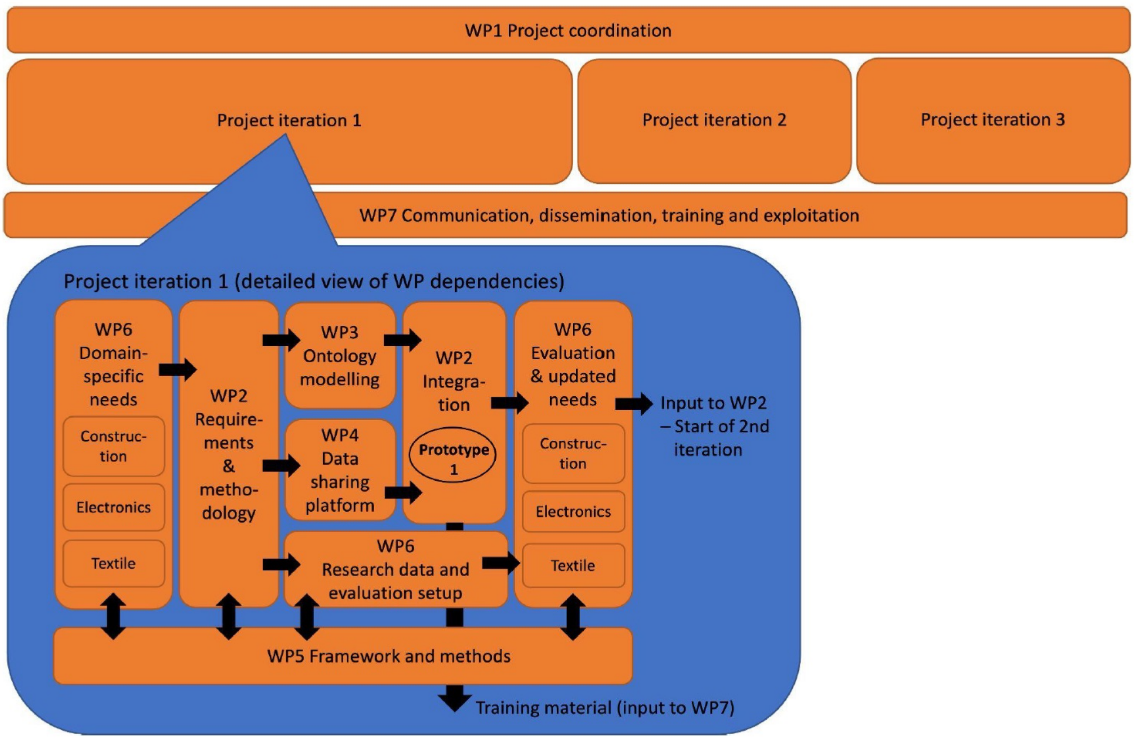
1 Introduction

The Onto-DESIDE project applies an iterative methodology, inspired by the cycles of action research, where research and innovation are driven by industry needs identified in a set of industry use cases, and solutions become more mature with each iteration. Three project use cases, representing three distinct industry sectors (construction industry, electronics and appliances, and textile industry), will contribute to identify the needs and technical requirements of the Open Circularity Platform, but also act as test beds and evaluation scenarios for the novel solutions produced.

In this way, the project aims to show that results produced are concrete enough to solve specific problems, i.e. in three specific use case domains, but also that the Open Circularity Platform has potential to be widely applied, thus constituting a cross-industry solution for ontology-based data documentation that works together with other value network flows, as well as being connected to several European initiatives, such as the Industry Commons and its Onto Commons project, the EOSC and European Data Spaces.

The project consists of three iterations, where each Work Package (WP) contributes to all the iterations. WP dependencies are illustrated in Figure 1 through detailing the first project iteration. The duration of the first project iteration is Month(M) 1-18, while the second and third iterations are shorter, encompassing M19-27 and M28-36 respectively. Each iteration ends with collection of feedback from the industry use cases, which is analysed and reported in a WP6 deliverable (i.e., evaluation report).

Figure 1- Project outline and detailed dependencies between work packages exemplified by the first iteration



1.1 Objectives and research methodology

1.1.1 Objectives

As mentioned previously, the industry use cases constitute a key part of the project, and will drive the technical development work, as well as validate the platform functionalities. In that way, the Work Package 6 aims to demonstrate the potential of the Open Circularity Platform with its semantic interoperability solution, i.e., ontology-based data documentation, for facilitating circular economy loops across industry domains. For that purpose, all three use cases (each a task of WP6) will:

1. **Define the business needs and requirements** from the specific perspective of their industry domain, which are generalized and integrated in **Work Package 2**.
2. **Provide research data**, both for technical development as well as validation and evaluation of results.
3. **Apply the tools from Work Package 5** (i.e., Circularity Compass and the Multi Flow Metabolism (MFM)) to map the business opportunities that are opened up through the ontology-based data documentation and related infrastructure, and to assess the potential gains in the life cycle of materials (e.g., reduced waste, reduction CO2, closing loops, etc.) including identifying incentives and quantifying the contribution of the ontologies.
4. **Perform evaluation experiments and provide feedback** of the intermediate releases of the ontology network and **open circularity platform developed in WP3 and WP4**, as well as validate and evaluate their final version.

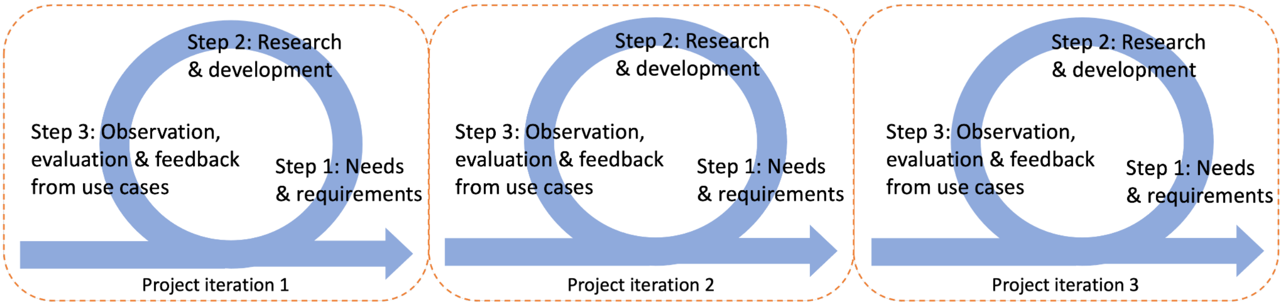
All three use cases will share the same technical infrastructure and method approach as how to apply and detail ontology artefacts. This is to ensure that the ontology building blocks that the project develops is industry-independent and usable across industry domains. Further, data will reside with the respective organization and will only be shared through the data-documentation vocabulary defined by the ontology, and by means of the secure and privacy-preserving data sharing platform. Each organization will add capabilities and data, i.e., specializing the semantic model, based on the type of business they are involved in.

1.1.2 Research methodology

The concrete research process will be divided into three iterations, each divided in 3 steps (cf. Figure 2):

- Step 1: a needs analysis and requirements elicitation
- Step 2: research and technical development, including solution integration into a coherent prototype
- Step 3: use case-based observation and evaluation, providing feedback as well as revised and extended needs to start off the next iteration.

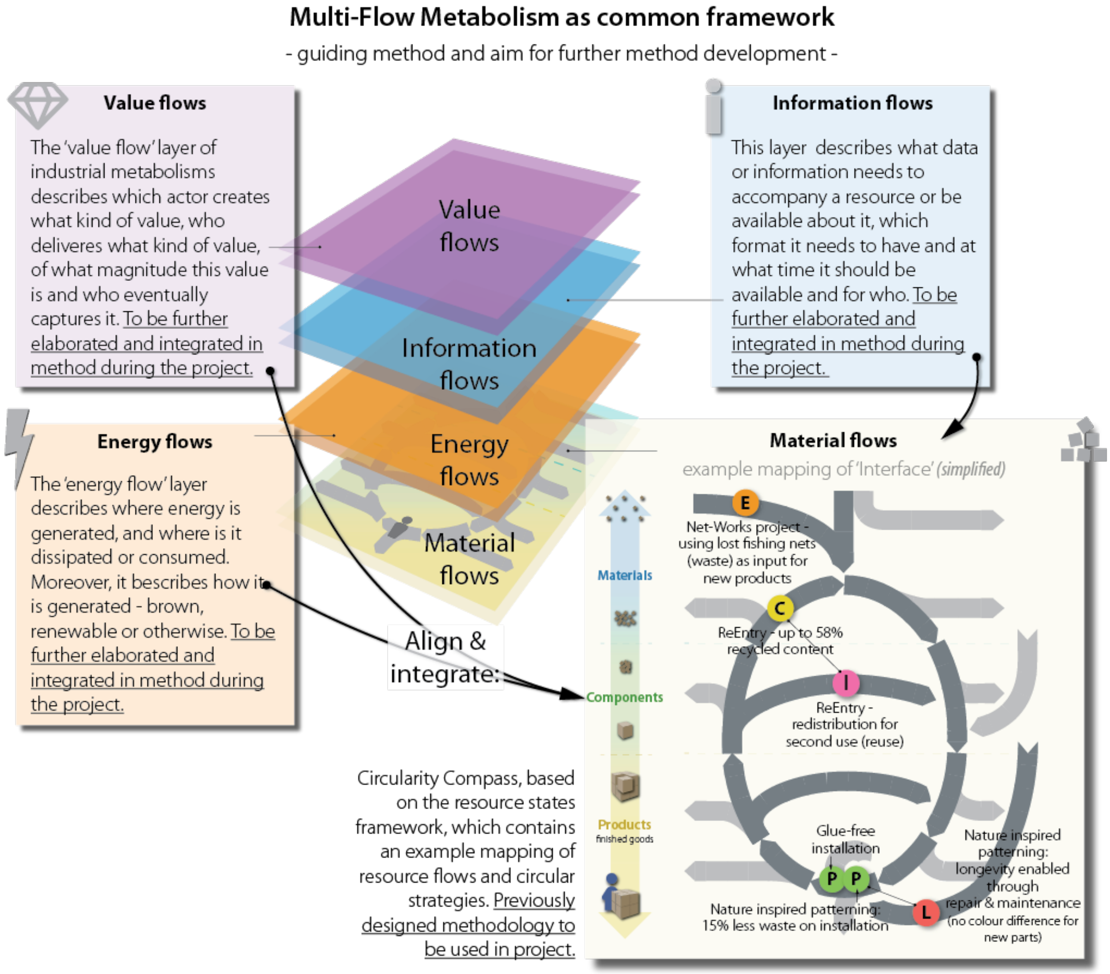
Figure 2 -The Onto-DESIDE research process, divided into 3 iterations, each consisting of three steps



For the steps 1 and 3, the existing tools and approaches of Circularity Thinking[4] (i.e., Circularity Compass and the Multi-Flow Metabolism (MFM)) are used as a common framework to align perceptions of current systems and explore possible new configurations of both resource flows and how different actors can collaborate in new ways (see Figure 3). In this sense, it offers a ready-made starting point for Onto-DESIDE use cases, both when mapping the details of each use case at the start of the project, analysing the industry needs and technical requirements (c.f. step 1 of each iteration), as well as a frame of reference when evaluating and assessing the potential contribution of the novel solutions developed in the project (c.f. step 3 in each iteration).

[4] Circularity Thinking is an approach that enables innovators to identify circular economy related opportunities, to explore possibilities and develop them into robust solutions, and to outline next steps. It consists of a suite of tools that have been developed based on scientific research and experience with businesses. For more details, see the article Blomsma, F., Tennant, M., 2020. Circular economy: Preserving materials or products? Introducing the Resource States framework. Resour. Conserv. Recycl. 156, 104698. https://doi.org/10.1016/j.resconrec.2020.104698

Figure 3 - Circularity Compass (bottom layer) and the Multi-Flow Metabolism as a common framework for analysing the use cases



Circularity Thinking – an approach for circular oriented innovation

Circularity Thinking is a method that enables identifying circular economy related opportunities, to explore possibilities and develop them into robust solutions, and to outline next steps. Circularity Thinking draws on the experience of many businesses, as well as concepts of systems thinking, life cycle thinking, resource management, design, collaboration, and value creation. Waste – in all its different forms – is the starting point and source of value creation in this approach. At the time of writing, Circularity Thinking is used across Europe and a certification scheme allowing users to demonstrate their knowledge of this approach is under development at EIT Climate KIC (outside of this current project).

Circularity Thinking structures the analysis of circular economy complexities by 'following the flows,' finding the value for both companies and other actors by uncovering what waste is currently in the system, and by making sure that one is asking the right questions regarding scale, complexity, people, competences and technology.

Starting point of Circularity Thinking

The starting point for Circularity Thinking is to regard CE as an 'umbrella concept.' This means seeing CE as an approach that focuses on how different types of value can be created, through implementing a variety of circular strategies. This way of viewing means recognising that there is not one interpretation of CE that is 'right,' or that others are 'wrong,' rather that there are more or less appropriate circular strategies - depending on the context. For example: neither recycling nor reuse are assumed to be preferable *a priori* – rather it is the circumstances that determine which is best, or whether both have a role to play. To be able to critically assess what are appropriate circular strategies, it helps to understand how resources currently flow, and what waste – in all its different forms – are present. This allows for tying together many waste and resource management practices in strategic efforts for organisations as it is this waste that is a potential source of value. Viewing CE in this way gives those pursuing CE driven innovation the freedom to determine how they can (further) contribute to greater circularity, whilst imparting innovators with the responsibility to find solutions that truly address structural waste – so that solutions are not merely 'circular for circularity's sake', but truly tackle excessive and wasteful resource use.

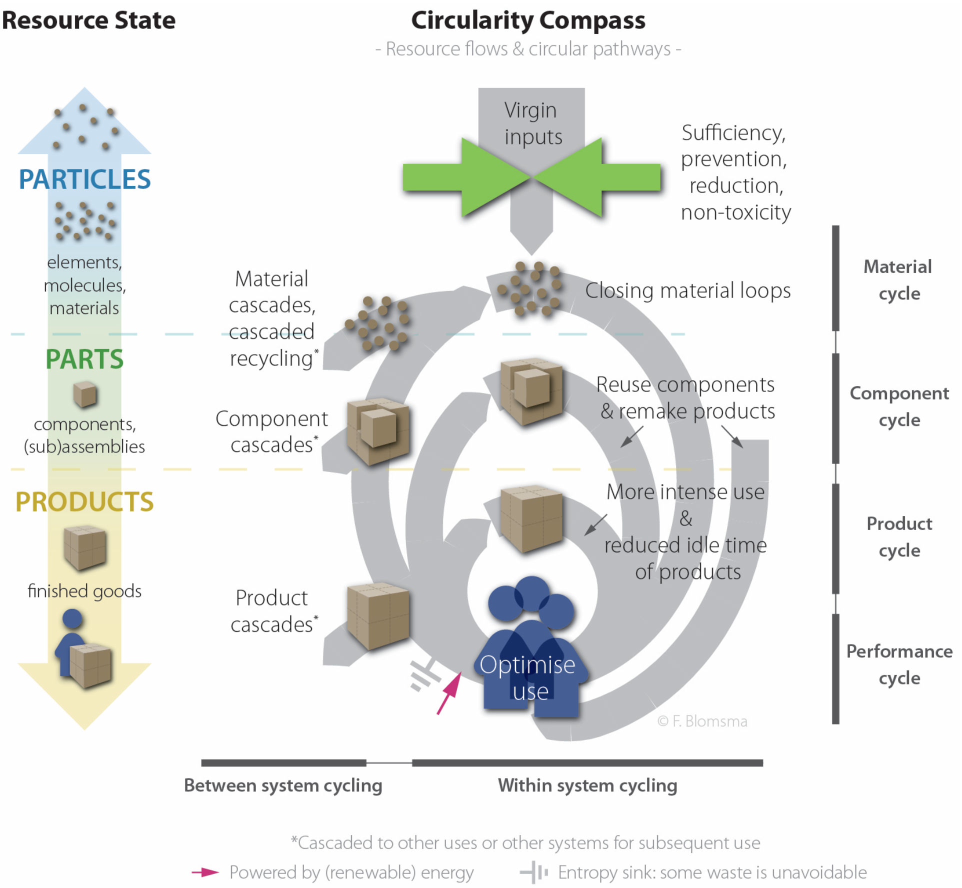
Circularity Thinking tool #01 - Circularity Compass

Circularity Thinking, see figure below, consists of a number of frameworks or tools, with which system mappings can be made to aid the analysis. The first of these tools is the Circularity Compass. The Circularity Compass, or simply Compass for short, can be used to understand resource flows. It consists of a visual template based on life cycle thinking that depicts common industrial processes, covering the beginning-of-life stages (sourcing, creation of bulk materials, creation of parts and subassemblies, finished products and distribution and retail), the middle-of-life stage (use phase), as well as the end-of-life stages (collection and reverse logistics, operations that extend existing life cycles and that enable new life cycles for products and components, as well as end-of-life strategies for materials). Arrows indicate the direction of movement of the flows, much like in a Sankey diagram.

