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ONTO-DESIDE

DELIVERABLE 6.8 REPORT ON EVALUATION RESULTS – V.2

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Deliverable name	Report on Evaluation Results – v.2
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; IMEC; LIU
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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 GmbH	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
12	Prague University of Economics and Business	VSE	Czech Republic

Document reference

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1.1	29-08-2024	Revision after review – final version	Maria Alejandra León Aguirre, Ben De Meester, Eva Blomqvist and use-case leaders	WP6 leader, Maria Alejandra León

Document approval

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0.2	18-08-2024	Teresa Oberhauser	WP 6 leader	Circularise
1.0	21-08-2024	Olaf Hartig	Internal reviewer	Linköping University
1.2	30-08-2024	Eva Blomqvist	Consortium leader	Linköping University

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Abbreviations

Abbreviation	Definition
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 (OCP), 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 OCP 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 **Error! Reference source not found.** 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).

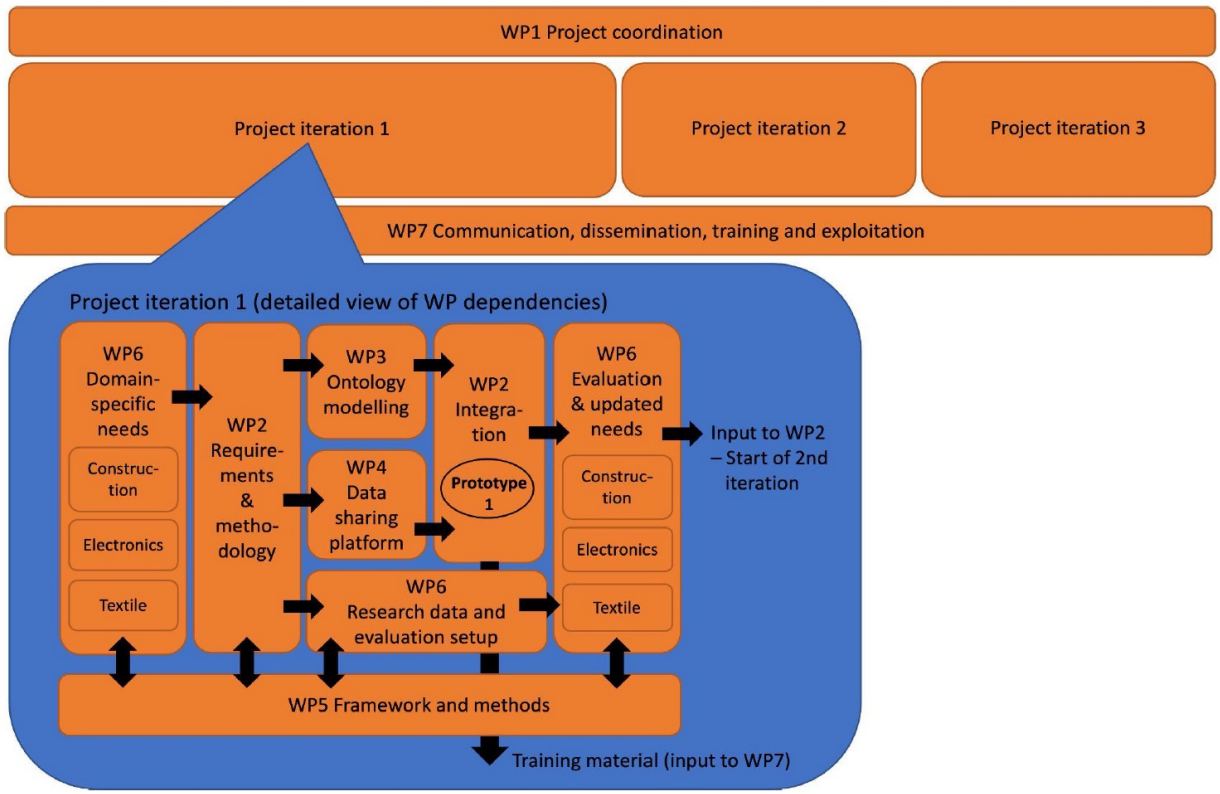

Figure 1- Project outline and detailed dependencies between work packages exemplified by the first iteration

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 WP6 aims to demonstrate the potential of the OCP 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:

- **Define the business needs and requirements** from the specific perspective of their industry domain, which are generalized and integrated in **WP2**.
- **Provide research data**, both for technical development as well as validation and evaluation of results.
- **Apply the tools from WP5** (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.
- **Perform evaluation experiments and provide feedback** of the intermediate releases of the ontology network and **OCP 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. **Error! Reference source not found.**):

- 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.

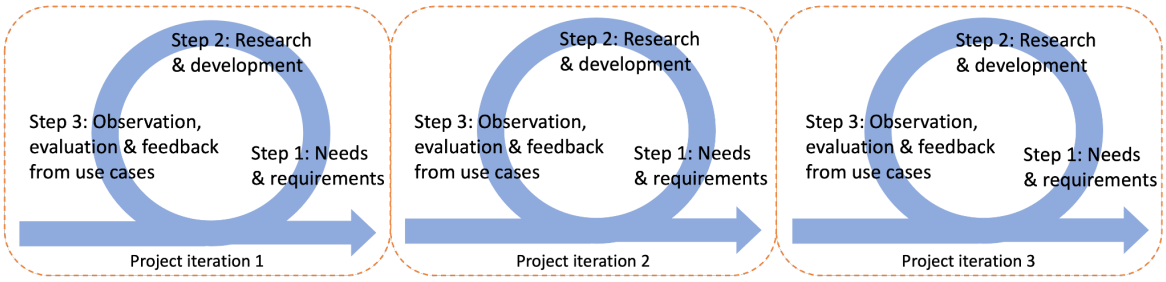

Figure 2 -The Onto-DESIDE research process, divided into 3 iterations, each consisting of three steps

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 **Error! Reference source not found.**). 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

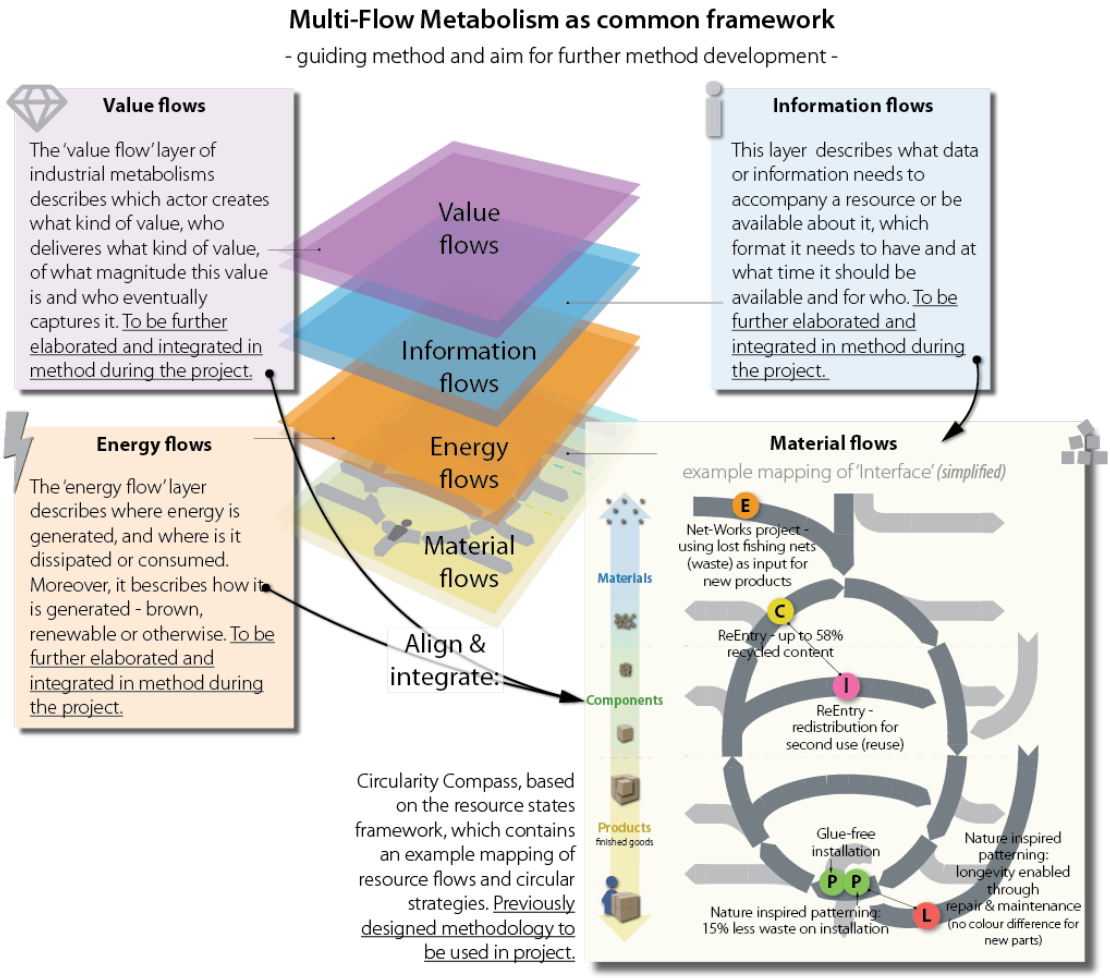

Figure 3 - Circularity Compass (bottom layer) and the Multi-Flow Metabolism as a common framework for analysing the use cases

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.

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/D6.2/D6.3 Use case needs analysis and circular value flow mapping** (v1 M3, v2 M18, v3 M27) – report
- **D6.4/D6.5/D6.6 Research data** (v1 M12, v2 M24, v3 M33) - data (project internal)
- **D6.7/D6.8/D6.9 Evaluation report** (v1 M18, v2 M27, v3 M36) – report

The present document is the report for D6.7 version 2. This file is divided into the technical and the use-case-focused evaluations. For the technical evaluation, first, the deliverable gives an introduction to the ontology developed in WP3 and the OCP built in WP4. Then it presents the methodology used to assess such developments across the multiple use cases and the results. On the other hand, the use-case-focused section evaluates the demonstrations conducted across the three different use cases (electronics, construction, textiles) employing the different software and methodology partners (Circularise, Concular, circular.fashion/PositiveImpakt). In this chapter, the use cases are presented (the actors, the components and overall objectives), as well as the methodology and the results of the different evaluations performed. Finally, conclusions are drawn from the multiple tests, including the viability and feasibility of such developments.