On this industrial life cycle the Compass superimposes three 'layers' that indicate the form a resource takes along its journey through the economy. These three layers are termed *resource states*, and the three most relevant states from a CE perspective are: particles, parts and products. The particles state indicates a phase where one would speak of resources in terms of elements, molecules, substances, or (bulk) materials. The operations in this state are primarily aimed at concentrating particles, purifying them and making them suitable for subsequent use. Think of, for example, the mining, smelting and manufacture of aluminium ingots and sheets. Next, particles are given an intermediary form in the parts state. This is where parts or components, intermediates, (sub)assemblies, or modules are created. In the example of aluminium, this would be when it is used to create the various parts of a car, such as the chassis and the doors and other parts are added to it to create sub-assemblies. Lastly, parts are assembled to form finished goods that end users can extract value and utility from in the products state. This is when the complete car is assembled from the parts and sub-assemblies, it is sold or in some other way made accessible to the end-user. The resource state indicator on the left-hand side of the framework shows how the resource states relate to industrial processes.

This forward part of the industrial life-cycle can already contain several industrial cycling processes, such as pre-consumer recycling and rework for products that do not meet specifications. The remainder of the circular options are depicted as end-of-use and end-of-life processes: e.g. ‘as-is’ cycling or redistribution, operations such as refurbishment and remanufacturing that require (partial) disassembly, and material processing in the form of recycling. Note that these options are ‘within-system’ cycling, and that ‘between-system’ cycling can also take place when resources are cycled in a separate but connected system, such as through materials, component or product cascades or alternate use.

Figure 4 - Circularity Compass, providing an overview of the main cycling categories. From: Blomsma and Brennan (2022).



Circularity Thinking tool #02 - Big Five Structural Wastes

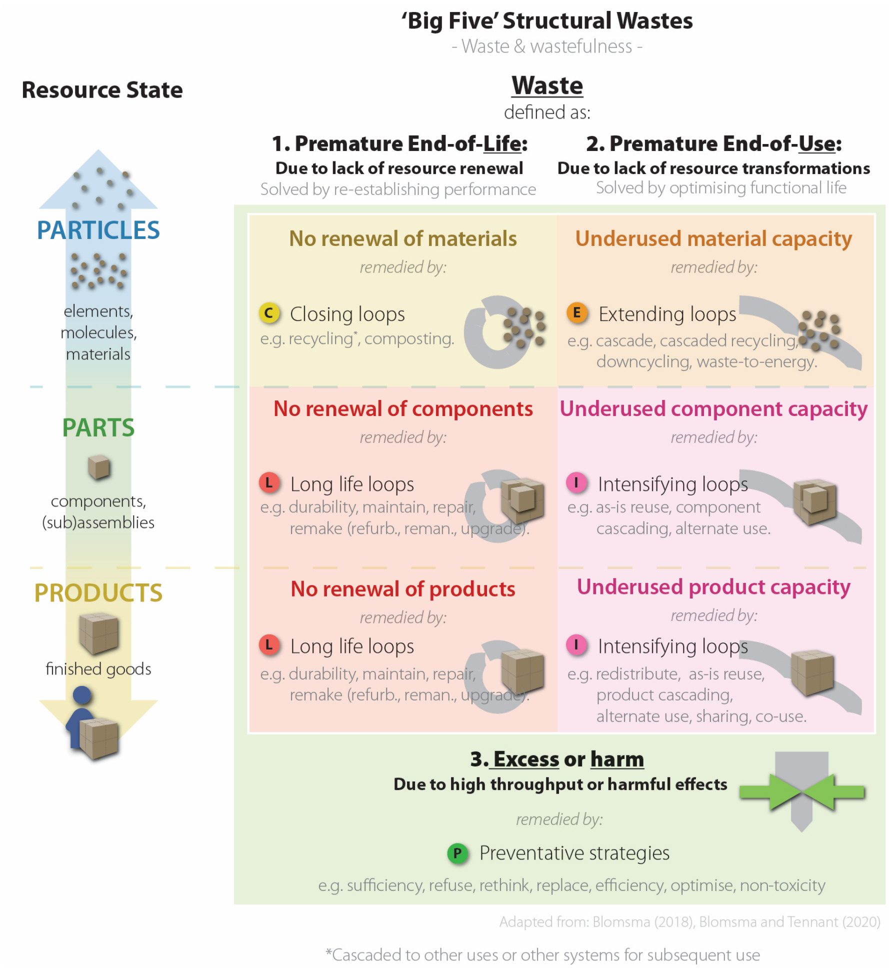
Thinking in terms of ‘flows’, with help of the Compass, allows for thinking about the larger system and in exploring what possible solution spaces are available – as sometimes solutions are unlocked by looking elsewhere in the system. However, as some types of waste are easier to identify than others, it is also essential to be able to examine where waste may be present in a more structured manner. This is what the ‘Big Five’ Structural Wastes allows: finding waste, wherever it may be present, in whatever form it is present.

Generally, it is agreed that waste is the loss and destruction of value - but this doesn’t really help us distinguish between different waste types. Some forms of waste are clearly visible and identifiable, such as the materials in a bin or a product with a clearly visible breakage.

In contrast, other forms are inconspicuous, invisible and more difficult to point to. Think of products that are unused for a significant part of their life or products that are designed to fail after a certain amount of uses without outward signs or a clearly visible reason. Such situations lead to more resources being needed and a higher level of material throughput than would strictly be necessary to fulfil human needs - and they can therefore also be seen as 'wasteful.'

So what, exactly, do we mean by the loss and destruction of value and how this can be avoided? Preventing waste from being created usually means to 'preserve' or 'continue' something. There are three principal ways in which this can be achieved: 1) addressing premature end-of-life through re-establishing performance, 2) addressing premature end-of-use through optimising functional life, and 3) addressing excess or harm through prevention[5], see Figure below for how this applies to the three resource states, and which circular strategies can be used to address the waste.

Figure 5 - Example mapping of problem situation (identifying structural wastes) and a proposed solution (identifying circular strategies solving the earlier identified problems, offering opportunities for value creation).



5 Blomsma, F. (2018). Collective 'action recipes' in a circular economy – on waste and resource management frameworks and their role in collective change. *Journal of Cleaner Production*, *199*, 969–982. https://doi.org/10.1016/j.jclepro.2018.07.145

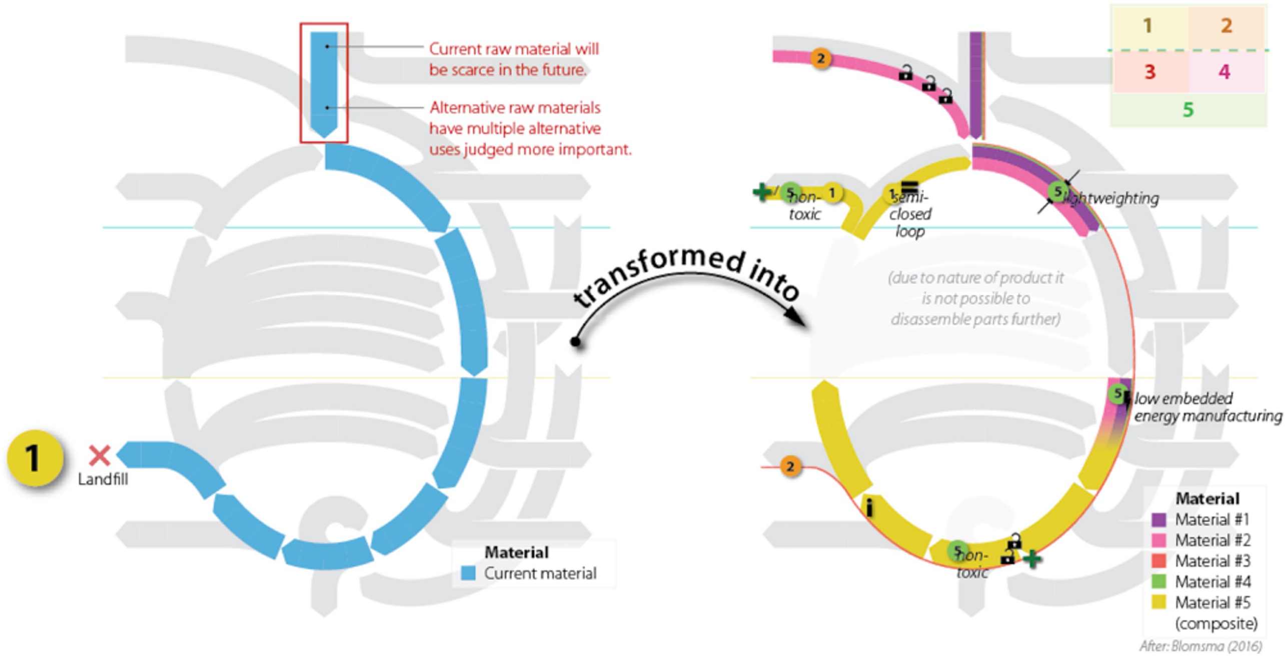
Blomsma, F., & Tennant, M. (2020). Circular economy: Preserving materials or products? introducing the Resource States Framework. *Resources, Conservation and Recycling*, *156*, 104698. https://doi.org/10.1016/j.resconrec.2020.104698

Exemplary Use of Circularity Thinking for Analysis

The figure below gives an example of a (simplified) mapping using both the Compass and Big Five to describe first, the problem situation (left) and second, the proposed solution (right). The problem situation shows the main issue: resources end up in landfill because they are difficult to recycle. Once in landfill, they are lost for subsequent use, take up space and potentially contribute to pollution. Additional issues are listed also, such as expected scarcity of the material in the future and there being more important uses for currently commonly used alternative raw materials. In other words: this analysis raises the question of why a recyclable material isn't being used which is made from more abundant alternatives and for which such competing uses don't exist.

Therefore, as the proposed solution, a different waste material is being chosen as an input here – that is a by-product from the mining industry which is also recyclable (Material #2 and #5 in figure below). This, together with a number of favourable material properties, such as non-toxicity, lightweight and no off-gassing during the use phase makes this a competitive alternative.

Figure 6 - Example mappings cases using the Circularity Compass: the left side contains an analysis of the main wastes and additional supply chain issues, where the right shows the proposed solution. See for key of coloured numbers - e.g. the 'Big Five' Structural Wastes – the previous figure.



Circularity Thinking in Onto-DESIDE

A similar (more extensive) analysis as described in the previous section, reaching increasing depth and detail in the project iterations, is proposed within Onto-DESIDE. In this first project iteration, the focus lies on the problem situation. That is: the goal is to understand structural waste in the use cases, understand supply chain problems and difficulties, and to capture and describe barriers currently standing in the way of capturing value through circular strategies.

To support this phase of the project, the following materials were made available to those involve in this task, to learn about Circularity Thinking and the tools:

- **Overview video here**: LINK to short video on Circularity Thinking (13min)
- **Documents containing explanation (in folder or as link):**
  - **Resources, waste and a systemic approach to CE -** *Blomsma and Brennan*
  - **Making sense of circular economy - understanding the progression from idea to action -***Blomsma, Tennant and Ozaki*
- **Explanation videos**
  - **Videos**: 3 videos from updated lecture series by Prof Dr Fenna Blomsma on Circularity Thinking:
    - 24 mins - The first explains about Resource States and the Circularity Compass.
    - 25 mins - The second covers Big Five Structural Wastes.
    - 31 mins - The third covers examples of how to use these concepts to understand circular configurations (incl. short company videos).

A Miro workspace was set-up for each use case. Further background materials were also made available. In addition to this, during the first face-to-face meeting in Sweden a presentation was given by Prof Dr Fenna Blomsma to provide an overview of this approach, also on-boarding those who didn't study the material yet, or who are not (yet) directly involved in the use case mappings.

Circularity Thinking tool #03 -Multi-Flow Metabolism

We also know, from previous research[6], that in circular economy-oriented innovation additional flows besides the material flows play a role. That is: the industrial metabolism - the 'flows' that make up the lifeblood of systems such as economies - can be seen as consisting of resource- (e.g. physical), energy-, information- and value-flows. When large-scale metabolism changes happen, these 4 flows - together with the accompanying infrastructure and technology - change in an integrated manner to allow for new flow patterns to emerge. Within CE the relevance of these flows is also acknowledged: see, for value flows, for example, work by Bocken et al.[7] or Pieroni et al.[8]; for information flows see

6 Blomsma, F., Tennant, M., & Ozaki, R. (2022). Making sense of circular economy: Understanding the progression from idea to action. *Business Strategy and the Environment*. https://doi.org/10.1002/bse.3107

7 Bocken, N. M., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, *33*(5), 308–320. https://doi.org/10.1080/21681015.2016.1172124

8 Pieroni, M. P. P., McAloone, T. C., & Pigosso, D. C. A. (2019). Business Model Innovation for Circular Economy and Sustainability: A review of approaches. *Journal of Cleaner Production*, *215*, 198–216. https://doi.org/10.1016/j.jclepro.2019.01.036

the work by Kristoffersen and colleagues[9], the call for a European Dataspace for Smart Circular Applications; and see for energy flows the work by Allwood and colleagues[10], Cullen or Bakker and colleagues[11].

So far, in CE, these 4 flows are studied with either an exclusive focus on one flow, or as a set, usually in relation to resources. However, Blomsma and colleagues [12] have recently shown that considerations regarding these 4 flows feature prominently and together in circular oriented innovation: they are usually designed together. For this reason, the Multi-Flow Metabolism (MFM) model was proposed to bring together these 4 flows. However, at present, little guidance exists as to what a robust circular metabolism looks like – and how these flows can be made into a coherent whole.

As a first step towards this, in this first iteration of WP6 – subtask D6.01 – the Compass is used to specifically identify and map current information flows and analyse where and how this enables or blocks circular flows in the future. In other words: it is a step towards identifying the information needs and with that for the ontology to be designed in Onto-DESIDE. This then also forms an important foundation for WP05 that further conceptualises, develops, validates and implements tools and approaches that transform the Multi-Flow Metabolism (MFM) model into a method for the accelerated development of systemic circular solutions by collating, expanding and validating relevant factors and value network dynamics for robust circular value chains.

Each of the organizations involved in the use cases is part of detailing the circular value networks, and related 'flows' according to the MFM. In particular, the actors within the use case analyse and enact a value network, specifically targeting the information flow, that was not feasible without data documented and shared through the ontology network defined in this project (by WP3 and WP4). The Open Circularity Platform should facilitate the digitalization and the automation of data exchange as far as possible at all interface points in the value chain, requiring minimal manual intervention. Making use of previously non-shared as well as open data, the capabilities of the ontology network and Open Circularity Platform will be evaluated, and its potential impacts assessed (e.g., economic impact such as time reduction and added value and sustainability impacts such as reduction of CO_2, reduction of virgin materials use, etc.).

For the step 2, the technical development of the Open Circularity Platform including ontology-based data documentation (by WP3 and WP4) is performed in an agile approach. Based on the industry needs identified in the three use cases, a shared set of evolving technical requirements is iteratively built up (in WP2). It means that requirements are put in a backlog list and are prioritized for each

9 Kristoffersen, E., Blomsma, F., Mikalef, P., & Li, J. (2020). The Smart Circular Economy: A digital-enabled Circular Strategies Framework for manufacturing companies. *Journal of Business Research*, *120*, 241–261. https://doi.org/10.1016/j.jbusres.2020.07.044

10 Allwood, J. M., Ashby, M. F., Gutowski, T. G., & Worrell, E. (2011). Material efficiency: A white paper. *Resources, Conservation and Recycling*, *55*(3), 362–381. https://doi.org/10.1016/j.resconrec.2010.11.002

11 Bakker, C., Wang, F., Huisman, J., & den Hollander, M. (2014). Products that go round: Exploring product life extension through design. *Journal of Cleaner Production*, *69*, 10–16. https://doi.org/10.1016/j.jclepro.2014.01.028

12 Blomsma, F., Tennant, M., & Ozaki, R. (2022). Making sense of circular economy: Understanding the progression from idea to action. *Business Strategy and the Environment*. https://doi.org/10.1002/bse.3107

iteration. Solutions are then built incrementally, i.e. extended and matured in each iteration, as well as evaluated in the three use cases. For the first iteration, a set of initial requirements will be selected and agreed upon in WP2.

1.2 Tasks and deliverables

The WP6, led by CIRC, is divided into 3 tasks corresponding to the three industry use cases as outlined below:

- **T6.1 - Construction industry use case** - lead: CON – participants: UHAM, LIND, RS
- **T6.2 - Electronics and appliances use case** - lead: CIRC, participants: UHAM, REIA
- **T6.3 - Textile industry use case** - lead: POS, participants: UHAM, FAS, TEX

Three deliverables are being produced in WP6 during the project:

- **D6.1 Use case needs analysis and circular value flow mapping** (v1 M3, v2 M18, v3 M27) – report
- **D6.2 Research data** (v1 M12, v2 M24, v3 M33) - data (project internal)
- **D6.3 Evaluation report** (v1 M18, v2 M27, v3 M36) – report

The present document is the report for D6.1 version 1. It provides a description of the industrial needs from the perspective of each use case and a mapping of circular business opportunities and challenges in each use case. The D6.1 is divided into three major parts. D6.1 will be used as a "living document" throughout the project. A revised version will be issued at M18 and at M27 to reflect new and changed needs identified after first and second prototype evaluation.

- V1: use case and technology introduction (inventory on how the three providers collect and manage data), methodology definition, first flow model (in drawing), M4
- V2: use case and technology description, and industry needs assessment, M18
- V3: detailed flow model and analysis, M27

2 Construction Use Case

2.1 Objectives of the use case

As described above, the objectives of the use case are to define the business needs and requirements from the perspective of the construction industry. The research data for this use case will be provided by the different partners in the construction use case team. Furthermore we will map out the business opportunities for raised floors using the tools from Work Package 5 (i.e., Circularity Compass and the Multi Flow Metabolism (MFM)).

2.2 Introduction to the construction industry

Of all the industries that require sustainable transformation to help us succeed in achieving the UN's Sustainable Development Goals, the construction sector is perhaps the most influential. Construction alone contributes to 23% of air pollution, 50% of climate change, 40% of drinking water pollution, 50% of landfill waste, and 40% of worldwide energy usage. Accounting for nearly 50% of annual global CO2 emissions, the built environment poses an existential threat to our planet.

The main reason is the "take-make-waste" model of construction materials. They are produced, put in a building and then - after sometimes just 5-6 years - are disposed.

While decision-makers and industry leaders are eager to adopt new technologies to address these problems, the development of necessary solutions is still emerging and sustainability isn't integrated into the beginning stages of the construction process.

A promising scenario could be to empower all professional actors in the construction industry with the tools and resources they need to succeed in circular construction practices. The most measurable and achievable way to do this is by leveraging the data we have to help guide decisions towards a closed-loop "take-make-reuse" mentality.

In the construction industry use case the objective is to design a circular value network for reuse based on semantically linked data that makes it possible to reuse construction components from a building. The use case will account for the following two scenarios in supplying components back to the manufacturer; the construction component is (1) reusable in its whole, or (2) as secondary raw-materials.

2.3 Partners and Contributors

Three organizations will be part of completing this use case;

- Lindner Group (https://www.lindner-group.com/), who is the producer of inner ceilings and floors.
- Restado & Concular (https://restado.de/, https://concular.de/), who assess material values in buildings and make secondary construction components and material available for reuse.
- Rang-Sells (https://www.ragnsells.com/), who collects and treats waste streams to turn waste into valuable raw materials.

These organizations will provide data, information and knowledge in the following domains; supply chains, product information, capabilities in collection/deconstruction, treatment and transportation of waste streams and materials.

For this use case one product from Lindner Group was selected and used as the object from which to elicit ontology requirements and apply the Circularity Thinking framework and the Circularity Compass to identify, among other things, the information needs. Rang-Sells will establish with Concular a take-back system and outline ways to integrate that system into a new building, using the ontology-based data documentation.

2.4 Workplan - Methodology for determining the user story

In a first step a non-exhaustive list of actors and partners in the construction industry was established. These are professional companies and institutions that impact and shape the construction industry. Accordingly we looked at the information these actors can provide on and/or need from a product.

Actors that can be distinguished and their possible needs defined

- Raw material supplier
- Recycling material supplier
- Building waste Disposer
- Manufacturer
- Planer
- Legislator
- Building Owner
- Building User
- Dismantling Company
- Refurbishment Company
- Recycling Company
- Permit Institution
- Reuse Market
- Etc.

In a shared information data system, one can expect the following information to be searched, needed, retrieved and provided:

- composant ID
- quality
- product ID
- composants
- production date
- take back program
- circularity possibilities
- policy on treatment
- state
- use span (installation date)
- dismantling costs
- reuse potential
- local availability
- costs
- recycling potential

- market value
- reuse potential
- Etc.

2.5 Use case description

The product we are studying in this user case is a raised floor manufactured by Lindner in 2022. The floor tiles are installed in an office building in Mannheim at the end of 2022. Ten years later the tenant moves out and the building owner decides to change the floor system. This means that the floor tiles will no longer be of use in the building.

Figure 7 - Nortec Application

2.6 User's motivation to search for information

The building owner now wants to make a decision on what to do with the raised floor based on economic and environmental costs. Economic aspects includes also the factor time. The building owner wants a clear overview in terms of the different and realistic scenarios, such as:

- Bringing the raised floor elements into a take back system by the manufacturer
- Selling the floor tiles for reuse
- Selling the floor tiles for recycling of their components
- Disposal of the raised floor elements
- Etc.

In order to enable the building owner to make a decision, it will be crucial to feed information into these scenarios, such as costs, time and environmental impact of the scenario.

2.6.1 User's needs for information

The building owner needs information concerning all different scenarios. This concerns both financial, practical and environmental data. This information can be provided by different actors in the construction industry, being: Manufacturer (take back system, information on components), Dismantling Company, Refurbishment Company, Recycler or Reuse Market:

- Take back system
  - Is there a take back system in place and how does it work?
  - Does the manufacturer dismantle the raised floor?
  - Does the manufacturer pick up the parts?
  - Who packs the material?
  - What are the costs and benefits of the take back system?
  - How much CO_2 and waste is saved through the take back system?
  - What does the manufacturer do with the collected material?
- Dismantling
  - What are the costs for a selective dismantling of the raised floor?
  - Which dismantling companies guarantee a professional dismantling?
  - How do I ensure that the tiles are not damaged by the chosen deconstruction company?
  - How do I include the dismantling in the tender?
  - How do I make sure that the deconstruction company has the skills for a selective dismantling?
- Demolition
  - What are the costs for a conventional demolition?
  - Will the material be sorted by the chosen demolition company according to the raw material of the components?
  - How is the waste treated after demolition by the chosen demolition company?
- Disposal
  - What are the costs for a disposal as mixed waste?
  - What does it cost to separate the components and dispose of them separately?
  - What happens to the waste after disposal?
- Refurbishment
  - What needs to be done to reuse the tiles?
  - What are the costs for repairing the tiles?
  - Are there adhesive residues? Do they need to be removed and if so, how?
  - Can the steel pedestals be saved and reused?

Figure 8 - Pedestals

- Recycling
  - What is the residual market value of the raw materials?
  - What are the costs for a selective deconstruction and separation of the raw materials?
  - What are the transportation costs to the next recycling facility?
- Reselling value
  - What is the pricing for similar reuse products?
  - What is the pricing for similar new products?
  - On which platform can this material be sold?
  - Does the seller need to give a warranty for the product?
  - Does the buyer pay for the dismantling and the transportation?
  - Does the manufacturer provide a potential buyers list?
- Request on market
  - Statistics on offer and demand for this product in the past 2 years
  - Shortage of raw materials
  - Shortage of skilled workers in the manufacturing industry
  - Delivery delays
  - Number of requests on online market places
  - Inside Information about new building projects

2.6.2 Product description

The specific raised floor product that we will use for this use case is Nortec by Lindner. Nortec floor panels are manufactured from calcium sulphate (gypsum): a non-combustible material with good structural and physical properties.

Technical Information

PANEL

fibre-reinforced calcium sulphate panel, with galvanised steel sheet at bottom side on request, optionally with surrounding edge trim protection against damage and humidity

PANEL THICKNESS

16 - 38.5 mm

DIMENSIONAL DEVIATION ACCORDING TO EN 12825

class 1

SYSTEM WEIGHT

32 - 62 kg/m²

STANDARD PEDESTAL HEIGHTS

25 - 2,000 mm

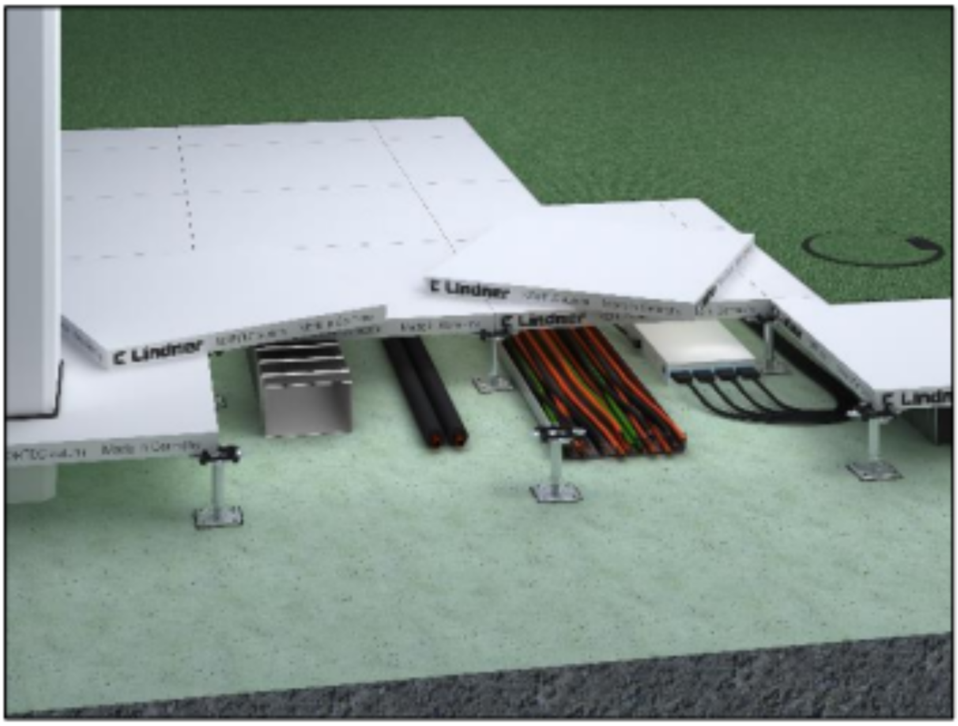
PEDESTAL GRID

600 x 600 mm

RESISTANCE TO EARTH

≥ 1 x 106 Ω (depending on covering)

Figure 9 - Demo case



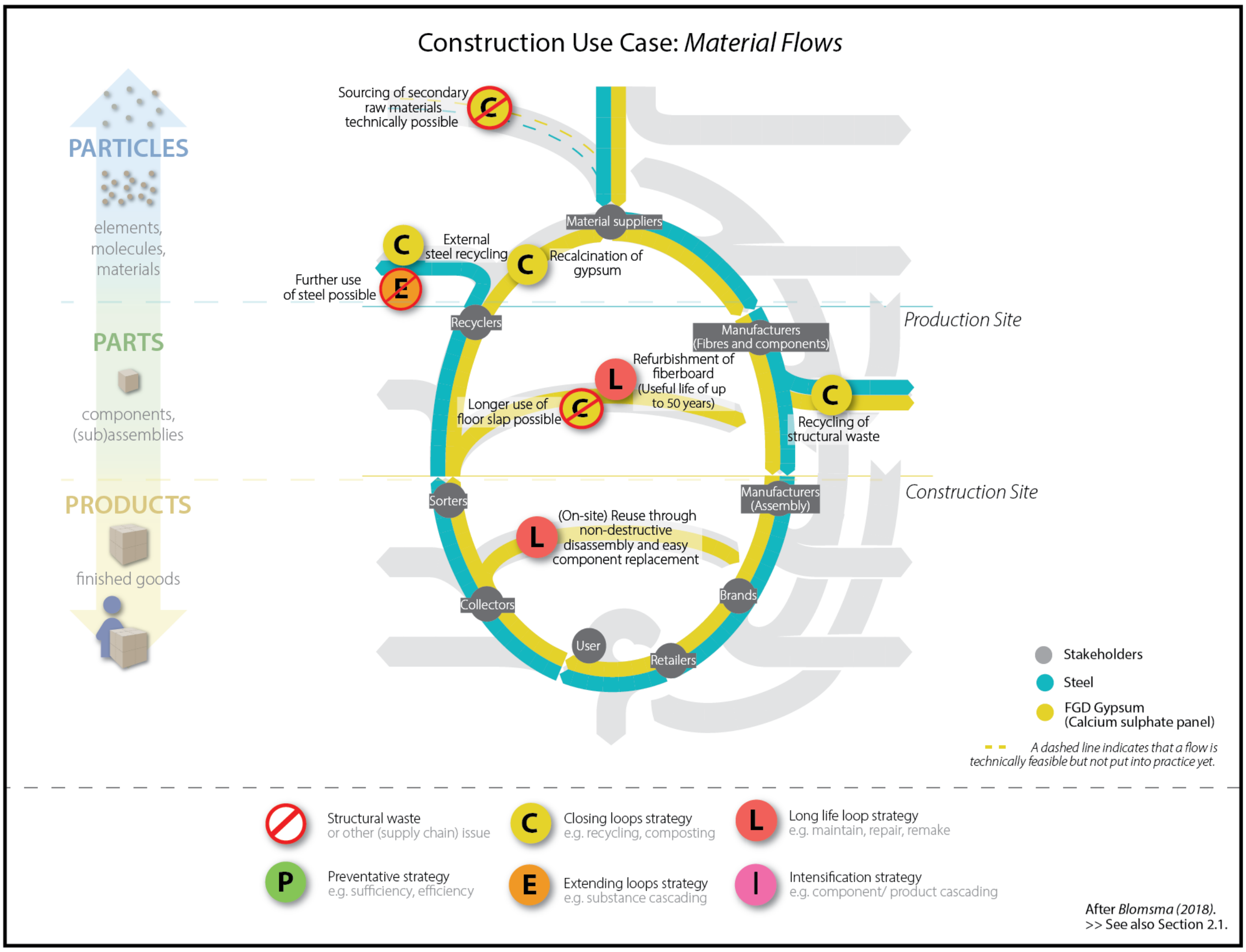
Material Health

The parts of the floor system have to be secure and not harmful for health and environment. Lindner develops raised floor systems which are environmentally friendly and also not harmful for the human being from the production up to the usage and reuse. The composition of the chemical components is known.Emission tests according to national and international standards (e. g. AgBB scheme) assure low-emission and harmless materials.

Material Recycling

The raised floor Nortec is a product with good reuse and recycling possibilities. A separation of all components is possible at the end of the usage phase. The carrier panel from calcium sulphate can be recycled to 100 % and be returned to the production cycle. The steel pedestals can also be recycled after conversions or demolition.

2.6.3 Material flows



Structural waste

With a water circulation concept, water consumption is systematically reduced. The necessary process water can circulate in the circuit due to sedimentation and cleaning of the solids. Waste that cannot be avoided during production is fed into recycling processes via specialist disposal companies. The NORTEC raised access floor has a material reuse value of 72.11, which is calculated from the proportion of recycled materials and the proportion of materials that can be recycled.

Reuse:

After redemption, the worn components will be replaced and the panel will be resold 100% technically complete as a NORTEC raised access floor panel. The components that may need to be replaced are the top application (all flooring variants), the statically effective steel sheet on the underside of the panel and the side edge band. If necessary, the edges and surfaces will be reformatted. The removal of the applications and the preparation of the surfaces can be carried out directly at the Lindner plant.

Through a single and non-destructive disassembly of the raised floor panels, the system can be easily reused. The reuse of the product can then take place in the same or in another building.

Further use:

Due to the functional longevity of the gypsum fiberboard, the product can be sold after the return 100% technically complete, as a floor panel.

Thanks to the leasing system and the worldwide take-back guarantee, further use of the access flooring is possible without any problems. The necessary reconditioning takes place in the company's own plant. The reconditioned panels are put back on the market as "ReUsed Products".

Increased service life:

The useful life of raised floors is up to 50 years (according to BBSR table, code no. 352.911, as of 02/2017, published by the Bauinstitut für Bau-, Stadt- und Raumforschung).

Multiple use:

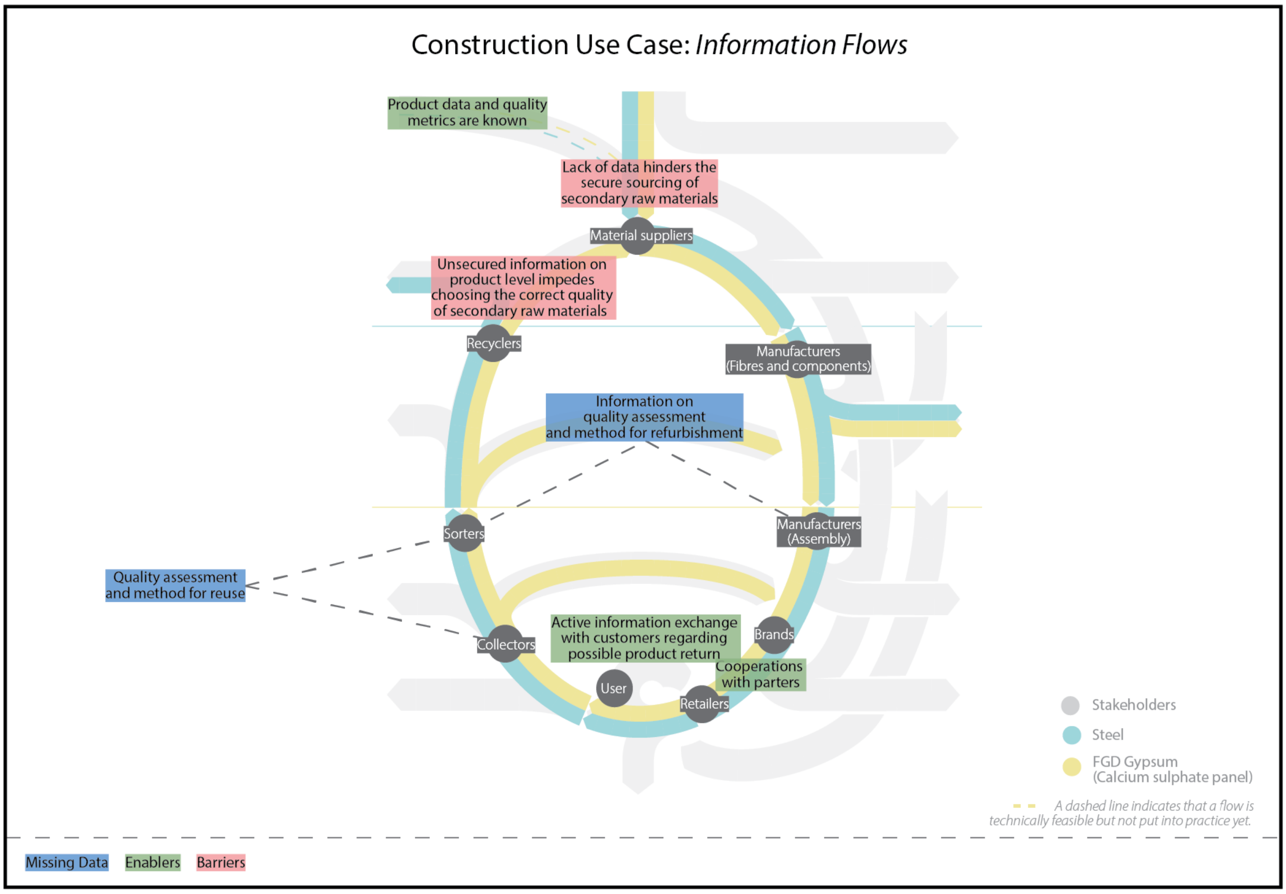
Through a single and non-destructive disassembly of the raised floor panels, the system can be easily reused. The reuse of the product can then take place in the same building or in another building.