2 Technical evaluation

In this section the technical evaluations of the ontology network and the open circularity platform are described. Technical evaluations in this case refers to quality assurance activities and measures that evaluate the technical artefacts on their own, i.e. without any actual users nor a use case setting in mind. Nevertheless, part of the technical evaluation aims to verify requirements set by the usage domain, but in this case without actually applying the artefacts in real domain-relevant scenarios. In this section we describe both the methods and the results of such evaluation, while the application and evaluation of the artefacts in our use cases is presented in the next chapter.

More in detail, this section provides first a short summary of the ontology network and the open circularity platform, as presented in D3.2 and D4.2, and released in D3.4 and D4.4 respectively, as well as the subsequent extensions to this network (created in WP3 and WP4) for covering the use case evaluation scenarios outlined in WP6 (and to some extent the data in D6.5). In addition, we describe the method for the evaluation of the ontologies and software platform, as outlined and set up by LIU and IMEC, and the results of the evaluations, based on among other things feedback from the use case partners. The section mainly focuses on the latest evaluation results, i.e. the results of the evaluation in the second project iteration, however, also the results from the first iteration are summarised, for completeness and to show the progress over the two iterations.

2.1 Introduction to the technical platform

The technical platform of the project consists of the two main technical contributions, i.e. the ontology network and the open circularity platform. In this section, we briefly introduce each of them and explain how they are connected. For further details, please refer to WP3 and 4 deliverables.

2.1.1 Ontology network

The purpose of the ontology network is to allow for data documentation, across use cases and industry domains, through a set of core ontologies (and Ontology Design Patterns) that can be shared by the actors in the Circular Economy (CE). Hence, the ontology development in Onto-DESIDE has focused on the cross-cutting concerns identified in D2.1 and D2.2, and further detailed in the requirements of D3.1, as well as the updated set of requirements in D3.2. The first release of the ontology network was described in D3.3, the subsequent (and latest one) in D3.4, and both are available using permanent URIs (https://w3id.org/CEON) and in our GitHub repository (https://github.com/LiUSemWeb/CEON/). From the CEON landing page, also the online documentation of the ontology network can be reached, in the form of documentation pages, and ontology visualisations.

In this deliverable we do not describe the complete ontology network, but merely give a brief overview of the core parts evaluated in the first and second project iterations, together with a high-level view of the use case-specific extensions of the ontology network. This focuses mainly on actors, resources, and information about resources, e.g. in product data sheets or Digital Product Passports (DPP), but also touches upon process modelling and data provenance (traceability).

To create an appropriate set of core ontologies, we first identified the core topics based on the requirements discussed in D3.1 and updated in D3.2. An overview, in the form of an informal

illustration of the ontology network modules is displayed in **Error! Reference source not found.**. Note that the boxes do not represent concepts, but rather areas (i.e. topics), that each are covered by one or more ontology module. The dark blue boxes contain new concept definitions, i.e. modules introduced by our network, while the light blue box (location) indicates reuse of existing ontologies. However, it should be noted that also the newly introduced modules in some cases make heavy use of alignments to existing ontologies. The lines between boxes indicate relations between the topics as mentioned in our requirements set, but are in the actual implementation of the ontology network replaced by formal relations between modules, e.g., in some cases owl:import and/or concept references across module boundaries, as well as alignments and dedicated properties.

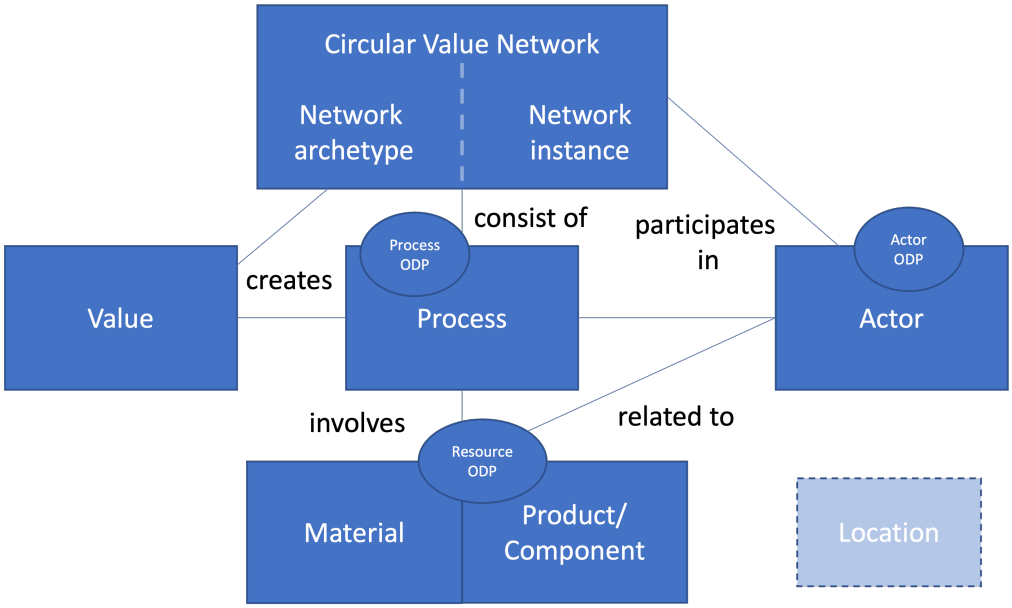

Figure 4 Informal illustration of the core topics of the ontology network.

In our first and second release, we have included three abstract Ontology Design Patterns (ODPs), i.e., modelling the CE-independent abstract notions of processes, actors and resources. The rationale for claiming these modules to be ODPs is mainly that they are entirely independent of the CE domain, i.e., they simply represent patterns of modelling these abstract notions but refrain from including any specific conceptualizations related to CE. Our intention is further to, in future releases, include alignments between these ODPs and top-level and foundational ontologies, such as EMMO, in separate alignment modules. Our focus in the first and second release has been on the central CVN module, and the modules for process, actor, and material/product. The value module is so far not elaborated, partly due to its close connection to ongoing work on standardising CE terminology in ISO/TC 323 (https://www.iso.org/committee/7203984.html). Hence, this module so far consists only of a “stub” for further extension in future releases. Additionally, the materials and product modules, as specialisations of the resource ODP, will be further extended in the next release, due to a limited coverage of the ontology requirements in the current release.

The Actor ODP[5] is at its core a variant of the common participation[6] and participant role[7] ODPs, although where the "event" in those patterns have been interpreted very generic, as any context with a time extent. Hence, the core concept is a participation relation (i.e. a reified relation), named Participation, that relates an Actor, to either a Resource or a Process where the actor is holding a specific Role. The participation may be indexed with time and spatial context. An actor can also be associated with an Actor Type and have a certain Capability, which is used by the participation in a process. The Actor module[8], specialises this pattern by adding concrete CE-relevant roles, both for processes (e.g. collector, sorter, recycler, remanufacturer) and resource relations (e.g. owner, issuer, holder, seller, buyer). An example of a participation in a resource relation is an organisation (actor) that owns (role) a certain batch of recyclable material (resource) at a certain point in time. An example of a participation in a process is an organisation (actor) that acts as the collector and sorter (roles) in a recycling process, as a prerequisite to the recycling.

The Resource ODP[9] is merely a small top-level ontology for resources, identifying two types of resources; Physical Object, and Information. Where physical objects in turn are composed of certain matter and may have some Constituent that is in turn another physical object. The Materials module[10] specialises this ODP by adding Material Component as a subclass of Constituent, and Material and Chemical Entity as subclasses of Matter. This is in line with the top structures of current materials ontologies, e.g., EMMO, to which alignments are planned in separate modules, and allows for modelling of materials at various levels of granularity. The Product module[11] in turn specialises the ODP by adding Product as a subclass of Physical Object and Product Component as a certain kind of Constituent.

These modules are primarily not intended to introduce new notions, as compared to the existing ontologies surveyed in WP3 earlier, but merely cover the aspects relevant for CE, with minimal ontological commitment to maximise reusability, and allow for alignments with existing, more detailed, materials and products ontologies.

The Process ODP[12] distinguishes between a Process and its concrete Process Execution, and also models the composition of processes from other processes and their ordering. In addition, a particularly important kind of process, in the CE context, is a Transformation that takes some input and transforms it to some output, i.e., moves the current state from one situation (context) to another (c.f. the Transition ODP in the ODP portal[13]). In particular, the Process module[14] specialises such transformation processes, and lists the typical processes involved in a CE, such as dismantling, deconstruction, refurbishment, recycling, reuse, and take-back processes, although their detailed transitions are still to be added in future releases.

5 https://liusemweb.github.io/CEON/ontology/actorODP/0.1/index.html
6 http://ontologydesignpatterns.org/wiki/Submissions:Participation
7 http://ontologydesignpatterns.org/wiki/Submissions:ParticipantRole
8 https://liusemweb.github.io/CEON/ontology/actor/0.1/index.html
9 https://liusemweb.github.io/CEON/ontology/resourceODP/0.1/index.html
10 https://liusemweb.github.io/CEON/ontology/material/0.1/index.html
11 https://liusemweb.github.io/CEON/ontology/product/0.1/index.html
12 https://liusemweb.github.io/CEON/ontology/processODP/0.1/index.html
13 http://ontologydesignpatterns.org/wiki/Submissions:Transition
14 https://liusemweb.github.io/CEON/ontology/process/0.1/index.html

The CVN module[15] models a CVN as a kind of Collaboration between actors, that implements some Circular Strategy aiming to produce some Value[16]. An important notion is also the one of a CVN ”blueprint“, which intuitively corresponds to a plan, in the sense of the difference between a plan and its execution (e.g., inspired by ODPs such as Task Execution[17]). Hence, the module intends to make it possible to describe an envisioned value network, i.e. the “plan” or blueprint of it, without knowing what exact actors will fill the needed roles and capabilities. This is important both for use cases where the task is to find such actors to fill certain gaps in the network, but also for being able to describe abstract network blueprints that can act as templates for future instantiation of similar networks, but with potentially different actors.

In addition to these core modules, being part of D3.3-4, the network was since then extended further, to illustrate how this generic CE ontology network can be applied within specific industry domains and use cases. This extension mainly consisted in modules capturing the notions of statements and data sheets, i.e., in order to be able to describe data such as in the research datasets of D6.4-5 as well as its provenance, but in addition also modules for describing quantities and units, to describe the concrete parameter values in such data sheets. To do this we have reused both the W3C PROV-O ontology (https://www.w3.org/TR/prov-o/) as a standard way of expressing provenance, as well as the QUDT ontology (https://qudt.org/) for quantities and units of measure. However, while PROV-O has been imported directly into one of the new modules, QUDT has been partly replicated in our repository and references are used instead, in order to reduce the size of the ontologies while still maintaining the link to the reused ontology.