Recycling:

If the gypsum fiberboard no longer meets the technical requirements after it has been taken back, it can be processed into a reactive raw material gypsum in the factory's own processing plant by means of recalcination. This serves as a starting material for the production of further gypsum fiberboards.

- Steel pedestals are fed into an external recycling process after removal from the building
- Soil application -> Waste or material recycling

2.6.4 Information flows



From Linder's perspective, all product data and quality metrics are known. On the other hand, Lindner does not have information on dismantled Nortec raised floor elements: where to find them, how many can be found, when we these elements be available? Therefore, procuring secondary raw materials in a secure way is hard due to lack of data on those materials. Access to more data, and at increased granularity, would increase the usage of those materials.

Additionally, an active exchange with customers regarding a possible return scheme of the product would further increase the reuse and also produce less waste. But creating such a scheme would require that the product could be identified with the correct quality metrics and that the required logistics could be arranged for it to be returned in a reusable state.

Information on product level are not registered throughout the lifecycle of the product which makes it hard to securely assess the quality and secure the correct handling of the product, either for reuse or to transform it into secondary raw materials.

2.7 Main challenges

The challenges in this use case will be the following:

- Many actors are involved which makes it complex to get a clear picture of what is the essential steps in the handling of the product and how these should be described and defined.

- How and who checks if the provided data is correct? For further modelling of the ontology, we need to take into account that real world actions need to be in place to validate what is used as input.
- How is the communication between the actors organised? To some degree there will be a agreeable consensus in what will later be defined in the ontology as a result of the use case, but at least initially, there will not be a complete flow and that will require more communication between actors to make up.
- Data security will need to be taken into account in every aspect of the work. As per design, we are aiming for the possibility to share sensitive product and process data at source.
    - Manufacturers might not want to provide information on the composition and manufacturing process of their building products to competitors.
    - Building owners might not want to make their demolition projects public.

3 Electronics And Electrical Appliance Use Case

3.1 Objectives of the use case

The electronic use case will demonstrate the implementation of the ontology-based supply chain communication technology in order to decentrally and confidentially connect many supply chain stakeholders and communicate material data along the supply chain. This approach is meant to fulfil several functions within the Onto-Deside project and specifically Work Package 6.

First and foremost, the developed ontology of the project is being tested and validated. This testing and validation process identifies whether 1) the ontology enables generalisation that is broad enough to function across three different sectors and 2) the ontology allows for the communication of material information without any mislabelling of materials that are not applicable to industry standards.

Furthermore the testing and validation identifies what concretisations are necessary for the specific sector and what industry standards and pre-existing data formats are to be taken into consideration and integrated. This entails for example proprietary classifications of data by big CRP system providers, the applicability of generic standards like CAS numbers, as well as the availability of different types of data around the product, production process and recycling process.

Furthermore, the electronics use case will demonstrate the combination of Circularise's supply chain communication technology and the developed ontology. In order for this assessment to take place, the ontology will be used to determine the data format on the Circularise system, which is then tested with real material data of components and the final product of a magnet containing speaker. This demonstration also specifically analyses the applicability of the ontology and the communication software for the electronics industry with the example of a selected group of suppliers to the demonstration product.

3.2 Partners and Contributors

3.2.1 Circularise

Circularise is a scale-up that enables value chain transparency without disclosure of material data or supply chain partners. The solution uses decentralised, encrypted data to track material and product characteristics, e.g. what chemical composition a product has and what sustainability characteristics it fulfils. The technology decreases auditing costs and scaled standards, certification schemes and transparency. This B2B software-as-a-service (SaaS) technology allows companies to adhere to government regulations and policies relating to the circular economy, sustainability and recovery and recycling of materials. The insights that can be shared and collated using the B2B SaaS can support companies to advance their circular economy innovation strategies and implementation.

Circularise's "Smart Questioning" technology enables companies to monetise data in 3 ways. Firstly, Circularise's technology provides real time monitoring of material flows through complex supply chains to better understanding the composition of the materials used and manufacturing impacts so that they can:

1. prove the source of materials used,
2. verify the materials are conflict or hazardous material free,

3. provide data on the content of their products and materials that can be recovered under Extended Producer Responsibility (ERP) regulations, and
4. prove the percentage of recovered or recoverable materials they are using.

As there is an increasing focus on providing “Life Cycle Assessment” (LCA) data, such as carbon emissions or water usage, companies are required to assess their supply chains beyond Tier 1 and 2 suppliers to include the full supply chain. Circularise’s technology allows companies to incorporate data from end to end of the supply chain to include and report on Scope 1,2 & 3 to aggregate the embodied energy of materials and products.

Finally, companies use Circularise’s technology to:

5. Drive growth by charging a premium for a digitalised version of their products,
6. Mitigate risks by identifying anomalies and risks before they become a problem,
7. Identify and reduce CO2 emissions within their supply chains
8. Perform Mass Balancing and Traceability operations
9. Reduce costs by using an automated system, which in turn removes the potential for fraud or human error, and
10. Drive collaborative innovation to implement new circular business models such as product lifetime extension, closed loop materials, or product take-back etc.

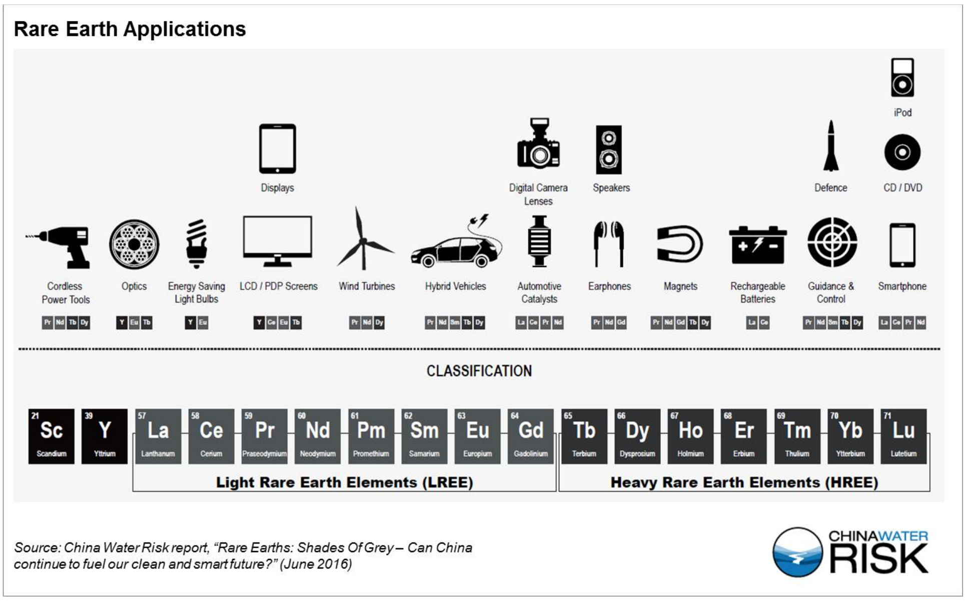
Currently, because many companies use manual auditing methods that lack visibility and real time data, the information they have is often insufficient and ineffective, flawed and sometimes corrupt, and doesn’t have real substance in driving change within a supply chain.
The pressure from NGOs, regulators and consumers mean more transparent data is becoming a necessity.

Circularise solves these problems by enabling clients to monitor and record in real time current material and product flows throughout their whole supply chain, enabling them to create a circular economy and reduce their environmental impact. Additionally, as substantial amounts of data are collected this means companies can monetise this to increase profits.

3.2.2 Rare Earths Industry Association (REIA)

REIA is a global association with a European foundation which aims to enable sustainable, responsible, collaborative and transparent Rare Earth Value chains, from mine to recycled sources. REIA provides a platform for stakeholder networks, conducts research and develops strategies, and supply chain standards. In the project, REIA will provide knowledge on the supply chain stakeholders and processes. Furthermore, it will further develop its own standard and engage stakeholders in the demonstration. REIA’s global network with 40 active and committed members on REE sustainability representing all spectrum of the value chain along with a large network of stakeholders from downstream. This large network will enable the consortium to commercialise the services and realize the project objective in a timely manner. REIA identified two stakeholders within the membership or professional network of REIA, who will inform the demonstration of the electronic use case on Circularise Technology. The stakeholders form part of the supply chain of a typical speaker system for end-users or as subcomponent for larger products like e.g. a car or a smart device.

Figure 10 - Overview of materials with rare earth materials



3.3 Workplan

The electronic use case demonstration entails preparatory steps of a) understanding the data needs of the industry in terms of material and supply chain data needed (e.g. chemical composition, Lifecycle inventory data, chain of custody etc.) as well as the data formats that are inherent to the sector. Afterwards the relevant adjustments are being made to the Circularise dashboard in order to reflect the industries and specific use case's needs. This assessment process also entails further research into the supply chain steps and circularity of the supply chain via the circularity compass model described in chapter 2. This mapping process of circular value flows identifies improvements towards circularity. The in-depth understanding of the challenges and opportunities of the electronics industry will be developed in cooperation with the Rare Earth industry association and its members.

The demonstration of the use case will entail the creation of a digital twin on the decentralised communication platform of Circularise employing the new semantic models designed in Work Package 2. This data-sharing demonstration will entail the involvement of several stakeholders of the electronics industry in order to determine great fit of the technical solution with the challenges of circularity in the industry. Several itineration between the demonstration and the ontology research in WP2 will result in a feedback and validation process for the ontology and respective improvements.

3.4 Use case description

The use case selected for the demonstration are speakers for typical smart devices sold on the B2C market. The demonstration entails typical components of speakers with a specific focus on the magnets and magnet materials used for the production of speakers.

A speaker typically contains the following materials:

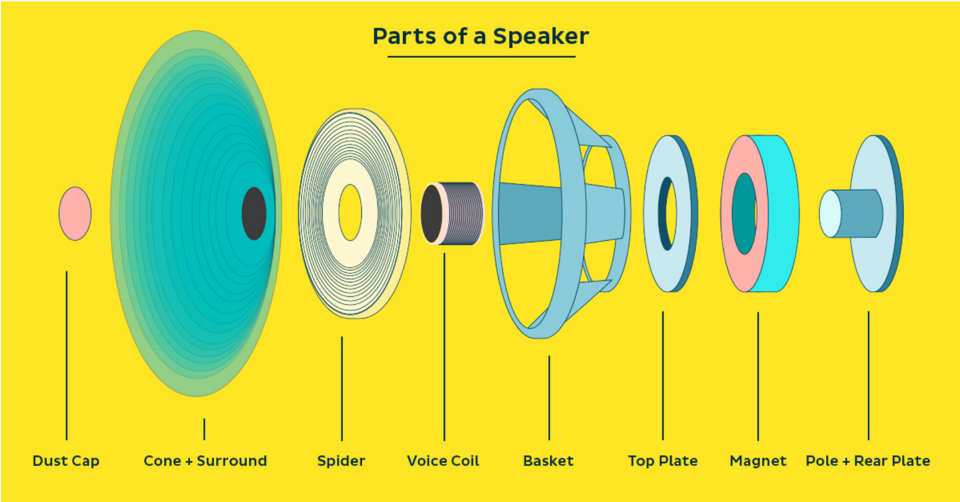
Speaker components:

- suspension

-basket

-spider
-voice coil
-dust cap
-diaphragm/ Cone + Surround
-magnet

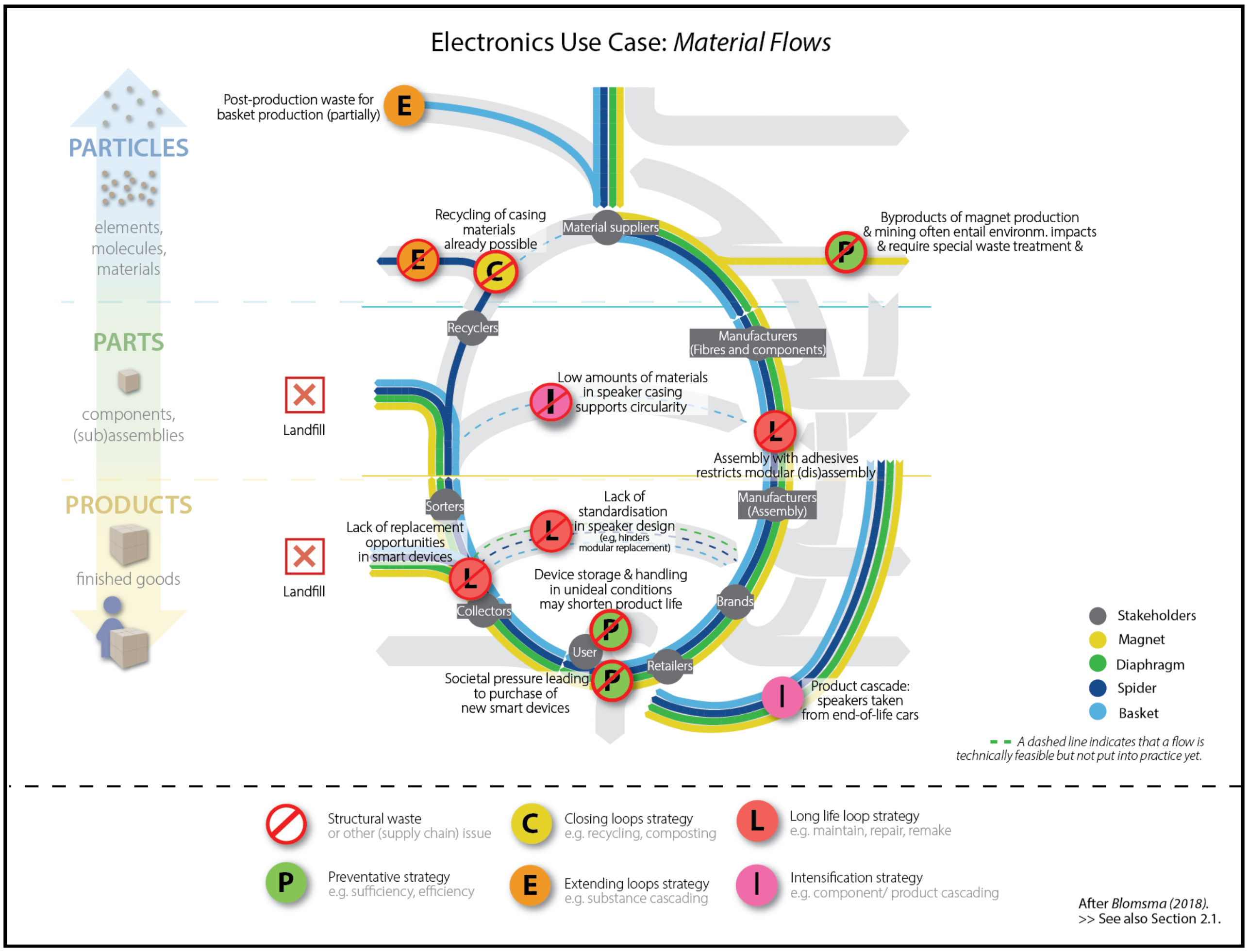
Figure 11 - Components of a typical speaker



The component which this product is specifically focusing on is the magnet. The latest developments especially in the renewable energy sector and its related energy storage systems has also reflected on the typical composition and production of magnets. The most common magnet components which the material flow analysis preceding the demonstration will focus on is as follows:

- Magnet components:
- NdFeB
-SmCo
-Ferrite
-AlNiCo

3.4.1 Material Flows

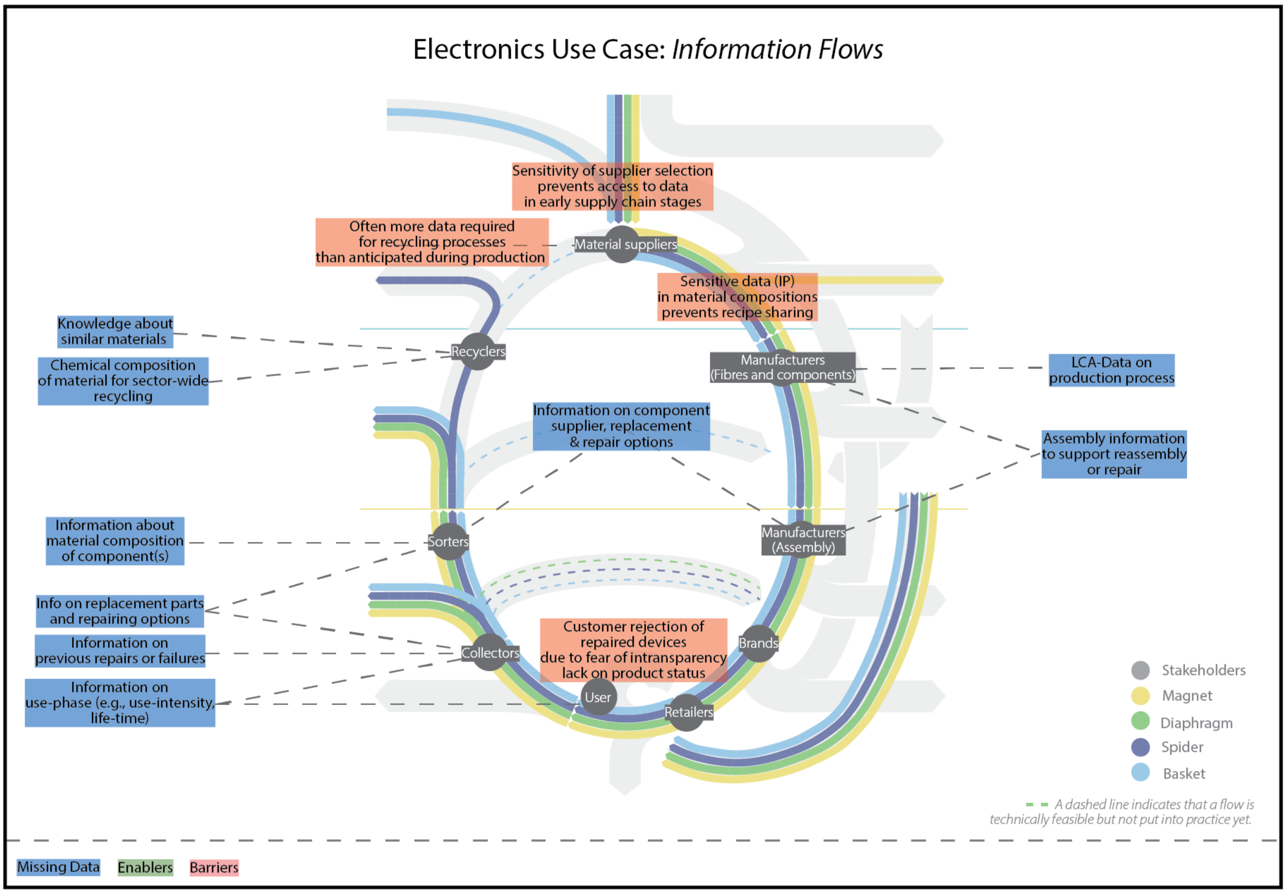


The material flows along the supply chain of the speakers are specifically interesting for the biggest components of the speakers, the basket, Diaphragm, Spider and Magnet. Most of the material used in the production process entails raw materials, with a small amount of post-production scrap material. The possibility to increase the share of this post-production or even post-costumer material flow increases with the use of certifications and traceability solutions that provide further information on the material content ensuring quality and the opportunity to use the sustainable practise as a marketing opportunity. Generally speaking, the material circularity within the supply chain on speakers varies a lot. The components with a simple composition and small amount of materials e.g. the spider and basket, containing mostly polymer-based materials are more easily reusable or recyclable. However the low material value requires regulatory adjustments or sustainability certification in order to increase in frequency.

The component with the highest material value is the magnet. The proprietary recipe of the magnet and the small amounts of rare earth materials decrease the possibility to recycle the material of the magnet. In newer product-designs involving small amounts of glue and aiming for eco-design the opportunities to repair or refurbish a speaker is higher. This is especially true in B2B business relationships, e.g. the equipment of cars with a standardised speaker system. The high volume of products and the rather centralised repair shops (usually contracted automotive partners) increases the feasibility and likelihood of extension of the lifecycle of the product. The shorter lifecycle of speakers in B2C sales, e.g., in smart devices or as components of other devices such as smartphones, decreases the opportunities for circularity not only due to the lack of individual repairing capacity, but also due to the cultural expectations of a frequent replacement of smart devices.

3.4.2 Information Flows

In order to assess the potential for circularity and the role of data towards this end, the information flow along the supply chain is being mapped and analysed.



The information flows along the supply chain of speakers and its components is characteristic for the general information flow along long supply chains containing different categories of materials (in this case metal-based, polymer-based and cellulose-based components). The re-use, repair, refurbishment and recycling process within the supply chain of speakers requires information about:

a) the status of the product (quality of product and material)

b) the material composition (chemical composition)

c) the chain of custody (which stakeholder held the material, components and product)

d) the sourcing composition and quality/ hazardous/ recycled/restricted substances

The information flow analysed for the example product shows missing information across all levels of circularity due to a) the ignorance of supply chain stakeholders on the type and detail of data required for circularity, and b) the sensitivity of data linked to material compositions and recipes involving intellectual property and customized production processes that involve sensitive data confirming suppliers unique selling point in the supply chain.

3.5 Main challenges

Table 1 - List of challenges related to data exchange throughout the electronics value chain

Nr.	Topic area	Challenge statement
1	Data security	Supplier selection and material recipes are sensitive data types which often form part of the intellectual property of a company. This is to be taken into account.
2	Standardisation of Data	A first analysis of the electronics industry has shown many different data formats including sector-specific databases on material classifications like e.g. the IMDB database detailing speaker materials used in the automotive sector with a classification numbers which is only used within the automotive sector
3	Transparency is an investment	The adoption of a supply chain-wide traceability system entails financial and time investments. In order to ensure such approaches are being taken up industry-wide, regulatory arrangements can be conducive and eliminate the problem first-movers would otherwise face.
4	Data availability and regulatory differences	Especially the electronics entailing rare earth elements are subject to intransparent upstream supply chains. This is often linked to the sourcing of materials outside the European Union and the different regulatory requirements especially for the materials with Chinese provenance.
5	Interoperability	One of the challenges in supply chain data communication is the harmonization of different data formats and communication systems or software.
6	Ownership	Companies are inclined to only store data on their own databases and to keep the ownership of data whenever possible. This points to the necessity of a peer-to-peer or decentralised solution.
7	Accountability	Material data is often collected by a centralised entity e.g. the original equipment manufacturer. This centralised accountability does however not reflect the fragmentation of data and its dispersion across the whole supply chain.

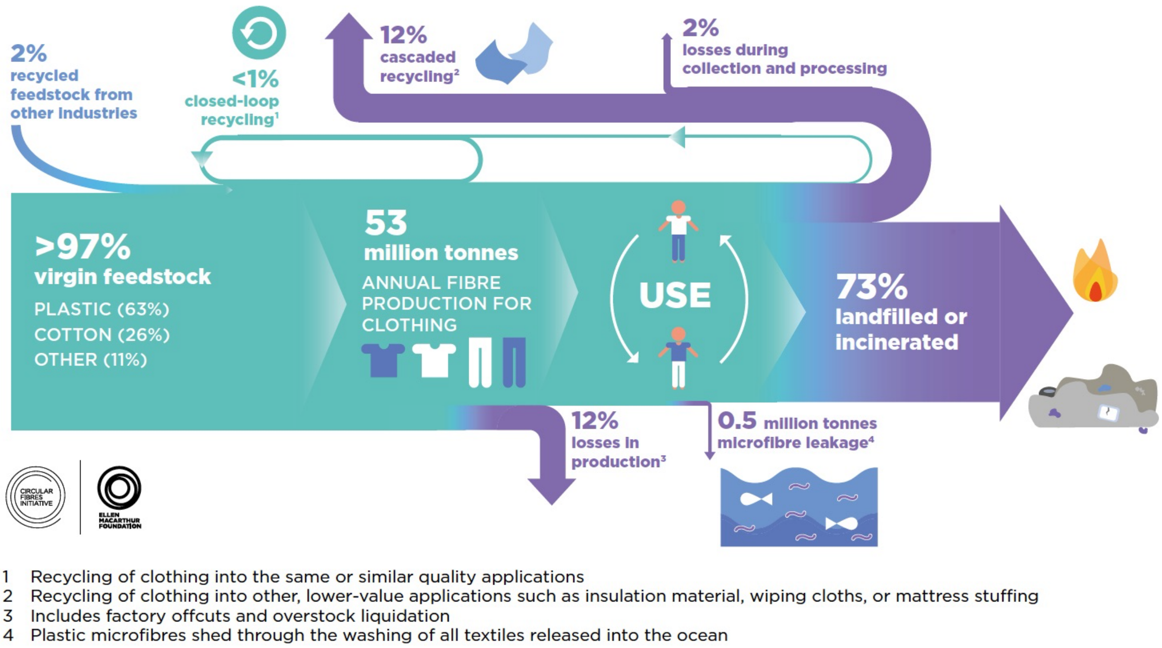
4 Textile Use Case

Textiles are fundamental to our society and used in everyone's daily lives, providing us with clothing, shoes, carpets, curtains, furniture, etc. for homes, offices, and buildings. However, according to the European Environment Agency (EEA), clothing, footwear and household textiles in EU are together the fourth highest pressure category for use of primary raw materials and water (after food, housing, and transport), the second highest for land use and the fifth highest for greenhouse gas emissions[13]. Furthermore, the complex and highly globalised textile value chain is also faced with social challenges like child labour, in part driven by pressures to minimize production costs to meet consumer demand for affordable products. Furthermore, textile production processes use a significant amount and variety of chemicals (about 3 500 substances), of which, 750 have been classified as hazardous for human health and 440 as hazardous for the environment. The release of microplastics from synthetic textiles and footwear adds to the environmental impacts of the sector. According to the EEA, half a million tonnes of synthetic fibres are released annually in the effluent of washing machines[13].

The negative impacts of the textile industry have their roots in the linear model characterised by low rates of use, reuse, repair, and fibre-to-fibre recycling of textiles, and that often does not put quality, durability, and recyclability as priorities for the design and manufacturing of products. For example, while EU consumers buy on average 26 kg of textiles per person per year, they discard about 11 kg of textiles per person per year[14]. Every second somewhere in the world, a truckload of textiles is landfilled or incinerated. Globally, less then 1% of textile fibres are recycled into new fibres, as illustrated in Figure 12. Finally, a recent screening of sustainability claims in the textile, garment and shoe sector suggested that 39% could be false or deceptive[15].

[13] EEA (2019) Textiles in Europe's circular economy. https://www.eea.europa.eu/publications/textiles-in-europes-circular-economy/textiles-in-europe-s-circular-economy
[14] EEA (2019) Textiles and the environment in a circular economy. https://www.eionet.europa.eu/etcs/etc-wmge/products/etc-wmge-reports/textiles-and-the-environment-in-a-circular-economy
[15] https://ec.europa.eu/info/live-work-travel-eu/consumer-rights-and-complaints/enforcement-consumer-protection/sweeps_en

Figure 12 - Global material flows for clothing in 2015. Source: Ellen MacArthur Foundation (2017) A New Textiles Economy: Redesigning fashion's future.



To achieve higher sustainability and circularity in the textile industry, traceability and transparency throughout the supply chain are essential according to the United Nations Economic Commission for Europe (UNECE). In that regard, in recent years, an increasing number of initiatives started to work on achieving better traceability and transparency, coming from a variety of organizations and with slightly different focus. Among some of the leading ones, one can name the UNECE initiative to improve Traceability for Sustainable Garment and Footwear[16], Trustrace[17], EonGroup's Circular ID protocol[18] and circularity.ID® Open Data Standard[19] developed by circular.fashion. Most of these initiatives developed Product Passports as a mechanism to capture and share relevant data across value chains. Some look at increasing the quality of textile recycling via smarter sorting solution, some at increasing product and material data transparency and others at increasing trust in the data collection from the supply chain. More recently, in line with the European Green Deal ambition, the EU Commission published the EU Strategy for Sustainable Textiles[20], which includes policy measures such as applying new sustainable product framework, eco-design requirements, empowering choices of sustainable textiles, providing incentives and support to textile circular business models. In particular, to achieve these objectives, the EU Commission will introduce a Digital Product Passport (DPP) as part of the measures under the new Ecodesign for Sustainable Products Regulation (whose requirements for textiles are not fully defined at the time of this report).

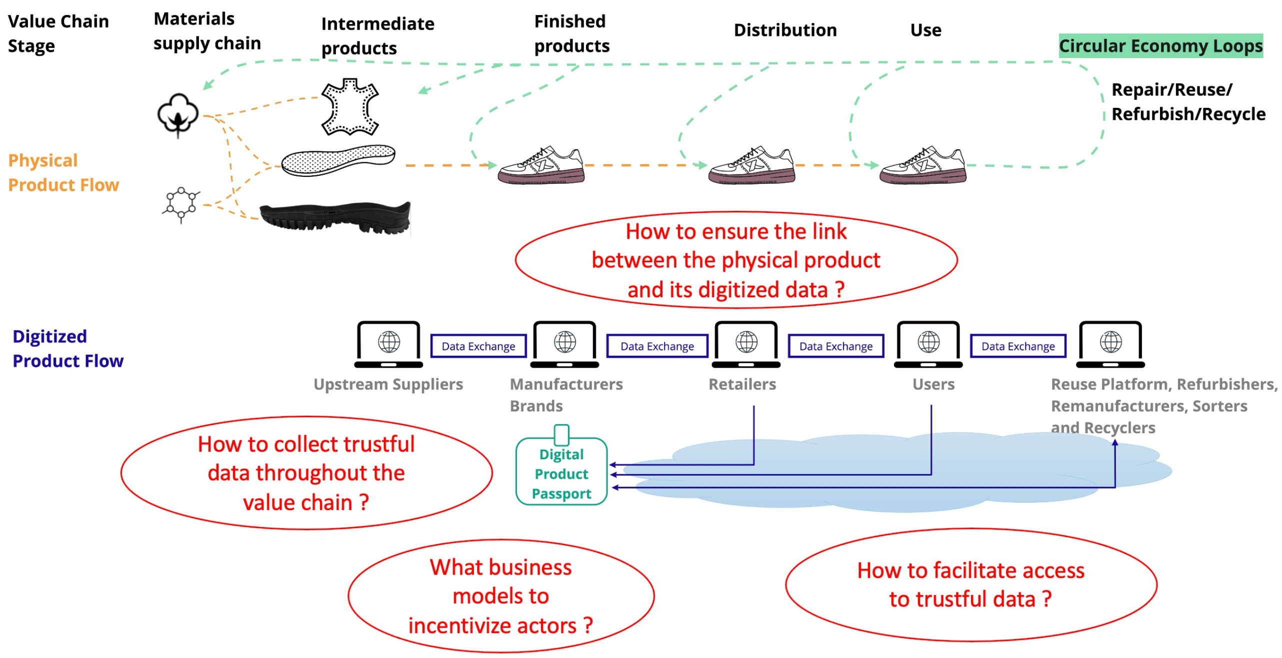
All these initiatives consume and produce data, which does not necessarily become available outside the immediate stakeholder context and in a format facilitating interoperability. In addition, they all are

[16] https://unece.org/trade/traceability-sustainable-garment-and-footwear
[17] https://trustrace.com
[18] https://www.eon.xyz
[19] https://circularity.id
[20] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12822-EU-strategy-for-sustainable-textiles_en

facing the challenge to access and collect trustful data from the supply chain, which currently requires a lot of too much human and financial resources. One the one hand, many companies have a limited view of the network of business partners within their value chain and do not get the full story behind their products. On the other hand, manufacturers are reluctant to share confidential information and are concerned with disclosure of intellectual property and the details on the chemical composition. Finally, while several proven tracking technologies exist (e.g. RFID, QR Code, NFC, etc.), ensuring and maintaining a link between the physical product and the digitized product throughout the product lifecycle remains a key challenge.

These challenges, summarized in Figure 13, call for more systemic solutions to capture and share standardized and fundamental data to establish a reliable and interoperable flow of information across industry value networks. In this context, the ontology network and the open data sharing platform developed in this project will specially aim at increasing sharing efficiencies of trustful product data throughout the supply chain from suppliers to the end of use of product and recycling. Thereby facilitating increased traceability and transparency, and thus the project results will be a crucial step towards a more circular and sustainable textile industry.

Figure 13 – Key challenges to share and capture data across the value chain



4.1 Objectives of the use case

The main objectives of the textile use case are summarized as followed:

1. **Define the business needs** (product data and data sharing platform) to support the establishment of **circular economy loops** through the analysis of case scenarios in the **footwear industry.** These business needs will be shared with WP2 as inputs for defining the requirements for the development of Ontology and the Open Circularity Platform.

2. **Design and test a translation layer**, making use of the Open Circularity Platform, to enable automatic data exchange between manufacturers' product data, a sustainability data scheme (i.e. Product Circularity Data Sheet (PCDS)) and a product passport (i.e. circularity.ID®)

3. **Evaluate and demonstrate the potential of the Open Circularity Platform** (developed in WP4) to support business circular opportunities through the ontology-based data documentation.
   It is increasingly recognized that clear, structured, and easily accessible information on the sustainability and circularity characteristics empowers businesses and consumers to make better choices and can unlock circular economy opportunities along value chain. In that regard, the main goal of the textile use case is to evaluate the **potential** of the Open Circularity Platform **to boost the visibility and the credibility of circular products**, thus providing a rewarding value for companies' sustainable efforts.