Based on these extensions we have then modelled one specific example ontology for each use case, for testing the capabilities of the generic ontology network to model also domain-specific concepts and data, and to cover the evaluation scenarios (for textile, construction and electronics use cases) that are available in full in section 2.2.3. For the textile use case, in the first iteration this mainly meant to model product compositions, and amount of recycled material content in components and products, as well as actors and their roles and relations to the product. In the second iteration, the scenario was extended to product breakdowns, provenance and manufacturing and disassembly processes. For the construction use case, in the first iteration this meant to again model the actors, and their relations to the product, as well as specific attributes of the product and individual items and batches, while in the second iteration adding processes, as well as costs. For the electronics use case, the scenario in the first iteration mainly entailed the modelling the product and the subcomponents as well as the data structures resulting from D6.4, while in the second iteration this was extended with material origin and other attributes, as well as traceability. Further details of how the models specify these notions and data examples, can be found in the survey illustrations in Appendix 1, representing the first iteration, as well as in the online documentation or the current version of the use case-specific ontologies (reachable from our CEON landing page). Important to note is that these (use-case focused) ontologies are to be seen as part of the testing and evaluation setup of the use cases, rather than well-deliberated domain ontologies. The current purpose of the

15 https://liusemweb.github.io/CEON/ontology/cvn/0.1/index.html
16 Value could be economic, but also social or environmental value. It is currently only modelled as a stub
17 http://ontologydesignpatterns.org/wiki/Submissions:TaskExecution

use case's specific extensions is to evaluate the general core modules of CEON, rather than to extend the network with domain ontologies – although these are also publicly available, as example usage of the ontology network.

2.1.2 Open Circularity Platform

The Open Circularity Platform (OCP) is an open framework for secure and privacy-preserving digital and automated data sharing, which enables decentralised sharing of data expressed and semantically annotated using the ontologies. The platform itself consists of an extension to the Community Solid Server, as built upon the family of Solid protocols and standards. Further details on the platform can be found in the WP4 deliverables. We provide a demonstrator User Interface (UI) to showcase how the functionalities of the OCP could be used in real-world applications, but this is not to be considered as part of the platform itself. It is rather a demonstrator for evaluation purposes, to illustrate and evaluate various functionalities of the platform itself.

2.2 Methodology

This section describes the methodologies and measures applied for evaluating the ontology network and the open circularity platform, respectively.

2.2.1 Ontology-specific Evaluation Methods

In order to evaluate ontologies, one may take different perspectives. Ontology evaluation may be seen as an intrinsic process, evaluating the internal structure of an ontology. However, most often there is additionally a need for assessing the fit for purpose of an ontology, i.e., extrinsic properties, such as requirement fulfilment, query and reasoning capabilities, and properties indicating the use of best practices and FAIR publishing. The Onto-DESIDE ontology network (CEON) has mainly been evaluated in relation to intrinsic properties, but two use-case-based evaluations have also been conducted, i.e., in the first project iteration in the form of a small use-case survey, and in the second iteration in the form of the usage of the ontologies for modelling the data used in demonstrating the use of the OCP in a set of scenarios, in both cases to gather feedback from the Onto-DESIDE use case partners. In the final project iteration, this part of the evaluation will be further elaborated, together with other extrinsic measures, such as comparison and alignment with existing ontologies and standards, while less focus will be put on intrinsic evaluations and requirement validation.

As mentioned, we have first focused on establishing the intrinsic ontology quality, i.e., establishing that the ontology network is consistent, and has an appropriate structure and semantics, following best practices and standards. Although basic characteristics, like size and depth of taxonomy, in themselves are not quality measures, these are parameters that can be used to at a generic level assess the level of modularity and the balance of minimal ontological commitments versus the size and complexity of modules. Hence, a few general characteristics of the ontology modules have also been gathered to be able to assess the nature of the modules and their relations.

In the two first project iterations, we have evaluated the ontologies using the following dimensions and methods/tools:

Table 1. Ontology evaluation dimensions and methods/tools

#	Dimension	Measure	Method	Tool
1	Ontology characteristics	Size (class, property, instance and axiom counts), depth of taxonomy, import count and external references	Inspection of the OWL code using a tool	Protégé
2	Consistency	Logical consistency	Consistency checking using a reasoner	HermiT reasoner (built into Protégé)
3	Adherence to modelling best practices	See [1]	OOPS!	OOPS! online API
4	Adherence to FAIR principles	See [2]	FOOPS!	FOOPS! online API
5	Requirement fulfilment and coverage	Ability to formulate SPARQL queries corresponding to CQs	CQ verification through manual query formulation	(Ontologies inspected through the online documentation and visualisations)
6	Coverage of use case evaluation scenarios in iteration 1	Degree of satisfaction of the coverage as assessed by domain experts **NOTE: first iteration only**	Assessment of data examples on a Likert scale (optional free text comments), as part of a survey sent to use case partners	Illustrations using the Grafoo notation [4] and MS Forms
7	Understandability of release 0.1 by use case domain experts	Subjective degree of understanding as assessed by domain experts **NOTE: first iteration only**	Assessment of data examples on a Likert scale (optional free text comments), as part of a survey sent to use case partners	Illustrations using the Grafoo notation [4] and MS Forms
8	Coverage and suitability to describe evaluation scenarios in iteration 2	Identification of issues by ontology engineers when modelling data for the use case scenarios **NOTE: second iteration only**	Ontology engineers noting missing, ambiguous, incompatible or insufficient elements in the ontologies when using them to create data mappings for the use case scenarios	Protégé for modelling and text editor for mapping files. Issues are recorded in GitHub issue tracking system.
9	Assessment of specific concepts and modelling solutions in release 0.2	Subjective assessment and qualitative feedback by domain experts **NOTE: second iteration only**	Discussion of specific concepts and modelling solutions, as identified by the ontology engineers as key notions while ambiguous or unclear from scenarios	PowerPoint slides and ontology sketches for illustrating modelling solutions. Discussion in Teams meeting.

The evaluation was practically conducted by researchers from LIU, in the context of WP3, but involved use case partners (dimensions 6, 7 and 9) as workshop and meeting participants, respondents of the survey, and discussion partners for the qualitative feedback. Ontology characteristics and consistency (dimensions 1-2) were assessed by using the Protégé ontology engineering environment, through manual inspection as well as plugins such as the HermiT reasoner. Furthermore, the two popular "quality checkers" OOPS! [1] And FOOPS! [2] were applied to detect violations of best practices (dimensions 3-4) in ontology modelling and publishing. The results of these validators fall into different categories, where some are merely information, or "warnings", while others are clear "errors". Examples of warnings may be missing restrictions in the ontology, such as domain and range. While this may in some cases be an error, it may also be a design decision to leave the domain or range of a property open, for increased reusability of the property, and resulting ontology. Hence, while we report all the findings of these tools in the next sections, not all of them should be interpreted as errors, but merely as observations that need to be carefully considered.

Regarding the requirement fulfilment (dimension 5), we have chosen to apply a testing method similar to [3] where the Competency Questions (CQs), i.e., requirements of the ontology modules, are verified by being formulated as SPARQL queries. However, since we do not have actual data corresponding to the answers to such queries (i.e. neither D6.4 or D6.5, our research dataset, currently covers all the CQs in D3.2) we have for now settled for testing whether it is possible to formulate a SPARQL query that in our opinion corresponds to the CQ, rather than also adding actual test data and running the query. The reason is that for doing the latter, we would have to also create "example data" (synthetic data modelled according to the ontology) ourselves, which would introduce a large bias, and we would likely not find many more mistakes by doing that. Instead, we envision that in the final project iteration, when the research dataset has been extended, we will be able to run the queries, but at the current point we do not see the benefit of that added effort.

As a second part of the evaluation, feedback on the ontologies was gathered based on a set of use case scenarios (dimensions 6-9), representing parts of the mapped flows in each use case. This evaluation took a slightly different form in the first and the second project iterations, however, the aim was the same – to validate the ontologies against real-world use cases, achieve and understanding and qualitative feedback on understandability, usability, and suitability of modelling choices and terminology, as well as to gather suggestions for improvements both from ontology engineers and domain experts.

For the first iteration, this meant gathering feedback in terms of the two dimensions (6 and 7) in the table above, i.e. the coverage of the CEON release 0.1 of the use case scenarios outlined for the first evaluation phase (see chapters 5.1.1 and 5.2.1 of the previous version of this deliverable, i.e., D6.7), and their understandability by the domain experts involved in the use cases. This feedback was gathered in two ways; (1) by conducting an in-person workshop at the consortium meeting in September 2023, and (2) by circulating an online survey to all use case partners after the consortium meeting. The two scenarios, i.e., one representing the first iteration of the textile use case, and the second one for the construction use case, described a small set of actors, as well as concrete data examples to be used for evaluating the platform and the ontologies jointly. For the electronics use

case no scenario was provided, hence, the starting point of the evaluation was instead the use case description itself, together with the data structure outlined in D6.4.

With respect to (1), the workshop was conducted in 2 groups of 3-4 use case partners being present in each group. Then the overview of the ontology network was first presented, together with an introduction to the notation used in ontology and data illustrations, whereafter a short discussion was held around one specific example (showing a part of the ontologies together with example data). The example used for discussion can be found in Appendix 1. Feedback from the use case partners was noted (by taking written notes of the discussion), both regarding the understandability of the example and the notation, as well as on the concrete modelling choices themselves. This feedback, and experiences from the understandability of the notation and examples were then used when creating the online survey.

With respect to (2), the online survey was created in three different versions, i.e., one per project use case. Overall, the three surveys cover mainly the same modelling choices and patterns, but illustrated with data examples from the evaluation scenarios outlined by the respective project use case. This was done in order to allow the use case partners to easier understand the ontologies, in terms of their usage with data related to their own industry domain, in turn gathering more feedback and better-grounded suggestions from the respondents. The focus was on evaluating the choice of core patterns, representing modelling choices, that underlie the whole ontology network. The three surveys can be seen in Appendix 1. And the evaluation scenarios outlined in each project use case are in Appendix 2.

As mentioned, this evaluation was not repeated as-is for the second project iteration. For two main reasons: the first being that the ontologies and the platform now were ready to be evaluated together, i.e., in terms of mapping actual data from the use case (dimension 8), using the ontologies, and then uploading and querying this through the platform (dimension 9), and the second being that the core notions and patterns are the same since iteration 1, and were already evaluated with the use case partners then (see above). However, similar to the first iteration, some scenarios were agreed with the three use cases, in order to select a subset of the mapped flows from D6.2 and describe a concrete example setup based on these, including sample data. Based on these scenarios, two dimensions were evaluated, i.e., on one hand the coverage and suitability for describing the sample data in the three scenarios (dimension 8), from a data modelling and ontology engineering perspective, and on the other hand subjective assessments and qualitative feedback from domain experts on specific modelling choices and terminology of the ontologies (dimension 9), i.e. a more specific set of concepts and modelling choices than in the first iteration. This feedback was again gathered in two ways, i.e.: (1) by letting the ontology engineers and data modellers (from LIU and IMEC respectively) record any doubts, ambiguities, and potential missing or erroneously modelled aspects in GitHub issues while attempting to describe the sample data, and (2) by identifying specific modelling choices, concepts and properties of the ontologies (while performing step 1) to be discussed with domain experts, and then use simplified illustration and PowerPoint slides to present these potential issues to the domain experts during the platform demonstrations in (online) meetings with each use case. In addition to this, the ontologies also play a crucial part in the demonstration of the platform itself, enabling the data sharing demonstrated. However, the result of the latter mentioned demonstration is presented under the platform evaluation sections.

2.2.2 Open circularity platform-specific evaluation methods

The technical evaluation of the current iteration of the OCP entails a functional evaluation. This evaluation focuses not on the platform's capacity to operate in a production-like environment, but rather on two criteria: (i) the provision of functionalities, and (ii) alignment with expected requirements of the use case members.

The testing of the OCP required consolidating all requirements that the industrial partners and the software/methodology providers have for the OCP. This entails concrete user needs that have been defined in user stories for each of the industry partners and revolve around practical aspects that a user faces when logging into the OCP and using it. It also entails the technical requirements that the data-sharing platform operators encounter regarding the interoperability of their software platforms with the OCP. These consolidated requirements were combined from previous deliverables and provided by WP6 members. We list below the main sources of our deliverables:

- D2.2 Project requirements specification and research methodology – Report v2: Functional Requirements in the form of User Stories.
- D2.2 Project requirements specification and research methodology – Report v1: Non-Functional Requirements.
- The Application testing scenario as presented in D6.7.
- Qualitative feedback of the WP6 members during the September 2023 consortium meeting.

After integrating this input, we categorized the individual requirements into the following categories:

- Authenticate: Initiate a secure session with the OCP to interact with your and other actor's data.
- Input: Add, update, and delete information in the OCP.
- Interoperable Data: Use FAIR data models such as WP3's CEON.
- Reference: Allow permalinks to individual data pieces
- Query: Retrieve specific data from one or more actors in the network.
- Calculate: Calculate derived information from existing data in the OCP (e.g., for Lifecycle Assessment).
- Notify: Receive notifications when data changes.
- Share: Request for and grant access to specific pieces of data.
- Validate: Validate that the retrieved data is genuine and has not been tampered with.
- View: Create custom views on top of existing data sources.
- Reproduce: Provide well-documented open-source code and APIs.
- Ethical: Align the OCP with ethical regulations such as GDPR
- Performance: Have a scalable system that can recover from calamities.

In Appendix 2, you can find the respective tables integrated in this deliverable, cross-referenced with the above-mentioned categories. This appendix consists of the consolidation and categorization of the requirement definitions from the User stories (Appendix 2.1), Non-functional requirements (Appendix 2.2), Application Testing Scenario (Appendix 2.3), and Qualitative feedback from the consortium members (Appendix 2.4) and gives them codes that are used in the following

subsections. The results of how we adhere to this group of requirements are detailed in the next section.

2.2.3 Combined platform evaluation methods

As mentioned earlier, in the second iteration of this evaluation, the ontology network and the platform were evaluated together, by applying them to the three project use cases. In each use case, a scenario was described, as a subset of the mapped flows from D6.2, accompanied with sample data, also provided by the use case partners. The purpose of these scenarios was on one hand to select, and connect, a subset of the user stories from WP2, but also to concretize them into executable examples. For instance, by specifying a precise set of named sample actors, as well as concrete products, processes, materials etc. This in order to allow for verification of the scenario implementation, with sample data. In the subsections below, we detail each of these scenarios further, and a set of PowerPoint slides that were developed to illustrate the steps in each scenario can be found in Appendix 3.

For each scenario, with its sample data, ontology and data engineers from LIU and IMEC then attempted to map this data into the ontology structure provided by the release 0.2 of the CEON network, together with extended versions of the use case specific demonstration ontologies. In this process, each use case-specific demonstration ontology was extended to cover the specific data elements required by the scenario, specialising or directly using the core CEON concepts and properties. This process served as a validation of the description capabilities of the core CEON modules, as well as an opportunity to identify any ambiguities or other issues in the models.

Once the sample data had been modelled, it was broken up into a set of data subsets assigned to each actor in the outlined scenario. An input procedure was envisioned and setup for each of these data subsets, e.g., how an actor would load that data into the platform, for instance, by importing a CSV-file or by gathering the data through an API call and then transforming and uploading it. This also included setting access rights for each data subset, according to the way the scenario was described.

Subsequently, IMEC developed SPARQL queries representing each of the information requests or transfers in the scenario descriptions, and set up the corresponding Solid pods to hold the data of each scenario actor. Finally, the data was loaded into this demonstration setup, and each query was pre-loaded into the demonstration user interface.

At this point, a meeting was held with each of the project use cases, in order to demonstrate the setup and run through the scenario together. In this meeting, the data loading process and the setup was explained by IMEC, and then the scenario was demonstrated through showing each actor's view in the demonstration user interface, and showing each scenario step, as represented by the pre-loaded queries and sample data. Throughout these meetings, the use case partner representatives were encouraged to ask questions, and provide any additional feedback in a think-aloud fashion, in case anything was unclear, or not exactly as they would have expected. Finally, each meeting ended with a specific discussion on some ontology-related questions and issues, which has already been described in the ontology-specific methodology sections.

Construction use-case scenario: For the evaluation scenario, the needs of the various stakeholders were brought together in order to obtain a holistic overview of the use of the platform in the construction sector. The manufacturer plays an important role in passing on the data to other stakeholders. This gives building owners, dismantling companies and recyclers access to the product characteristics and treatment of the product (e.g. for end-of-life options, dismantling instructions or recycling). Building owners can share their information about the building and the conditions under which the products are to be reused or recycled. To retrieve data on the sale of the product via a marketplace, the sales prices from the marketplace can be retrieved from the dismantler, for example. Overall, all options for the End-of-Life (EoL) of the product can be explored to provide the building owner with a basis for choosing the best EoL scenario in terms of environmental and economic impact.

More in detail the construction use case scenario developed for iteration two, involved 5 main actors sharing and consuming data using the platform. A floor manufacturer turns raw materials and components into a floor system, where data about this product is then published and shared using the open circularity platform. Subsequent actors in the scenario can at any time access and query this data directly from the manufacturer. A building owner then uses this floor system in a building, whereas data about the location and integration of the floor system in the building is made available from their side (to selected actors of the network, with appropriate access control). When the floor is to be replaced, a dismantler is used to remove it from the building, and the resulting components may be either offered for reuse, using an online marketplace such as the Concular platform, or recycled for material reuse. This scenario thus involves a number of interactions between these actors, requiring both appropriate access control as well as data access and querying. A more detailed illustration of the scenario can be found in the Appendix 3.

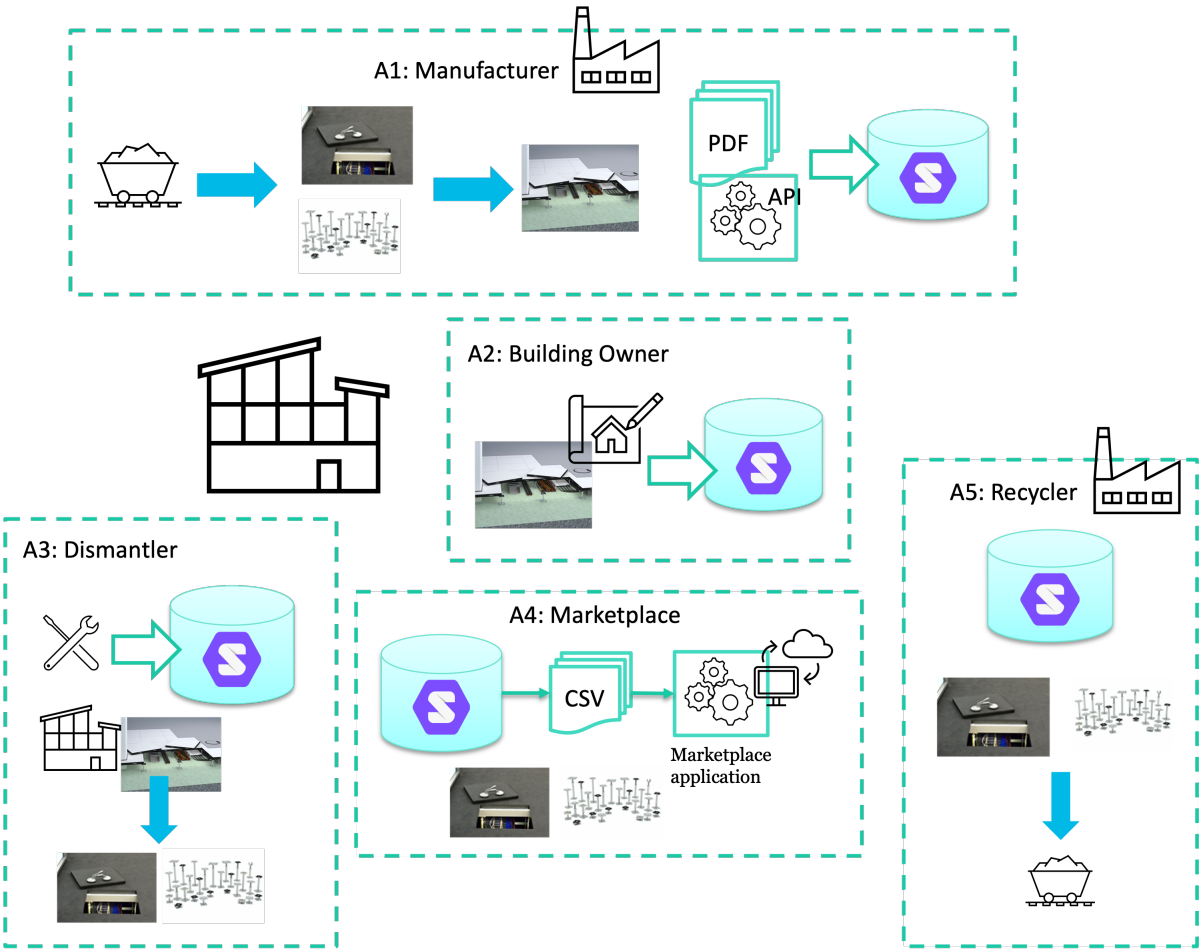

Figure 5 - Summary of the actors and processes involved in the evaluation scenario of the construction use case.