Ontology-based translation layer concept

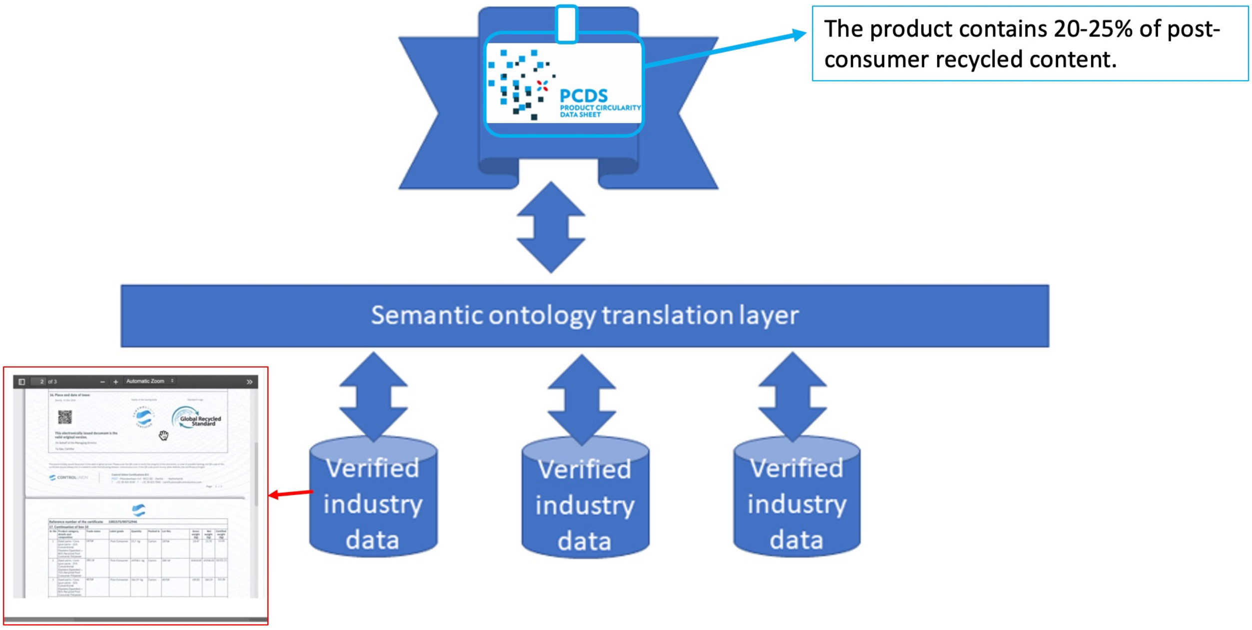
The objective of the translation layer is to automate data exchange and access throughout the value chain. In particular for the textile use case, sustainability and circularity data related to a selected product will be translated to map the set of statements in the PCDS and the set of data in the circularity.ID®. Through this mapping:

1. Claims entered in the PCDS can be automatically verified in real time against external data sources stored at the manufacturers. For example, the Figure 14 illustrates the case of one PCDS statement related to post-consumer content which is publicly available and the proof supporting the claim (i.e. Global Recycled Standard certificate) which is stored in the manufacturer's IT system.

2. Actors providing traceability solution such circular.fashion will gain the ability to pull verified data from the textile supply chain and make them accessible via their circularity.ID® platform for consumers through a digital product site and for textile sorters and recyclers through the intelligent sorting stations.

In addition, mechanisms for authorization and validation of access to data will be accounted for through the Open Circularity Platform established by the project. Finally, when designing the Translation Layer, we will evaluate the potential of the True/False statements approach used by the PCDS as a mechanism to ensure interoperability across sectors and to solve the conflict between confidentiality of information and the need for transparency to enable circular material loops.

Figure 14 - Ontology-based translation layer concept



4.2 Involved partners and contributions

Three organizations will actively contribute to the Textile Use Case. They will provide data, information, and knowledge in the following domains: supply chains, product information, and criteria for sustainability, circularity and recyclability claims as well as their evaluation. A brief description of these organisation, their technology and expertise is presented below.

1. **+ImpaKT Luxembourg** (http://positiveimpakt.eu/en/pcds/), which stands today among the most experienced Cradle-To-Cradle & Circular Economy experts in EU and Luxembourg. It has done extensive work on the topic over the last years in Luxembourg, contributing to several national strategies (e.g. National Circular Economy strategy, National Zero Waste Strategy, Supporting Emerging Circular Business Models and Roadmap for A Sharing Economy). Since 2018, +ImpaKT has been leading since 2018 the development of the international standard **Product Circularity Data Sheet (PCDS)** (https://pcds.lu/), an initiative funded by the Luxembourgish Ministry of the Economy. Working with more than 50 international organizations from 12 EU countries and USA, +ImpaKT has developed an open standardized data format to facilitate product data sharing of circular economy characteristics across value chain networks[21]. The PCDS will be an ISO standard in the next 2-3 years (https://www.iso.org/standard/82339.html) and it is currently being piloted by companies and data aggregation platforms in several key supply chains.

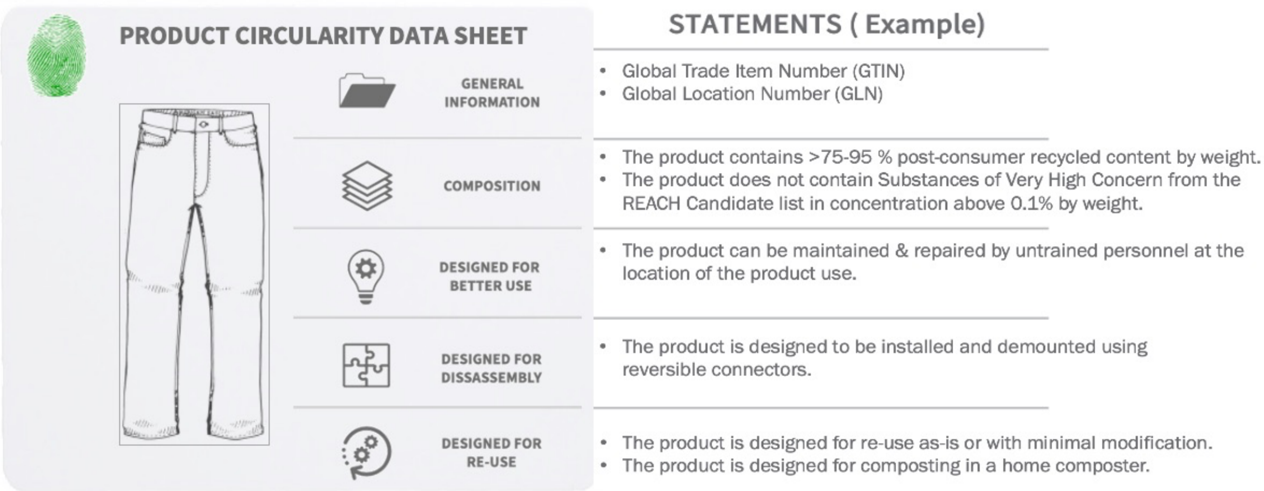
   The PCDS is a product declaration in a machine-readable format that provides standardized and verifiable data about the circularity characteristics of a product. To solve the conflict between confidentiality of information and the need for transparency when implementing a true circular approach, the PCDS is using “true/false statements” to describe a certain set of

[21] Mulhall, Ayed, Schroeder, Hansen, and Wautelet (2022). "The Product Circularity Data Sheet—A Standardized Digital Fingerprint for Circular Economy Data about Products" Energies 15, no. 9: 3397. https://doi.org/10.3390/en15093397

features that can be transparently stated as true or false without having to disclose to every party the manufacturer's production secrets. By doing so, this helps manufacturers to take the first step in transparency and product circularity practice. To ensure trustworthy content and reliability, the originating data are verified by an independent audit and authentication mechanisms combined with unique ID per created PCDS are being developed.

As shown in Figure 15, PCDS standardized statements include information about chemical substance thresholds, design for reuse and disassembly, recyclability, recycled content, biocompatibilities, hazardous materials thresholds, and actively positive impacts. The PCDS is not a scoring or rating mechanism. Instead, its data are inputs for other product schemes and platforms to do that.

Figure 15 - Content of the Product Circularity Data Sheet (PCDS)



2. **circular.fashion** (https://circular.fashion/en/index.html), is a sustainable design agency creating product and system innovation for a circular economy in fashion and textiles. The company develops services and software for circular design and closed loop recycling to enable a transparent flow of information between material suppliers, fashion brands, consumers and recyclers. At the centre of the circular.fashion system is the circularity.ID® including the Open Data Standard (https://circularity.ID/open-data-standard.html), which holds material and product data, along with a product's entire story. This ensures future reuse, reselling and recycling at the highest possible level of sustainability. Through this system, data becomes accessible to stakeholders in the fashion ecosystem at any point in time to assess and handle products in a circular economy. The rationale for developing the circularity.ID® is based on the identification of three main challenges that need to be overcome to realize a circular economy for fashion:

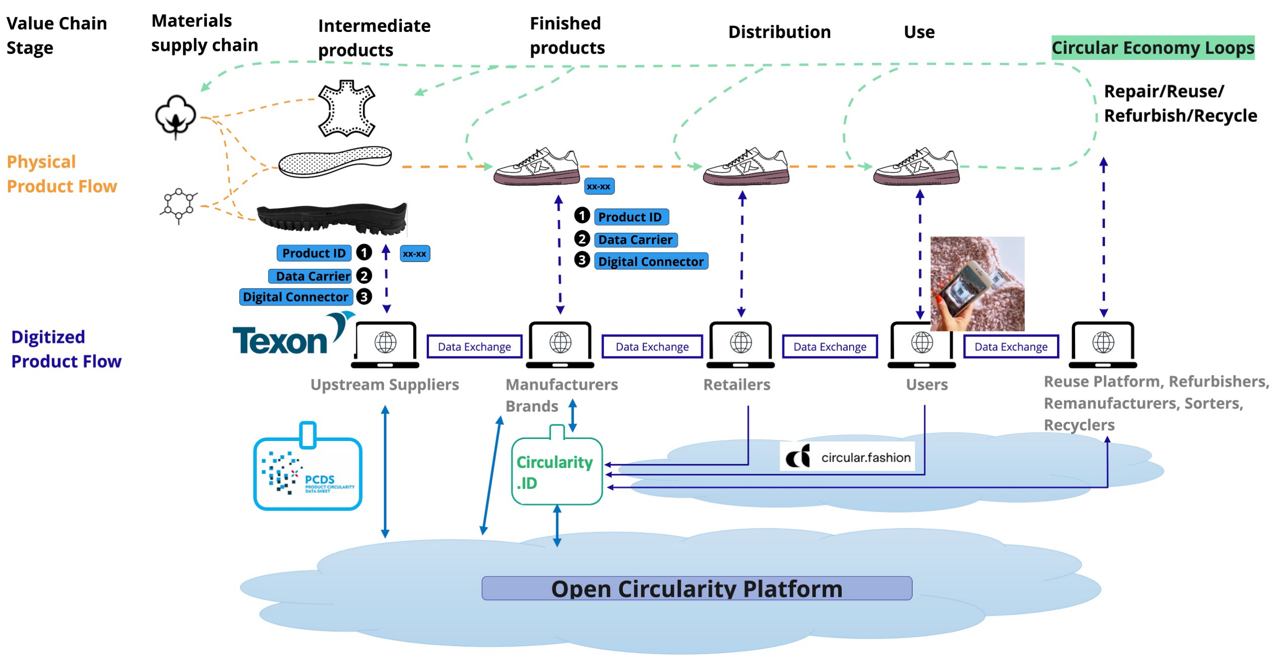
- fashion needs to be designed for circularity,
- product life must be extended and consumers need to know where to return clothing for reuse and recycling, and
- sorting facilities need to identify products and their materials for fibre-to-fibre recycling.

To enable a reverse supply chain for fashion and textiles, sorting companies play a key role. The process of sorting is primarily manual today, based on a sorter's optical impression and sense of touch and smell. The specific feedstock requirements of innovative fibre-to-fibre recyclers bring current sorting processes to their limit as many requirements are not recognizable in a manual decision process. ID-based sorting of post-consumer garments has the potential to optimise the process, reaching a higher-quality level output to serve fibre-to-fibre recyclers and make the operations commercially viable. To test ID-sorting in a relevant environment, circular.fashion developed a working prototype of an intelligent sorting workstation, featuring different scanners mounted below and on a table with a screen above. When moving a garment over the table in the sorter's usual workflow, the screen displays crucial information to support the sorting decision-making, based on possible sorting fractions such as fibre-to-fibre recycling or valuable second-hand fractions. The workstation can read and process all products with IDs identified as potentially suitable.

3. **Texon** (https://www.texon.com/), which designs, manufactures and supplies high quality, high performance, sustainable material solutions used in footwear applications. They have deep knowledge and accumulated expertise in the footwear supply chain and the challenges related to circular product design and product data exchange from raw materials to final product assembly.

The Figure 16 indicates the position of the partners within the value chain and how the interactions with the Open Circularity Platform are envisioned. Texon will work with their suppliers and customers to ensure the data collection from the supply chain. Texon will select three main components of one existing footwear product for which we will collect product data based on the identified business needs to support fibre-to-fibre recycling. +ImpaKT will provide their expertise on the Product Circularity Data Sheet standard and how it can be used to support uniform circular metrics and to ensure interoperability across industries. circular.fashion will provide their expertise on circular product design and traceability solutions for closing (including data carrier and product passport). Finally, the Open Circularity Platform with the ontology-based data documentation will be designed to enable automatic data exchange between manufacturers' product data, the circularity data scheme Product Circularity Data Sheet (PCDS) and the product passport circularity.ID®.

Figure 16 – Role of the Open Circularity Platform and its interactions with the partners in the textile use case



4.3 Methodology and work plan

4.3.1 General Methodology

Due to the complexity of the footwear supply chain, it was agreed between the partners and WP leaders to focus on only one case scenario (i.e. **fibre-to-fibre recycling**) and on one existing footwear product, to ensure getting meaningful results within the timeline envisioned by the project. Fibre-to-fibre recycling is one of the top priorities of the EU Commission mentioned in its EU Strategy for Sustainable and Circular Textiles[22]. Therefore, footwear recycling is a leading opportunity, but also one of the biggest challenges in the textile industry. It is also a downside as we might lack product data and requirements for sorters and recyclers that are able to process footwear products. To mitigate this risk, we will apply an **agile and iterative approach for the data collection.** This means that we will focus first on one material of a typical footwear product selected by Texon, for which we will analyse the data received from the suppliers, and document learnings, potential gaps and barriers. We will then expand it to two more typical footwear materials. Using this approach, we will quickly discover potential challenges in receiving mandatory data needed for completing the whole lifecycle and the fibre-to-fibre recycling.

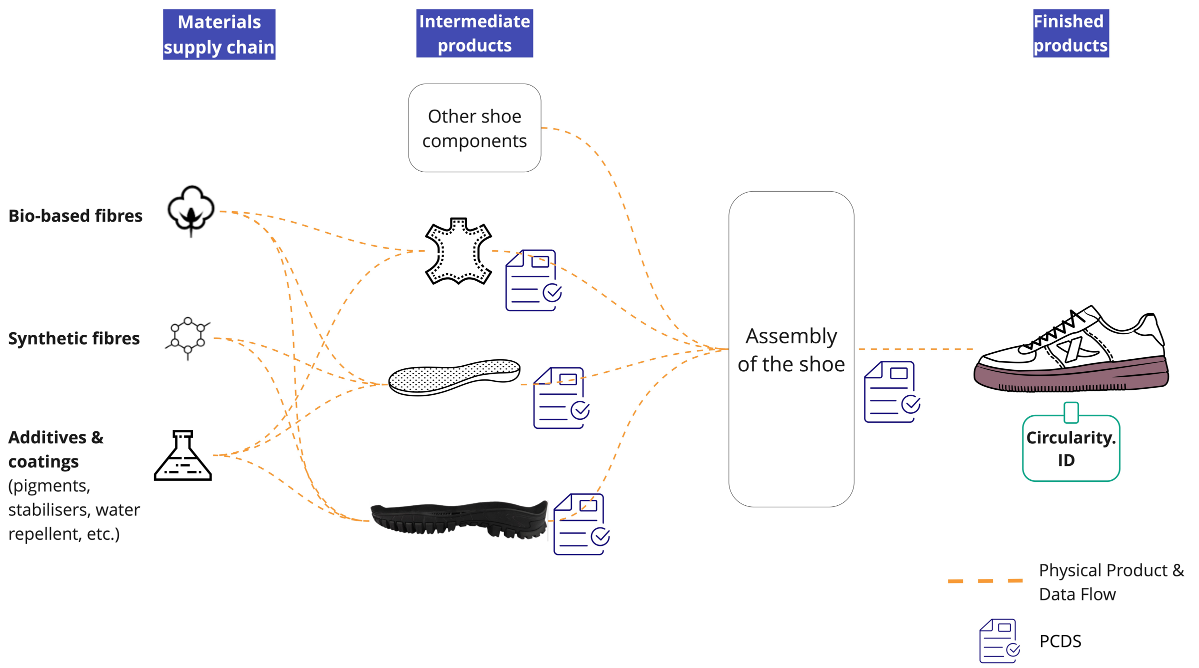
As specified earlier, the Onto-DESIDE research process is divided into 3 iterations. Each iteration shall enrich the ontology-based data documentation and refine the requirements of the Open Circularity Platform ensuring that it meets the business needs of the key stakeholders in the value chain. In addition to common objectives, each iteration will have a specific focus as explained in the following and detailed in section 4.3.2.