Electronics use-case scenario: For the evaluation scenario, the needs to complement a traceability platform such as the one offered by Circularise was considered. Certain traceability data, collected from the supply chain of a product, will already be present through the CIRC API. However, the OCP can be used to collect additional data from actors not on the CIRC platform, and for data currently not covered by that platform. In this scenario, supply chain resilience and diversification were used as a motivating example for collecting data on material and component origin from the supply chain. For instance, a supply chain could be considered more resilient if there are several redundant origins, and if the origin of materials and components are not in parts of the world involved in current, or potential near-future, conflicts. In addition, the scenario involves collecting information about REACH compliance, rare earth content, and the amount of recycled content in a product, by collecting information from the supply chain. Not all of this is currently covered by the CIRC platform, hence it presents a realistic scenario for combining CIRC API calls with collecting data published on the open circularity platform. An overview of the actors involved in the scenario is presented in Figure 6, and for more details on the scenario see the Appendix 3.

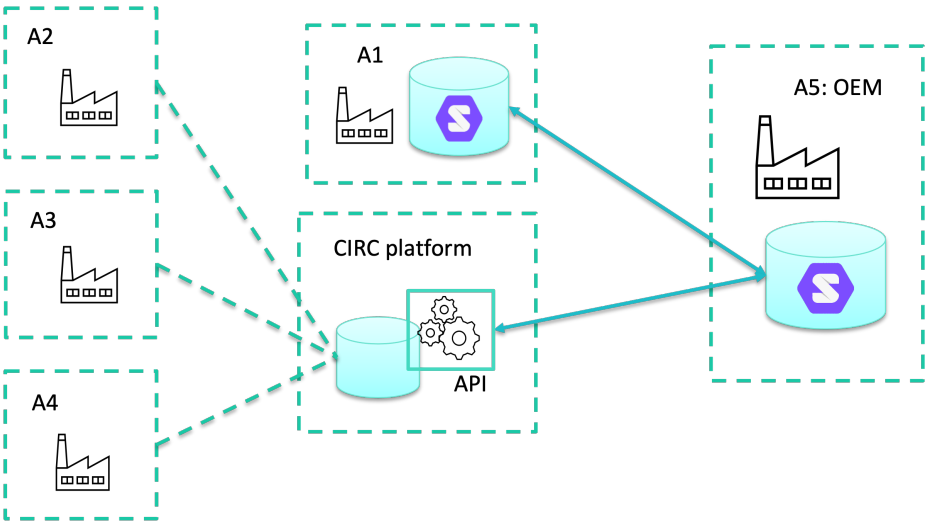

Figure 6 - Summary of the actors and processes involved in the evaluation scenario of the electronics use case.

Textile use-case scenario: For the textile use case, the scenario focuses on manufacturing and recycling of shoe components. In order to fulfil the data sharing needs of actors in the textile industry, the use of the OCP is tested for facilitating the exchange of product information including product composition, presence of hazardous substances, disassembling instructions, etc. Certain aspects of this data are strictly confidential, such as the detailed material content of a textile product. However, by using appropriate access control on the shared data, this can be restricted to the partners in the circular value flow setup, rather than published openly. In this specific scenario, four fictive shoe component manufacturers are used (A1 to A4, in Figure 7), who share data about their respective components, e.g. textile uppers, soles, laces etc. The shoe manufacturer or brand (A5 in Figure 7) can access this data when buying their components and integrate this into their data sheet about the complete shoe. Generally, the shoe manufacturer and the brand are two separate actors, but for testing the platform, the number of actors has been limited, by simplification. At its EoL stage, the used shoe is being collected by a collector, which needs to retrieve some of the data from the manufacturers, e.g. to perform correct disassembly, and choose an appropriate recycling process for the components. In reality, the collector refers to the company which collects the used shoes and is also in charge of the EoL treatment of shoes and preparation for recycling of shoe materials. The actual recycling process of materials from used shoes is done by the recycling company. In our case, the function of collector and recycler are assumed to be done by a single actor (A6 in Figure 7). The recycler subsequently shares data about the new, recycled, materials that they provide to their customers, for further use in other products. A summary of the actors involved in this scenario can be seen in Figure 7, and more details are available in the Appendix 3.

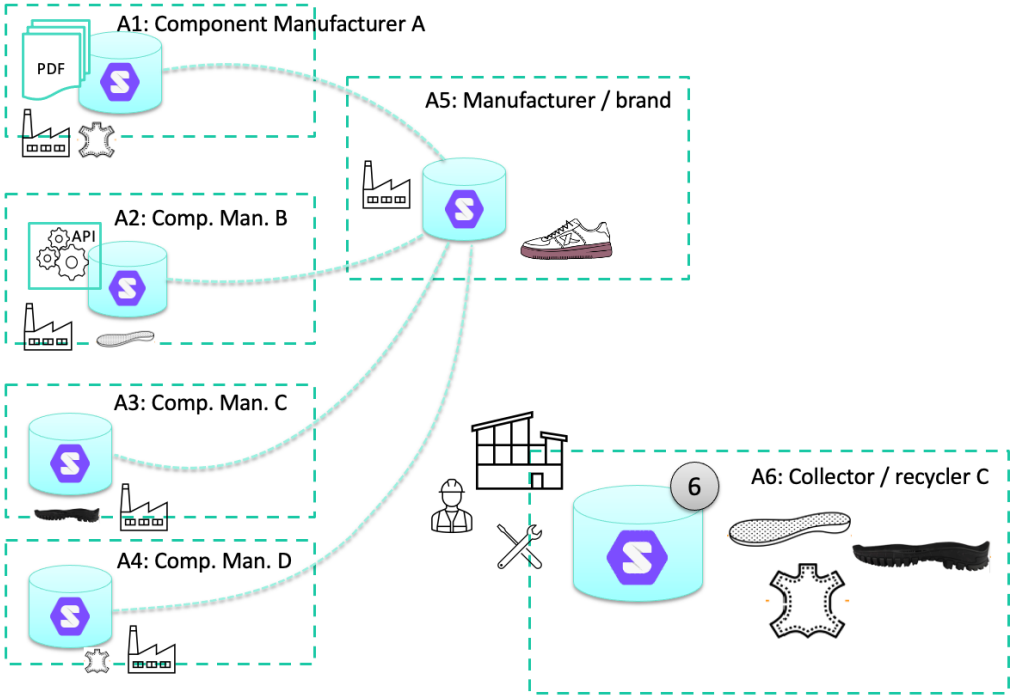

Figure 7 - Summary of the actors and processes involved in the evaluation scenario of the textile use case.

2.3 Results

In this section we describe the results of the technical evaluation, as outlined in the methodology section previously.

2.3.1 Ontology technical evaluation results

In this section we describe the results of the first 5 dimensions in the table of ontology evaluation measures (Table 1). The results of each of these evaluations are presented in the tables below (Table 2 and Table 3), for both the first and second project iteration.

Table 2. Technical evaluation results – Ontology characteristics and statistics

Ontology module title & version	Class #	Object Property #	Datatype Property #	Indivi-duals #	Total axioms #	Max Depth of Taxonomy	import #	External ref (module #)
Actor 0.1	18	2	0	16	255	3	1	3
ActorODP 0.1	7	9	3	0	93	2	0	3
CVN 0.1	4	7	3	0	313	3	1	2
Material 0.1	5	2	4	0	98	3	1	0
Process 0.1	25	4	0	0	181	3	1	1
Process ODP 0.1	5	10	0	0	76	2	0	0
Product 0.1	2	1	0	0	69	3	1	0
Resource ODP 0.2	5	2	0	0	42	2	0	0
Value 0.1	2	0	0	0	15	1	0	0
Actor 0.2	18	2	0	16	273	3	1	3
ActorODP 0.2	8	11	3	0	111	2	0	3
CVN 0.1	4	7	3	0	333	3	1	2
Material 0.2	21	2	4	0	185	5	1	0
Process 0.2	25	4	0	0	133	2	1	1
Process ODP 0.2	6	14	1	0	100	2	0	0
Product 0.2	4	6	1	0	161	3	1	2
Resource ODP 0.2	9	8	0	0	95	2	0	0
Value 0.1	2	0	0	0	15	1	0	0

As can be seen in the table above, the 0.1 versions of the ontology network modules were quite small, i.e., between 2 and 34 classes, with 0 to 18 object properties defined in each one. The versions in the 0.2 release are not much larger, but it should be noted that some extensions were made in response to the evaluation results in D6.7 (first iteration evaluation). The modules with the suffix "ODP" constitute the most abstract of the core modules, only representing some core modelling patterns without any CE-specific concepts. Hence, they are also the smallest modules. The exception is the Value module, however, this is not to be considered a complete module, but it's still only a "stub" for further development. The taxonomical depth of the modules is also quite small, where 1 means that all classes are direct subclasses of owl:Thing, and 2 means that there is a second level in the taxonomy below that. The inclusion of concrete individuals in an ontology is not uncontroversial, however, in this case, they represent specific roles that can be taken by Actors in a CVN, such as recycler, reuser, issuer (e.g. of a datasheet), owner (e.g. of a resource) etc., as well as specific CVN processes, sometimes called circular strategies, such as recycling, refurbishment, reuse etc. Hence, these are not considered to be at the data level, but rather a commonly accepted set of possible roles and strategies applied in a CVN. The reason for modelling these as individuals rather than classes is that they can then be used as values for object properties in an RDF dataset structured according to the ontology.

In addition to these basic characteristics, the table also illustrates the modularisation strategy, where each ODP is a basic building block, with no imports, while the other modules import at least one other module/ODP (except the value stub again). However, the imports are not covering all dependencies between the modules, hence, we also show the number of external references (except annotation properties and language references, such as OWL and RDFS). This is an indicator of to what extent the modules in the network are decoupled from each other, and what effects changes to the network might have. Perhaps not surprising, it is the CVN and Actor modules that have the most dependencies. This is due to the fact that a CVN obviously involves both resources, value, and actors, and regarding the actor module that actors can be involved both in processes and have roles in relation to resources. While such dependencies of course cannot be avoided entirely, it is still concluded that the number of dependencies introduced so far is certainly manageable, and the network seems to have a reasonable decoupling of its modules.

Next, the HermiT reasoner (version 1.3.8.413, built-in to Protégé) was used to check the consistency of the ontology modules. No inconsistencies were discovered, and no unexpected inferences were noted when going through the list of inferred axioms manually (neither in the first nor the second release of the ontology network).

Table 3. Technical evaluation results – OOPS! and FOOPS

OOPS! - # pitfalls detected

	Release 0.1 (first iteration)			Release 0.2 (second iteration)		
Ontology module	**Minor**	**Important**	**Critical**	**Minor**	**Important**	**Critical**
Actor	18	6	1	2	2	1
ActorODP	14	4	1	2	2	1
CVN	29	7	1	2	2	1
Material	10	5	1	4	2	1
Process	40	10	1	2	2	1
Process ODP	15	6	1	2	2	1
Product	5	1	1	2	2	1
Resource ODP	4	1	1	2	2	1
Value	2	1	1	1	1	1

	FOOPS! validator %	
Ontology module	1st release	2nd release
Actor	70	74
ActorODP	61	74
CVN	60	73
Material	68	69
Process	64	74
Process ODP	70	74
Product	72	76
Resource ODP	65	70
Value	60	72

Using the OOPS! and FOOPS! pitfall scanners, we have then assessed the extent to which the ontology modules follow best practices. In the tables above, the overall results can be seen, both for the first and second evaluation iterations. Regarding the OOPS! results in the first project iteration, the critical pitfall detected in all the ontologies was an apparent mismatch between the ontology ID and its permanent URI. This was an issue that was not correctly identified by OOPS! Since the ontology is in fact correctly identified in the file. Nevertheless, an issue was created in our GitHub repository, and the reason was laterinvestigatedfor this pitfall being triggered, despite the file being correct according to manual inspection. After investigation, this seems to be an issue related to the way that our w3id permanent identifier is being redirected, including the version IRIs of the ontologies, and hence, this has unfortunately not been possible to resolve for the second iteration. However, all the IDs do resolve correctly, hence, we will investigate if this could even be a bug or ambiguous pitfall in OOPS!, by contacting the OOPS! team in the coming months. In terms of the "important" pitfalls, every ontology module triggers the pitfall "missing disjointness", since at this point no module contains any class disjointness axioms. This is a design decision of the current modules, which may be changed in the future. The other "important" pitfalls are all missing domain and range restrictions on properties. Again, this is a design choice that has been made for these core modules, that contain many abstract properties. For instance, properties such as hasPart and hasConsistuent could be applicable to many different kinds of classes, hence we have intentionally left the domain or range open, and instead added subclass restrictions on classes where the

properties are intended to be used. Nevertheless, we still added a GitHub issue for this after the first project iteration for checking each of these pitfalls triggered, and as can be seen in the second iteration some of these domains and ranges were actually added, reducing the number of triggered pitfalls. Finally, the minor issues consist of missing annotations, missing inverse properties, and unconnected ontology elements. The latter is due to the modular nature of the ontology network, where sometimes a module merely defines a class, that is then not used (e.g., mentioned in any axiom) by that ontology module, but instead used in more specific modules. While missing annotations (i.e. missing documentation of ontology elements) is definitely a bad practice, and as can be seen this was fixed for the second iteration, after again adding GitHub issues to fix these missing annotations. The missing inverse properties are again a design choice rather than something actually missing. Inverse properties add complexity (even in a logical sense) to the ontologies and have deliberately been omitted, unless explicitly needed.

Regarding the FOOPS! validation, the main issues in the first iteration again pertained to the ontology URIs, i.e., see the pitfall discussed above, which needed further investigation, and while we have confirmed that all URIs and version IRIs do resolve correctly, this pitfall is still triggered also here. Another common pitfall discovered in all modules is the lack of registration in ontology registries. This is however on purpose, since our ontologies are not yet stable and properly evaluated, they have also not been registered in public repositories (neither prefix ones nor metadata registries). The remaining issues in the first iteration pertained to missing metadata and provenance of the ontology. However, some of the missing elements were present in the ontology files, e.g., license information, but were apparently not detected by FOOPS!. In these cases we investigated why this was the case, and only in the case of actually missing data we added a GitHub issue to fix the problem. Where again we can see that the percentage of FAIR coverage has gone up for all modules from the first to the second iteration.

The final non-use case focused evaluation perspective is the validation of ontological requirements using SPARQL queries, i.e., formulating the CQs in D3.1-D3.2 covered by each ontology module as a SPARQL query using the ontology as its vocabulary. The results of this evaluation can be seen in the table below:

Table 4. Evaluation results - SPARQL-based CQ verification in the first iteration

		Single module			Network coverage		
Ontology module title	# CQs	# CQs covered	# CQs partly covered	# CQs not covered	# CQs covered	# CQs partly covered	# CQs still not covered
Actor	4	2	2	0	4	0	0
ActorODP	14	3	10	1	11	3	0
CVN	8	5	1	2	5	1	2
Material	9	8	0	1	8	0	1
Process	2	1	0	1	1	0	1
Process ODP	13	4	4	5	8	3	2
Product	7	4	3	0	4	3	0
Resource ODP	11	10	0	1	10	0	1
Value	0	-	-	-	-	-	-

For the first ontology release, each ontology module (or ODP) was at the time of development annotated with a number of CQs that it intends to cover (# CQs above), according to the ontology engineer developing it. When attempting to formulate SPARQL queries to test each such CQ, the success of this task was assessed on the scale “CQ covered” (when the SPARQL query could

obviously be formulated given the vocabulary referenced in, or imported by, the module being tested), “partly covered” (when the concrete terminology was not present, but for instance more generic concepts and properties were available, or a small part of the CQ was not modelled), or “not covered” (when some aspect of the CQ was obviously missing, or a completely different terminology had been used). Two assessments were made, i.e., whether the query could be formulated using only the module being tested, and secondly whether it could be formulated when taking into account the whole ontology network built for D3.3. In the second iteration, instead we checked all of the CQs formulated in D3.2, not only the ones claimed to be addressed by the modules. Resulting in a more comprehensive overview of the extent to which the network covers our ontological requirements.

As can be noted, in the first iteration, most of the CQs claimed to be covered by each module could indeed be formulated as SPARQL queries over that module. However, for a substantial amount of CQs there is some specialisation of the concepts needed to be able to formulate a query exactly using the terminology of the CQ. Hence, the substantial amount of partly covered CQs in the first iteration, when looking at each module independently. An example of such an issue occurred in the ActorODP, which only models resources in general, but where some of the partly covered CQs mentions more specific resource types, such as products and materials. This is illustrated by the number of partly covered CQs being reduced to 3, when instead considering the whole ontology network, where the Product and Materials modules obviously include such more specific concepts. A conclusion that can be drawn from this analysis is that a more careful annotation of modules with their respective CQs should be made (and has been considered for the second iteration), but that the overall coverage of CQs aligns well with the intended set of CQs for the first release of the ontology network.

However, looking more in-depth into the CQs that are still not covered, even when considering the whole ontology network, we did find some aspects that were still untreated. In the CVN module we found two uncovered CQs. One was related to modelling the value provided by different actors in a CVN, where we have so far not modelled value in enough detail to solve this CQ. This also holds for the second iteration, since the definition of value is still under discussion. The other one was due to an ambiguous CQ, “What is the type of this CVN?” where it is not clear what is meant by type. Assuming it means the strategies implemented by the CVN, this can be answered by the module, but given that this is not clear we chose to mark it as not covered in order to investigate this question further, and it has in fact been reformulated in D3.2 A similarly ambiguous CQ could be found for the Process ODP, which stated “What are the resources of the current input?”. At the moment an input to a process IS a resource, hence it does not make sense to ask for the resources OF the input. This question should be clarified further and has been reformulated in D3.2. The remaining uncovered CQs were related to the detailed characteristics of products, e.g., quality characteristics, quantities of the product composition, and similar aspects. These were aspects not included in the general core ontology modules at this time, but which are for the time being instead present in the use case specific extensions, which is still the case for the second release, however, give the current evaluation results, these will now be lifted from the demonstration ontologies to the core network in the third release(see discussion below).

In the second release, as mentioned we now checked the complete set of D3.2 requirements to get a more comprehensive overview of the requirements coverage. In D3.2 there are four subsets of

requirements, i.e. the generic CE-requirements, and one set of requirements derived from each of the use-case specific user stories of D2.2. The main focus of the ontology network is to cover core CE notions and bridge more domain-specific ontologies. Hence, the CE requirement set is the one we would expect to directly cover with the core modules by the end of the project. However, using the core modules, we should also be able to construct more specialised ontologies for the use case specific requirements. Hence, in this second iteration, we have performed the requirements verification task over all the CQs from the four sets in D3.2. However, in terms of evaluating coverage, it is mainly the CE requirements that are interesting, as presented in Table 5 below.

Table 5. Evaluation results – SPARQL-based CQ verification in the second iteration

	Total	Covered	Partly	Not covered
CE questions	90	16	33	41
Construction questions	72	17	29	26
Electronics questions	65	18	14	33
Textile questions	46	5	10	31
Total	273	56	86	131

Overall, we cover (completely or partially) about 52% of the total set of the requirements elicited, and just above 54% of the core CE requirements. When analysing this more in detail, there are two main areas left, regarding the CE core requirements; energy and value. Currently, we have not treated the energy concept, nor any of its related CQs, such as what energy is used in processes, amounts of energy, kinds of energy of a value network etc. The reason for this lack in coverage is mainly that energy was not a concept in focus in the requirements and value chain mappings of the first project iteration, but appeared in the second iteration. This led to the fact that we have so far not done a comprehensive survey of existing energy ontologies, nor assessed what energy concepts should be included in CEON, and what should be left as mappings to existing ontologies. This will be a topic of study during the third and final project iteration.

The value concept on the other hand has been identified as a central concept from the start, but in this case it is not well defined in the domain. What value should be discussed in relation to CE and value networks is still an open research question in the CE research area, whereby it is difficult to design an ontology that corresponds to such a concept. Hence, in this case CEON will follow current emerging standards and definitions, but most likely this research will not be finished by the end of the project, and hence the CEON value module will still be preliminary even in the final release.