[22] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12822-EU-strategy-for-sustainable-textiles_en

The focus of the first iteration is to evaluate the *state of play* in terms of product data sharing, based on a first set of requirements. In a first step, +ImpaKT Luxembourg and circular.fashion will establish a list of product data for footwear products based on the standard PCDS and the circularity.ID® Open Data Standard 4.0, and including requirements for traceability, sorting and recycling. A set of business needs for the data sharing platform (data security & privacy, storage, access, etc.) will be elaborated based on an analysis of leading initiatives and leveraging the accumulated knowledge of the partners. Then, in a second step, we will collect and document the data of three typical materials used in the production of an existing footwear product selected by Texon (cf. Figure 17). As a typical shoe is manufactured with around 40 different materials which are assembled using diverse types of processes (stitching, gluing, etc.) and multiple additives and coatings, it was decided to focus on a limited number of footwear components and not the whole shoe. We will validate the received product data, identify missing data, and analyse potential ways of getting the data needed from suppliers. Finally, the set of requirements for product data and data sharing will be enriched based on the feedback of Texon's suppliers and on the data, we are able to receive.

The second iteration will focus on analysing and identifying circular design opportunities for the existing footwear product. The third iteration will focus on testing the closed-loop data exchange from suppliers to recyclers by creating a mock-up with circular.fashion of the footwear product equipped with a data carrier. This iteration will evaluate which data carrier can be used based on the learnings of circular.fashion and how do we ensure life-cycle tracking (e.g. The Open Circularity Platform and the relevant stakeholders should receive an event notification when their product data are accessed by an external actor and when their product is scanned at a recycling facility).

Figure 17 - Data collection process for a specific footwear product



4.3.2 Work Plan

The Table 2 provides details about the tasks and expected outcomes for each iteration. It is important to note that the tasks of the iterations 2 and 3 may be subject to changes depending on the results of the iteration 1. A more detailed work plan will be provided as part of the deliverable D6.1 v2 at M18.

Table 2 - List of tasks and outcomes for each iteration in the textile use case

Iteration	Tasks and Outcomes Description
Iteration 1 ***State-of-Play*** **(M1-M18)**	**Tasks** 1. **Identify three materials/components of a specific footwear** (Lead: TEX) 2. **List Product Data Needs** (Lead: POS & FAS) 2.1. Compile and align requirements from the EU Digital Product Passport (DPP), PCDS v3.2 and circularity.ID® v4.0 2.2. Review and validate with Texon 3. **List IT Infrastructure Needs** (Lead: POS & FAS) 3.1. Analyse other leading initiatives (e.g. EU Digital Product Passport, EU-funded DigiPrime project, PCDS initiative, Textile Exchange (TEX.EX), EonGroup, Global Textile Scheme, etc.) 3.2. Compile best practices and learnings from the partners and other initiatives 4. **Data collection and documentation** 4.1. Collect the product data from the supply chain: suppliers T-3, T-2 & T-1 + brand (Lead: TEX) 4.2. Collect feedback on the IT architecture needs from key actors in the supply chain (i.e. Suppliers, Assembly Manufacturer, Brand, Sorters, and Recyclers) via semi-structured interviews (Lead: POS & FAS) 5. **Summarize and communicate outcomes to WP2** (Lead: POS & FAS)
	Outcomes - Version 1 of the Business Needs (Product Data and IT Architecture) - Identification of data gaps and availability - Identification barriers & enablers (i.e. value drivers & incentives) for data sharing/access - General reflections to be addressed in a transversal way with WP6 partners - Recommendations for improving data gaps and data sharing, which are used as inputs for the WP2, WP3, WP4 to improve Ontology and the prototype of the Open Circularity Platform
Iteration 2 ***Circular Design Opportunities*** **(M19-27)**	**Tasks** 1. **Analyse the three materials/components of the footwear product** and **identify circular design opportunities for fibre-to-fibre recycling** 2. **Establish product data-based circularity indicators** for each of those three materials which can boost visibility of circularity efforts from the companies via the Open Circularity Platform 3. **Data collection and documentation for the alternative materials or component design** 4. **Discuss enablers and potential challenges** with the relevant stakeholders in the supply chain 5. **Summarize and communicate outcomes to WP2**
	Outcomes - Version 2 of the Business Needs (Product Data and IT Architecture) including a list of recommendations for improving data gaps and data sharing - Identification of circular design opportunities and recommendations (material cyclability, longevity, disassembly, etc.) for the three footwear materials/components

Iteration 3 ***Mock-up of the closed-loop data exchange*** **(M28-36)**	Tasks **1. Test the data exchange with the Open Circularity Platform at each stage of value chain, from suppliers to recyclers** 1.1. Gather all data from the suppliers 1.2. Create a mock-up with circular.fashion of the Intelligent Sorting Station by adding a data carrier on the footwear product (e.g. RFID hybrid tag) **2. Summarize and communicate outcomes**
	Outcomes - Version 3 of the Business Needs including updated Product Data based on recommendations of designing for Circularity - Learnings from the pilot test at circular.fashion with the data carrier and the footwear product including recommendation of how connection to Circularity Platform could be set up to make sure that lifecycle tracking is possible - Detailed flow-chart and handover of all final results and requirements to WP 2

4.3.3 Structure for reporting the business needs

One of the key objectives of each use case is to define the business needs, for both product data and data sharing platform, to support the establishment of circular economy loops. These needs will serve as inputs for the WP2 to specify requirements for the development of the ontology-based data documentation and the Open Circularity Platform.

The Table 3 and Table 4 presents the structure that will be used to report the business needs, respectively for:

1) **Product Data:** what product data are needed to facilitate footwear fibre-to-fibre recycling? And which data is needed by which actor in the value chain?
2) **Open Circularity Platform:** under which conditions and what format shall the product data be shared and accessed?

This structure is based on one of the latest presentations of the EU Commission on Digital Product Passport[23]. In addition, user stories will be used to document the business needs from the perspective of each actor in the value chain. Finally, when reporting the business needs for product data, a classification will be used to facilitate prioritization in the development of the ontology and Open Circularity Platform:

1. **Mandatory**: already necessary to provide by legislation
2. **Preferred data**: high relevance to enable CE loops and low implementation effort
3. **Optional information**: high relevance to enable CE loops but high implementation effort or potential barrier due to confidentiality/privacy issues

[23] EUCircularTalks: EU Digital Product Passport - learning from frontrunners (13 July 2022). Accessible via https://youtu.be/oQJL-QlWxZI

Table 3 - Structure to list business needs for the product data

Nr	Requirement topic	Business need statement	Priority level
P.1.1	**Track & Trace ("Biography)**	*Examples* - *Product ID code* - *Company name and address* - *Production site name and address*	
P.2.1	**Sustainability and circular data requirements**	For each requirement: - Indicator name - Description - Assessment method based on existing standards ISO and CEN/EN - Valid proof	
P.3.1	**Compliance related documents and information**	*Examples* - REACH compliance declaration	

Table 4 - Structure to list business needs for the Open Circularity Platform

Nr	Requirement topic	Business need statement
B.1.1	**Unique Identifiers (Digital Twin)**	*Compliance with ISO/IEC 15459*
B.2.1	**Data carriers (Digital Twin)**	
B.3.1	**Interoperability (vertical and horizontal)**	
B.4.1	**Access and edit rights management**	*Examples* *The details of Bill of Materials shall be accessed on "need to know" basis with specific access rights for authorized parties. Any stakeholder involved in the footwear product life-cycle shall be registered with specific rights to access information.*
B.5.1	**Data security and privacy**	
B.6.1	**Data authentication, reliability, and integrity (TRUST)**	*Examples* *Authentication mechanism to assure that:* - *the actor using the system is a trusted party* - *the accessed data were not corrupted by any non-authorized third-party* *The system shall support the verification of the product data by facilitating access to the proof.*
B.7.1	**Data storage**	*Examples* - *Standardized and machine-readable format to store the data (XML)* - *The data shall be stored at company's IT premises.* - *For companies with limited IT capabilities, the IT architecture shall provide a storage function.*

4.4 Use case description

This section provides an overview of the state of play (practices and processes) of the footwear sector in terms of material and information flows: what is already there and what is missing? To describe and analyse the use case, it was agreed among the WP leaders and partners to use Multi-Flow Metabolism (MFM) as a common framework. Through the analysis of material and information flows, the MFM is used to describe the current realities in terms of circularity of materials and to highlight the barriers and enablers facilitating (or not) the implementation of circular strategies. While several circular strategies are described in the state-of-play, only the case scenario of fibre-to-fibre recycling is further detailed in the analysis.

4.4.1 State of play and circular economy opportunities

The Circularity Compass framework is used to provide an overview of current circular economy practices in the footwear value chain. The Figure 18 provides a high-level description of the key material flows in the footwear sector and the circular pathways which are currently happening. The Table 5 provides a description of the key business partners involved in the footwear sector. For illustration purpose, the example of Texon Reform 2.0 solution (https://www.texon.com/reform-2-0/) was selected. And for the visibility of the diagram, only the two main material flows, bio-based fibres and synthetic fibres, are represented. Texon's structural solution is designed to be 100% recyclable and it contains up to 59% recycled content (i.e. 49% of recycled PET bottles and 10% of post-industrial content) plus an additional 7% renewable content (i.e. pine tree resin). In the next stage of the supply chain, the fibres-based components such as heel counter, toe reinforcement, foam, midsole cushioning systems, outsoles, footbed, etc. are supplied to B2B distributors which are in charge to ensure a continuous supply of components to shoe assembly manufacturers. At this stage, additional materials and substances are used during the assembly process to create the finished shoe product. In general, brands do not own these final assembly production sites which create some barriers for supply chain traceability.

Figure 18 – Circularity Compass of the footwear value chain showing the state of play in terms of resource flows and circular pathways

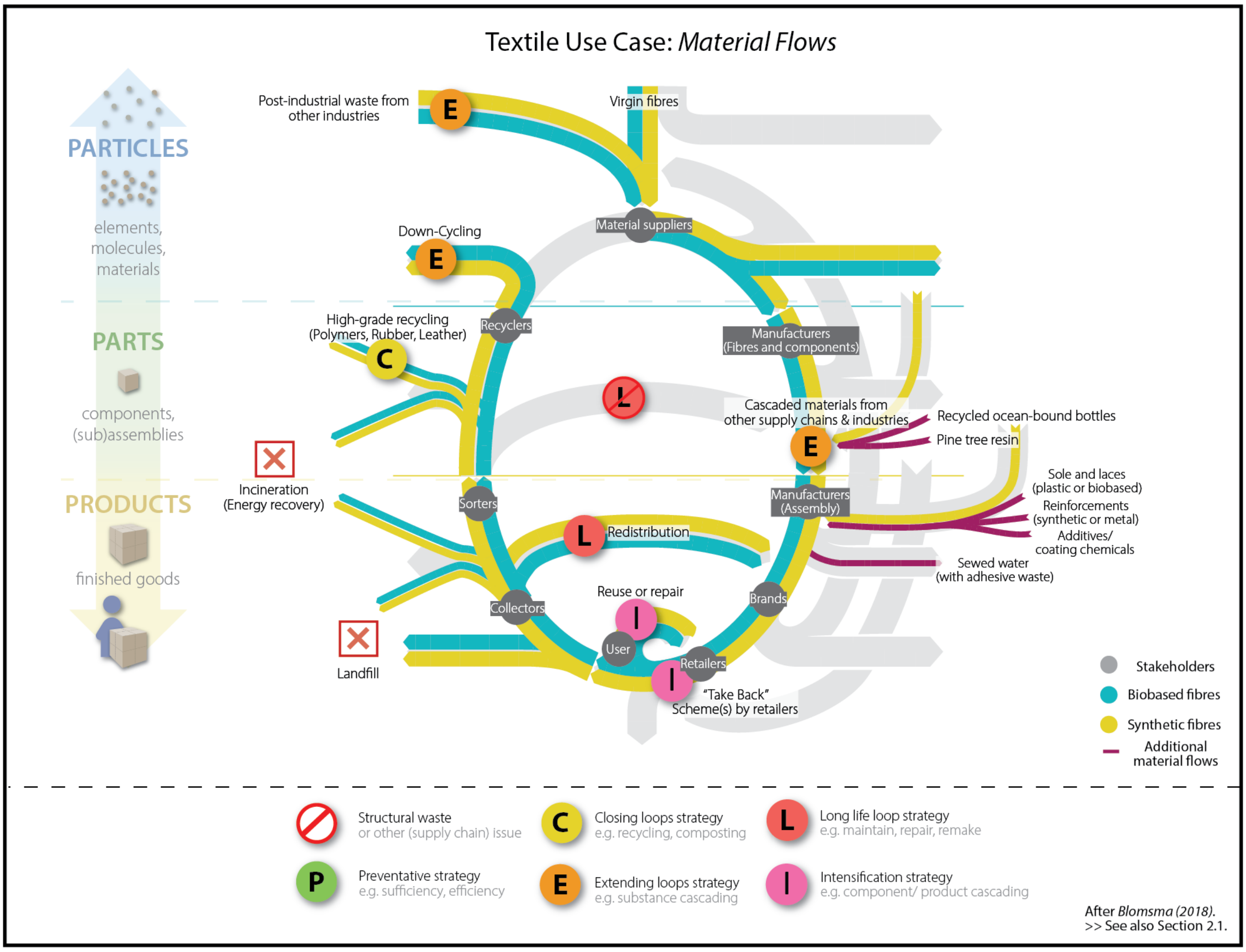


Table 5 - Key business partners in the footwear sector

Nr.	Business partner	Definition
A.1	**Consumer**	A person who purchases goods and services for personal use.
A.2	**Customer**	A person or company who buys goods or services from a company.
A.3	**Auditor/Certifier**	A person or company who inspects something, such as a product, process, or organization, to ensure that it complies with requirements or regulations.
A.4	**Suppliers**	A person or company that provides something needed in the manufacturing stages such as feed, equipment, materials, intermediary and finished products, chemicals or a service etc. Suppliers also include those who supplies data carriers.
A.5	**Transformation actor**	A party that processes or changes one or more inputs to create different outputs (i.e. Farmer, Slaughterer, Ginner, Spinner, Tanner, Weaver, Dyer, Finishing Provider, Manufacturer, Subcontractor).

A.6	**Product guardians**	A party, such as a Transporter, Warehousing Party, Agent/Trader, Distributor, Wholesaler that makes no changes to a product or raw material; they only store, transport, sell, or purchase it. Product Guardians also include those who undertake redistribution and resales activities for reusing the product. Their possession of the product can be recorded in order to establish the chain of custody, since product contamination or substitution could take place during their custody. They may also perform the role of Information Requestor.
A.7	**Brand owner**	A person or company who sells any commodity under a registered brand label.
A.8	**Retailer**	A person or company that sells goods to the public in relatively small quantities for use or consumption rather than for resale.
A.9	**Life-extension actor**	A person or company that perform repairing or refurbishing activities on an existing product in order to extend its lifetime. Since product modification or replacement of components could take place, these transformation activities must be recorded with the newly product data in order to establish the chain of custody.
A.10	**Provider of IDs**	A party that supplies identifiers and data carriers. For a product or component to be traced, it must have a unique identifier that cannot be duplicated or moved from one (compliant) product to another (which may not be compliant). Parties and locations in the value chain also need to have unique IDs. This value chain partner's role is to provide the identification. The role can be carried out by a Transformation Partner, but it could also be done by a certifier or an inspection organization or an association that specializes in identifiers (such as GS1) or a government (for example, if a company is identified by its tax ID).
A.11	**Information requestor**	A person, organization or authority needing traceability and transparency information about product(s) for their sustainability statement(s) (claims) regarding environmental, health, human rights and socio-economic impacts. If the products being traced are regulated, the data could also be used to verify compliance and enforce laws. Information Requestors can also include those who aggregates product data into traceability system or platforms.
A.12	**Waste disposal provider /Collector**	A person, company or body having a role in waste disposal; the collection, processing, or deposition of the waste materials of human society. The waste disposal provider may also perform the role of sorter and recycler.
A.13	**Sorter**	A party that is dividing all textile post-consumer waste deciding whether a garment is resold or recycled. Sorters can also be waste disposal provider and recycler.
A.14	**Recycler**	A person or company who recycles or uses machines to recycle.

In terms of circularity pathways, the current practices in the footwear sector include:

1. **Reuse and repair,** e.g. replacement of shoelaces or soles.
2. **Redistribution and second-hand sales** are also a common practice, but to a very limited extent in comparison to garments.
3. **Refurbishment and remanufacturing** of shoe is not occurring.
4. Used footwear products are generally collected via dedicated textile waste stream or via take-back schemes handled by retailers.
5. Finally, **footwear recycling** faces several challenges described below, which limits the current practice to downcycling for a very limited volume, the rest being landfilled or incinerated.

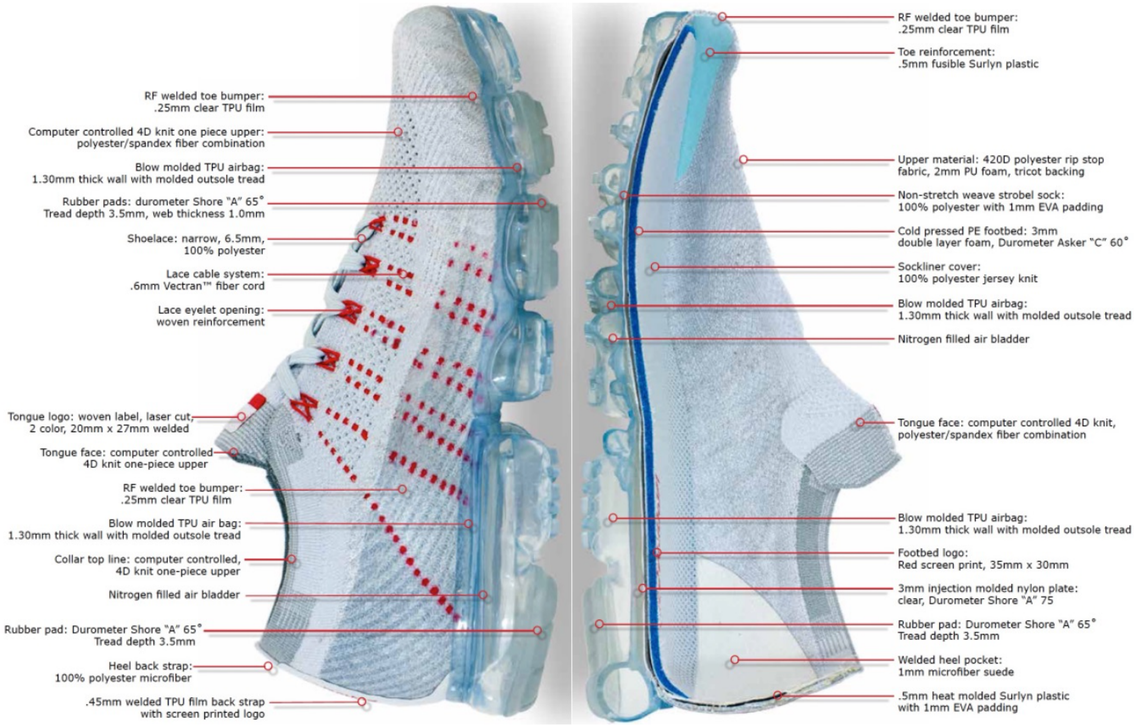
Exploring the barriers to fibre-to-fibre recycling

While the worldwide consumption of footwear is estimated to be more than 21 billion pairs of shoes per year[24], less than 5% of end-of-life shoes are being recycled, with most being disposed of in landfill sites around the globe[25]. To date very little work has been done to develop material recycling solutions for mixed footwear products. According to Texon, fibre-to-fibre recycling in the footwear industry is nearly to 0% due to the product design as showed in Figure 18. In fact, most modern footwear products are made of a complex mixture of more than 40 different materials which are assembled using different types of processes (stitching, gluing, dyeing, etc.) and multiple additives and coatings. The Figure 19 illustrates this complexity by showing the components breakdown of a typical sports shoe. Commonly used materials include bio-based fibres (e.g. leather, cotton, wool), synthetic fibres (e.g. polyethylene terephthalate (PET), nylon, polyurethane (PU), rubber, poly vinyl chloride (PVC), ethylene vinyl acetate (EVA)), metallic materials (e.g. steel, brass, aluminium).

[24] https://www.centreforsmart.co.uk/projects/footwear-recycling

[25] M. James Lee and S. Rahimifard (2012) *An air-based automated material recycling system for postconsumer footwear products*. Resources, Conservation and Recycling. Volume 69, December 2012, Pages 90-99.

Figure 19 - Typical sports shoe with main parts and used materials. Source: Wade Motawi (2018) SHOE MATERIAL DESIGN GUIDE.



This material complexity combined with the diversity of shoe types and construction techniques poses significant challenges to achieve high-quality closed-loop recycling with cost-effective processes. Even with the use of highly mechanised recycling systems[26] (currently employed by other industries such as electronics and automotive), the extensive use of additives and coatings pose additional barriers to fibre-to-fibre recycling as they affect the recycling process and the quality of its outcome. For example, the use of water repellence coating poses great barriers to fibres' recyclability and protective and stabilizing chemicals added to natural biodegradable materials such as leather, natural rubber, etc. disable them to degrade naturally[27]. Finally, due to the intrinsic shortening of the fibres at each recycling cycle, the recyclability is limited to an average of 8 recycling cycles for synthetic fibres and an average of 5 cycles for natural fibres.[28] These effects require then the addition of virgin fibres to reach the desired performance level.

Design for high quality closed loops of fibres

The above-described barriers to fibre-to-fibre recycling show the crucial role of product design in achieving cost-effective closed loop system and high-quality recycled fibres. At the same time, there is also a clear need to boost visibility and to reward the efforts of companies which design 100% recyclable fibres solutions for footwear. In the second iteration of the project, with the expertise of

[26] These recycling processes typically involve shredding or granulation, and subsequently separation machines which exploit the differences in material properties (such as material size and density) to provide automated separation into different material streams.
[27] Rahimifard, S., & Staikos, T. (2006). End-of-life management of shoes and the role of biodegradable materials. … University, UK.
[28] Celep, G., Tetik, G. D. , & Yilmaz, F. (2022). Limitations of Textile Recycling: The Reason behind the Development of Alternative Sustainable Fibers. In (Ed.), Next-Generation Textiles [Working Title]. IntechOpen. https://doi.org/10.5772/intechopen.105118

Texon and circular.fashion, several design options will be created, evaluated and documented. These design options include better materials selection (as detailed by the Better Shoes Foundation https://www.bettershoes.org/home/material-selection#common) and circular design strategies such as:

- **Minimal design** which means removing unnecessary components without compromising the basic function of a shoe and reducing the number of different materials. For example, to achieve 100% footwear recyclability, Adidas has completely rethought their design process and came up with the running shoe FUTURECRAFT.LOOP[29] which is made of only one material and using no glue.
- **Alternative manufacture and assembly methods:** for example, choosing processes that minimise the amount of energy needed or using a glue less construction.
- **Bio-sourced materials:** 60% of textile fibres are synthetic and polyester is the most commonly used fibre, produced from carbon-intensive processes requiring more than 70 million barrels of oil each year[30]. In that regard, bio-sourced materials represent a key opportunity to mitigate climate change and resource scarcity. Microplastics released in the environment during the use phase of footwear are also a key challenge that bio-sourced and biodegradable materials can tackle. For example, PUMA recently experimented a biodegradable version of its most iconic shoe, called RE:SUEDE[31].
- **Modular Design and Design for disassembly**: this is one of the key design strategies to enable cost-effective fibre-to-fibre recycling. This strategy considers how shoes can be easily broken down into clean components once they wear off, in order to minimise waste and promote repairability, recyclability, and durability / product longevity.
- **Easy-care / Repairable**: Enable features to freshen up tired shoes and increase their lifespan. For example, resoling expands the lifespan of a shoe.
- **Multipurpose use**: Enable the user to wear one pair of shoes for a range of occasions.

4.4.2 Main challenges related to data sharing

In a circular economy, it is not only resources that need to circulate but also information. The Open Circularity Platform should facilitate the digitalization and the automation of data exchange as far as possible at all interface points in the value chain, requiring minimal manual intervention. This section describes the main challenges related to the information flow throughout the value chain, with a specific focus on the data gaps hindering the implementation of circular material loops (described in the previous section).

The Figure 20 describes the key challenges related to the data exchange hindering footwear recycling. The lack of data on materials, additives and coatings, production methods and assembly techniques, and the (unstable) quality of materials does not currently allow for a closed fibres cycle in the footwear sector. In particular:

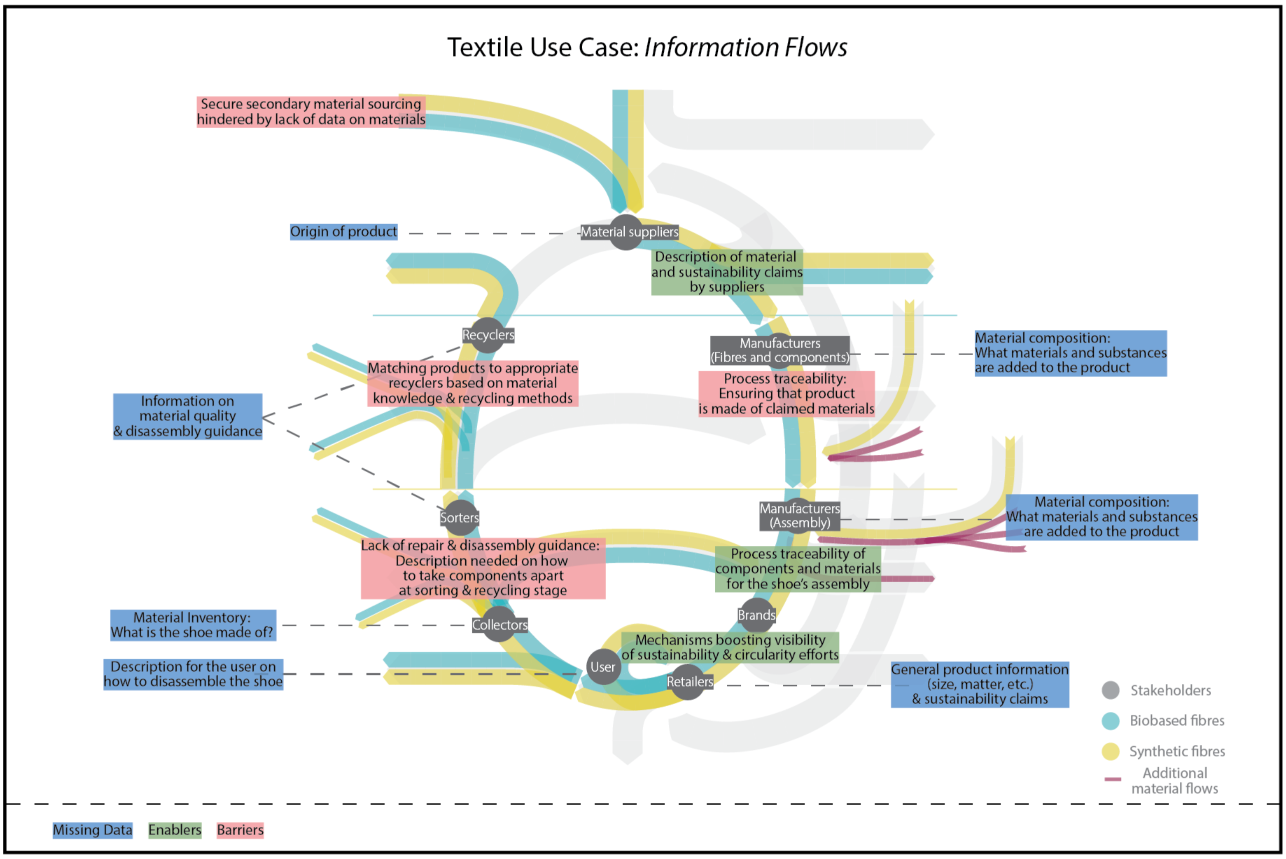
[29] https://news.adidas.com/running/adidas-unlocks-a-circular-future-for-sports-with-futurecraft.loop--a-performance-running-shoe-made-t/s/c2c22316-0c3e-4e7b-8c32-408ad3178865
[30] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12822-EU-strategy-for-sustainable-textiles_en
[31] https://about.puma.com/en/newsroom/corporate-news/2022/04-21-2022-start-re-suede

- The lack of information on additives and assembly processes does not allow for transparency and product knowledge that would favor the implementation of disassembly protocols to improve product repair and fibre-to-fibre recycling.
- The absence of traceability process for materials does not ensure their quality and therefore does not allow for a proper assessment of their real potential for recovery (e.g. addition of chemical substances, like water repellent).

In terms of enablers, two main solutions to be explored in future work are:

- Reward mechanisms to boost visibility of the sustainability and circularity efforts made by companies on their product/materials. This would create incentives for manufacturers to share product data and for brands to design shoes made to be 100% recyclable.
- Traceability mechanisms to ensure that the product is made of the claimed materials and that this information can be made available to authorized parties. This would make it possible to match footwear products with appropriate recyclers, so that they are recycled to best knowledge and method according to the current state of technology at end-of-life.

Figure 20 – Current data gaps, barriers and enablers for data exchange throughout the footwear value chain



The Table 6 provides a list of the challenges related to data exchange that shall be addressed to ensure a successful implementation of the Open Circularity Platform. This list will be refined and validated in the first iteration through the interviews with key stakeholders of the value chain.

Table 6 - List of challenges related to data exchange throughout the footwear value chain

Nr.	Topic area	Challenge statement
C.1	**Value proposition**	How to value the efforts made by companies to achieve sustainable and circular products? So, it can be translated into the final price. The Open Circularity Platform shall support companies by boosting the visibility on their sustainable practices and efforts.
C.2	**Global reach and inclusive for SMEs**	- Textile value chains are complex and international with a lot of subcontracted generating of products with short life cycles and by small and smallest companies, often with poor IT capabilities and competences. - For a high adoption by the market actors, the platform must be easy to use in terms of costs (training, IT implementation, etc.) and interoperable (i.e. compatible with the organizations' IT systems). - Socio-cultural factors and regional regulations and policies may influence the understanding of a same concept/ statement/ etc., which may to various interpretations of the same elements. It is crucial to create a globally harmonized product data model for circular material flows. The platform shall provide the data creation methods for each key stakeholder in the value chain to minimize human and technical costs related to data creation and exchange.
C.3	**Lack of digitalization**	There remains today an existing lack of digitalization of many companies in the textiles sector leading to heterogeneity of IT-related capability of companies, especially for SMEs which often lack IT capabilities. The platform shall be easy to use in terms of IT competences and ensure interoperability.
C.4	**Product Traceability**	The platform shall address the following challenges: - Lack of standardized product classification systems, like e. g. ETIM in electronics - Lack of traceability of the manufacturing process to ensure that the product is made of the claimed materials. The footwear industry is extensively using chemicals at the different stages of the manufacturing process (dyeing, coatings, glues, etc.). These chemicals have a huge impact on the recyclability. In addition, for cost reason, it is common practice to mix low-quality fibres with high-quality fibres without considering the impact on recyclability. Technical issues in identifying the material types and the appropriate recycling streams when sorting textile and footwear products at the end of their life cycle (which is currently a highly manual task).
C.5	**Security and privacy**	- The platform shall ensure that sensitive data is not displayed and not shared with third parties without authorized permission, as manufacturers are highly reluctant to disclose detailed product data such as product composition. For example, the manufacturers may agree to provide access to some details about their product composition to a list of authorized recyclers.
C.6	**Trust**	Trust in the Open Circularity Platform occurs at different level:

		1. Between the stakeholders using the system (e.g. authenticate method to ensure that stakeholders using the data exchange platform are trusted parties) 2. In the integrity of the data shared via the platform 3. In the accuracy of the product data and claims
C.7	**Verification of sustainability and circularity claims**	As highlighted in the EU Strategy for Sustainable and Circular Textiles, the accuracy of green claims made on using recycled content is a specific growing concern by the EU Commission. In particular, the common practice of brands to use recycled plastic polymers from sorted PET bottles (and not from fibre-to-fibre recycling) is "not in line with circular model for PET models" and is misleading for consumers[32]. The platform shall facilitate the access to the valid proofs (e.g. certificates, audit report, etc.) of circular/sustainable claims (e.g. recycled/renewable content, etc.)

5 Conclusion

The project was initiated through the identification of fitting example cases for the testing and validation of the technology and ontology created within the Onto-Deside project. The three demonstrators identified three supply chains of different length and regulatory circumstances. The example products have been well-chosen to span as many types of materials as possible in order to portray circularity and data communication across different industries. The presented circularity compass identified a methodological framework of analysis that enables the comparison of the use cases on circularity terms and information flow with the possibility to describe and analyse the processes conducted in the demonstrations after this first assessment of the status quo. Despite the differences of the use cases, the first assessment revealed interesting similarities.

When assessing the material flows along the supply chain, the demonstration products reveal usually initial and in the case of the textile case even advanced circularity practises in relation to the reuse and recycling of generic material types. All example cases show serious limitations whenever materials get more complex, supply chains get longer and information about material composition and production processes are not traceable yet.

The information flow along the three supply chains portrays a first analysis of the availability and detail of information available to the manufacturer. The assessment will have to be detailed further as per the assessment of raw data on materials, chain of custody and production process throughout the demonstration activities with supply chain stakeholders. The initial overview showed similar limitations in information availability whenever supply chains got very long, or international and material compositions got advanced. Furthermore, the availability of data showed improvement whenever products were for the B2C market and subject to regulations, like the textile industry. In addition, the complexity of a product and its intellectual property rights on compositions correlates with difficulties in accessing reliable and detailed material data. All information flows show a bias towards recycling practises with little to no existing efforts in refurbishment or remanufacturing of products.

[32] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12822-EU-strategy-for-sustainable-textiles_en

The version 2 and 3 of this report will intensify the analysis in line with more engagement with the demonstrating manufacturers and detail the industry-related needs in data standards and data needs.