The remaining uncovered CQs belong to a small set of modelling problems that still must be considered in the final project iteration:

- To what extent should the ontologies support reasoning on plans and executions? There are several CQs that indicate the need for assessing if a plan can be executed successfully with the given resources, whether a plan has been successfully implemented, etc. However, such reasoning is logically complex using the OWL language, and would add excessive logical complexity to the ontologies. Whereby we will most likely choose to slightly modify the CQs instead, to indicate the presence of data that can be used to make such assessments, rather than indicating that the assessment should be made by the ontology itself.

- Quantities and units of measure are required for several CQs, that involve asking for concrete data about products, components and materials, amount of certain material contents etc. However, currently the core CEON modules do not include these notions. Instead we have used the QUDT ontologies about quantities and units, when modelling the use case specific data. However, given the number of CQs requesting these notions, we will lift the alignment and use of QUDT to the core CEON modules, instead of the use case demonstrations, in the next release.
- Similarly, several CQs request the provenance, both of materials, components and products, but also for the information itself, while this is currently only modelled (reusing the PROV-O) at the use case ontology level, and not in the core CEON. Again, these notions will be lifted to alignments with the core CEON modules in the next release.
- Finally, the notion of preconditions and postconditions need to be included in CEON, since a few CQs also involve the conditions for when a CVN can be successfully set up, or the preconditions of a process being executed etc. Currently only input and output of processes are modelled, but not their preconditions, for instance.

Regarding the sets of requirements originating from the use cases, i.e. the construction, electronics and textile CQs, it should be noted that the aim is not to cover 100% of these CQs. Instead, the aim is to cover the intersection between these three use cases, i.e. the cases where the same, or very similar, CQs appear in all three sets of requirements indicating that those are generic cross-domain CE requirements. We note a small set of such CQs that are not yet covered by CEON, including the following notions:

- Costs and market-related concepts, i.e. being able to use the platform to request and offer resources, including the questions of whether there is a demand for a certain resource or service.
- Location and temporal information at varying levels of granularity, in order to support the logistics of a CVN in operation. The current location model in CEON is too simplistic, and timestamps are generally not present, although the core model is designed to support such extensions.
- Links to additional information, such as manuals, instruction documents, as well as certificates and supporting information about testing and quality assurance procedures. Not all of this data may be available in a structured form, hence links to supporting textual documentation are still necessary.
- CE metrics and other standardised sustainability parameters. For instance, certain emerging standards, such as the PCDS, contains entries for the amount of recycled content that is included in a product. When a full trace of the material content and origin is disclosed, this may be derivable from the supply chain. However, in most cases those details will not be public and only aggregated information is made available according to schemas such as the PCDS.

2.3.2 Coverage and understandability of the ontology network– first release

As a first step, in the first project iteration, the ontologies were discussed in a workshop at the consortium meeting in September 2023, using the material shown in Appendix 1. In this workshop, an example illustration was shown and feedback both on the modelling itself but also the understandability of the example was gathered. Overall, the result of the discussion was that the

software providers among the use case partners could very well relate to the notation and examples and could also compare the modelling examples to their internal data models. In this way they were able to comment on a) the relation between the example shown and their internal models and data structures, and b) to some extent assess the coverage and usefulness of the excerpt of the model shown. Overall, the correspondence to their internal models was high, although also some minor differences in modelling and terminology could be identified, and the examples were found useful. For the non-software providers, e.g., recycling companies, material and product producers etc., the modelling examples were harder to interpret directly but had to be explained and discussed more than evaluated directly. Although some missing parts were pointed out, also all these partners found the examples interesting and probably going in the right direction.
Concrete comments from this workshop included the following detailed feedback on the modelling example:

- Some data will need to be captured on the product level, while other data needs to be captured on the item or batch level.
- In the construction case some data will be captured on the product level, but some will also be available only at the level of a whole building (i.e., a large composition of lots of products).
- What is considered a product and what is a constituent is highly context dependent, and it must be possible to describe such contexts in detail.
- Roles may need to be more detailed, e.g., in relation to owning data – who is allowed to access or update data?
- Certification is not only done per product, but also per organisation (actor), e.g., a manufacturer can be certified according to a certain standard.
- Quantities of materials are essential to capture, and as it goes through a process the amount of recycled material goes down as the material is combined with other things to form a product. It should also be clear that the amount of a certain (recycled) material that is contained in a product is only a claim, and not necessarily the objective truth.
- There is a need for flexibility of datatypes for certain parameters, in some cases this should not be fixed beforehand.

There are some parameters that are quite static, while others are highly dynamic and will change during the product's (or material's) lifetime. Whether such changes have to be recorded or not is dependent on the use case, and to some extent the context (e.g., different legislation).

- It is important to keep models "minimal" in order not to cause an information overload.
- A suggestion was to evaluate the ontologies against the data in a bill of materials for a product.

The full evaluation surveys that were then sent to use case partners after this workshop session can be seen in Appendix 1. The total number of respondents was 7, distributed over 1 respondent for the textile use case, 4 for the construction one, and 2 for electronics. However, this should be interpreted considering that it was also suggested to the use case partners that they could discuss and fill out the form together, rather than individually. Hence, while the textile use case chose to submit one form with a shared view, the construction and electronics use cases submitted the form individually. Consequently, we do not report on absolute numbers of responses here, but merely point out interesting trends, outliers or comments.

The first question in each form asked for the familiarity and confidence of the respondents with the notation used in example figures, after being provided a short-written example and a graphical

illustration. The responses range from 2 to 5 on the scale where 1 signified “not very confident at all” and 5 “completely confident”. Hence, replies should be interpreted with the fact in mind that most of them are not completely confident in interpreting the examples notation, however, at least most are to some extent comfortable with the examples.

The second question in each survey then concerned the basic participation pattern underlying the modelling both of relations between actors and resources, with their roles, participation in processes and networks etc. This pattern was perceived as mostly clear by a majority of the respondents, although one mentioned that the pattern did not really make sense (selecting “quite poorly”) and two that they did not understand the pattern very well (“quite poorly”). One respondent also commented that the provided example did not align with their internal data structures, which is a valid comment, but which is also not necessary given that it will still most likely be possible to provide an alignment between the structures despite them not being identical to start with. Nevertheless, the ratings if this question is also most likely due to that this is a quite abstract pattern, where the usage does not really become clear until the following questions, where the respondents also have consequently given the modelling solution better ratings.

There were however some comments around the notion of a role, mentioning that roles were not clearly defined in the ontology, i.e., what it means to be a supplier of something, for instance, and how that differs from being the manufacturer etc. Another comment was concerning the fact that there was no role hierarchy in the ontologies, which was requested. This arises from the fact that roles are currently modelled as individuals in the ontology, which has its benefits and drawbacks, and which should be considered further. However, it does allow for an actor to have multiple roles, even in the same context, which was also noted in one of the comments.

The following questions, around more specific uses of the basic participation pattern, were found much clearer than the basic pattern itself, as was the next example showing how the pattern can be used to model products and their components.

The following section of the survey concerned the way that the ontologies modelled statements and collections of statements, such as a data sheet. This part seemed to be quite clear to most of the respondents, and comments concerned more the concrete examples, rather than the way they were modelled, hence, no major changes seemed to be needed in this part. Only one negative comment was received regarding the fact that issuing date of a datasheet was outside of the first iteration evaluation scenario of the use case. While this was true, this is again a question of how minimalistic the ontologies should be, since they should eventually cover the data collected for the project research dataset, which contains such information.

For the overall rating of the ontologies, represented by the survey examples, the respondents agree that they cover the evaluation scenarios very well (average of a 4 on a 5-grade scale, from “not at all” to “completely”). Hence, we can conclude that despite the fact that some minor issues have been identified, and some aspects not being understood completely by the use case partners, the overall evaluation of the ontologies in relation to the use case scenarios are satisfactory for the first project iteration.

Direct feedback on the ontologies from the use cases

In addition to the quantitative survey results presented above and the written comments on the survey questions, each use case was offered to provide an additional summary of their impression of the first release of the ontology network and its applicability. This feedback is presented below.

Textile use case

Ontology models are used to represent knowledge in a structured and semantically meaningful way. The examples provided for the evaluation of the ontology for textile use case are based on the simplified scenario chosen for the first iteration: three components from a component manufacturer (e.g., Texon) with varying recycled content being supplied to a shoe manufacturer for shoe production.

The evaluation involves assessing the understanding of ontology concepts by members of the Textile use case including the provided documentation, accuracy of the textile ontology model, completeness, relevance, and usability.

Members of the textile use case were introduced to the ontology model through various formats. The introductory workshop offered a broad introduction to fundamental concepts of ontology and basic models. Subsequently, use-case specific ontology examples and associated explanations were distributed through a questionnaire format. These examples, within the scope of a simplified scenario, were designed to assist in evaluation. The scenarios suggested for evaluation are as follows:

- Puma is the brand of shoe x
- M is the manufacturer of shoe x
- Texon is the supplier of components A, B, C
- Shoe x is composed of components A, B, and C
- Shoe x contains 20% of component A
- Data sheet 1234 contains the statement that “shoe x contains 20% of component A”
- Data sheet 1234 was issued by organisation M on date 2023-09-20, and contains the statement that “shoe x contains 20% of component A”
- Data sheet_1234 was issued by the organisation M on date 2023-09-20, and contains the statement datasheet_2345 is issued by the actor S, and at a different date

The ontology encompasses several concepts, including:

- Actor: represents the identification of entities (e.g., company name).
- Role: refers to roles in the supply chain (e.g., manufacturer, supplier, brand) and, interestingly, data providers.
- Resource: refers to products or constituents within the system.
- Datasheet: contains information in the form of concept “statement”
- Statement: describes the data type present in a datasheet, such as a text string, numerical value, or another defined parameter.

Moreover, the ontology's examples illustrate various relationships within the domain:

- Actor and Resources Relationship: demonstrates how actors are linked to resources (e.g., an actor supplying three components).

- Resource-to-Resource Relationships: show connections between different types of resources (e.g., how a product is composed of multiple components).
- Actor and Datasheet Relation: reflects the role of an actor as an "issuer".
- Product and Component Relationship: details the composition of products (e.g., a shoe containing 20% of component A, where 20% represents the recycled content of component A).
- Actor, Datasheet, and Product Relationships: displays the interconnections between actor and information provided.
- Relationship between Data Issue Date and Datasheet

These concepts and relationships within the examples of ontology provide a comprehension of the associations between actors, resources, data that exist in the represented textile system.

The provided documentation regarding the ontology application offers a clear understanding of the basic approach through simple examples. However, for more complex examples, there are explanations missing. For instance, the absence of the introduction to the concept “TextileProductComponentRelation” is rising uncertainty in understanding its role within the model. Additionally, the introduction of “TextileProduct” concepts lacks clarity, particularly in the case of the recycled content. One example elevated it to the level of concept, contrary to other examples where it's one of composition descriptions, in line with a real-world. Commonly recycled content is one among several data attributes to be communicated and shared. Additionally, there is a lack of explanation for some relationships, in particular the definition of participating subjects, objects, resources within this context.

Regarding the visual representation, black arrows are used to represent the relationships between concepts. However, it lacks clear direction definitions, making it difficult to verify if the concepts are correctly interconnected. For instance, considering the source of information, it might be more relevant for the arrow to direct from component A to composition A. The distinction between solid and dotted arrows remains unexplained. Moreover, the connectivity is ambiguous; for instance, it's unclear whether 'datatype' connects to the concept or to the attributes represented by the pink dots. These areas requiring additional detail and clarity within the documentation to ensure a comprehensive understanding of the ontology model and its visual representation.

The ontology examples demonstrate a consistent and coherent structure without any inconsistent or contradictory statements.

Regarding completeness, the examples address core concepts, but it could be enhanced for specific properties, qualities, or relationships that are associated with concepts and visualized with pink dots:

- Data attributes: data is primarily described in terms of data type, leaving out critical attributes like data format, mandatory or optional fields, statement nature (certified or not), sensitivity/access rights for data sharing, and validity. These attributes are important for data sharing among actors. To ensure its comprehensiveness, these aspects could be integrated.
- Role: while the distinctions between roles (e.g., brand, component manufacturer and product manufacturer) are depicted, a more defined hierarchical structure for roles within the ontology is recommended. The introduction of the new role "Data Issuer" underlines the importance of

clarifying actors' roles. The ontology could benefit from a more extensive categorization and differentiation of roles.

In terms of real-world relevance, the ontology captures information essential for the simplified textile scenario. The example of Date of Issue is currently not relevant, however incorporating a "time stamp" for data versioning in subsequent iterations may be beneficial for maintaining historical records of product modifications.

The ontology displays potential for scalability, accommodating new concepts and changes.

The simplified textile use case scenario lacks explicit mention of data sharing, despite its significant relevance to the project. It is more beneficial to include data sharing and data access attributes within the scope of the first iteration, rather than “date of issue”. However, data sharing would necessitate a more extensive characterization of the "Statement" concept than currently presented.

The simplicity of the provided examples aids in comprehension, but it also poses challenges in assessing the exhaustivity of the information. It raises questions about whether some data is missing or intentionally omitted for simplicity. For instance, the "statements" focus primarily on quantity, potentially omitting other critical data characterization attributes. Therefore, in the next iteration, recommendations include the incorporation of data sharing, access rights, and the display of distinct content based on roles.

Electronics use case

In order to evaluate the ontology developed, Circularise assessed the way data is structured on its blockchain-based communication system and identified possible differences. The differences were then analysed as per the possible advantages and disadvantages in comparison to each other. In case of practical examples, the data collected from the speaker use case was taken into consideration.

Reference levels

Circularise does not just use batches of objects but units, products and batches of material, so 3 reference levels.

Participation

Circularise noticed that actors on their system (different from the Ontology) are not characterised as a specific resource relation. Actors do not identify as a certain type of supply chain actor, but only in relation to each other e.g. as an actor on the Circularise system I can add someone as my supplier or customer or auditor, so the relationship is always defined in relation to me specifically, not in the supply chain as a whole. That is of course due to the fact that the circular economy abolishes clear starts and ends of supply chains where for example a recycler is at the same time also a raw material supplier of a new chain. This is also in line with the way blockchain is used to track materials as blockchain data storage is based on transactions of ownership of a digital twin of the product or material with data attached to it. This chain of custody of the materials, components or products is followed rigorously by the technology and therefore makes clear classifications of actors less relevant (resource relation), even though their identity (actors) is still added for informative purposes.

Furthermore, the Circularise system differentiates between roles who own a product (manufacturer, supplier....) and roles that simply edit a product that remains in possession of a different stakeholder (e.g. a certification agency or auditor or testing lab). It however does not differentiate between supply chain steps that conduct changes on the product and supply chain stages that merely enrich the status quo with data (lab results, LCA report by external). Instead, the data is just added in a new incident (new supply chain step) while the development of a better solution is still ongoing. Additionally, actors may have several registered users on the organisational account, as well as several sites.

Roles

The definitions of roles and how it relates to products and batches and their identity is clear. The only difference to the Circularise system that might be relevant for interoperability seems to be the unclarity in the role of supplier and manufacturer. A manufacturer of a speaker is a clear definition. The supplier of the speaker leads to further questions in terms of what type of supplier e.g. is it a retailer or is it just a different name for a manufacturer that simply does not detail the manufacturing role. In the Circularise system, all relations between stakeholders are customer/supplier relations no matter their concrete identity in the chain, independent of their identity. It would therefore be valuable to define if this is the case for this supplier, as well, or whether it refers to the concrete identity of a e.g. a raw material supplier or component supplier.

Constituents

The Circularise understanding matches this example very well in the sense that both the product speaker and its components (magnets and dampers) are considered a product, even though the two components are constituents of the product speaker. Only their location along the supply chain clarifies the role of the supply chain actor.

Basic pattern

The basic structure of the data sheets seems well in line with how data is handled by the Circularise system. It is at this stage unclear to us why "product" has a relation to "statement" and to "resource relation" and why both are needed.

Basic statements

It is unclear why "Nonmetal carbon" is a participating object of "composition" and not a subclass.

Issuing of data sheets

The Circularise system only allows stakeholders to communicate statements about material or production processes they themselves perform. The issuer of the data sheet is therefore automatically the manufacturer of the raw material non-metal carbon, as this person would be the only one allowed to communicate data about it. This working structure has been taken as it allows a maximum level of data reliability and decentralisation. The data is picked up at the stage of the supply chain where the data (e.g. data on refurbishing the radio) is originating. The data sheet from this specific supplier would then through the system be connected to the many other data sheets of stakeholders along the supply chain who themselves make statements about their data.

Product components and their contents
It is unclear why "resource relation" is no longer referenced. All other parts of the ontology are clear and matching.

Processes, batches and statements
On the Circularise system, the differences between communicating product properties (all previous ontology examples) and the processes/collaborations are kept minimal on purpose. Processes are communicated as per their result (dismantled products). This enables the system to use the same ontology as for e.g. composition information. Collaboration participation is therefore not needed as a concept and the identity of the communicator of the data statement is automatically the actor.

All in all, the ontology was already (at the end of the first iteration) very aligned, considering this deliverable is the first draft of a 3-step process. Further testing with industry partners and further collaboration in identifying the different ontology models of the software platforms employed in all three use cases will reveal interesting findings on different ways of handling ontology in the practical and commercial examples. Dialogue between the three software practitioners under the scientific leadership of Linköping University and their theory driven approach will lead to further refinement and an interoperable ontology or translation system at project finalisation.

Construction Use case
The ontology modules identified in the first iteration of the project cover the high-level needs of concepts that need to be modelled for the completion of the use case test cases. Actors, products and their constituents, as well as process components, are represented. The existing modules are enough to start querying for data, but at this stage, the completeness of the data retrieved is limited. This is due to two reasons, one being that data are rather versatile in nature and the process of aligning it to the ontology requires more work and interaction with domain experts. The other reason is that as requirements are further defined in the coming phases of the project, more data will be possible to map in a meaningful way.

At this point in the project (end of the first iteration), the ontology network, and the process and methods used to work with detailing and extending it, support the completion of the construction use case. As such, we see potential that further work on extending the network will eventually reach the goals of the use case scenarios.

2.3.3 Coverage and understandability of the ontology network – second release

In the second project iteration, the ontologies were evaluated in a more integrated fashion with the open circularity platform. The use case-based evaluation is described further in the next chapter, while here we focus on the ontology-specific take-aways, on one hand from the ontology engineers and data engineers modelling the use case specific demonstration ontologies and further documenting the data supporting the use case scenarios (dimension 8), and on the other hand direct feedback on specific aspect of the ontologies from the use case partners based on discussions in the evaluation meetings (dimension 9).

Ontology usage feedback by ontology engineers

Overall, the ontologies were usable and easy to apply in the evaluation scenarios. The modular structure of the ontologies produces a slight overhead when searching for specific concepts and relations, since multiple files and/or documentation pages need to be visited to find the appropriate entities to use. On one hand this is unavoidable when targeting a modular ontology network, to instead benefit from the flexibility and reusability of modules, while on the other hand this effect could be further reduced by improving the documentation of the ontologies. For instance, a joint index page, with all classes and properties from the complete ontology network, could be a point of entry when searching for where to find specific entities. Similarly, an integration module, importing the whole network, could be provided for the case when all modules are needed for a specific use case, or when an ontology engineer wants an overview of the complete network. This is not yet provided in the second ontology release.

Additionally, a recurrent comment was the lack of appropriate documentation and examples of the intended usage of the ontology classes and properties. While most of the entities now have a label, and the central concepts also a comment describing their intended meaning and usage, this is still not the case for every single class and property of every module. Such documentation is essential, especially explanatory comments defining the intentional meaning of the classes and properties, as well as their intended use, are crucial for reuse. Providing this will be a focus of the third project iteration. However, still, comments and textual descriptions alone are sometimes not sufficient, since they can in themselves be ambiguous or hard to understand by both ontology- and data engineers, as well as domain experts. To further support ontology usage, a set of examples could be provided, illustrating the use of the ontologies in an easy-to understand manner. While the three use-case demonstrator ontologies constitute such examples, they are (i) large and (ii) highly domain-specific, which does not make them easily understandable by experts from a new domain, nor ontology- or data engineers in general. Therefore, we envision the addition of a set of more generic data samples, illustrating the use of specific ontology modules, and their classes and properties, to model typical (domain-independent) data.

Finally, a set of other GitHub issues were created based on potential issues discovered in the data modelling and mapping process. Mainly, these were of two kinds; (1) concerning missing datatype properties for representing specific values needed in the data samples for the evaluation scenarios, and (2) concerning missing classes to represent regulation/standard compliance of products and processes. While the first is more an issue of the coverage of the use case demonstrator ontologies, the latter is a more general issue that will most likely lead to subsequent updates to the core ontology modules. For the time being, however, all the additions made were included in the use case demonstrator ontologies, i.e. some classes and properties are now duplicated in these ontologies (existing for instance both in the construction and the textile ontologies), while we intend to lift this from the use case-specific level to the core ontology network in the final project iteration.

Discussion of specific aspects

The first aspect identified when modelling and documenting the data for the evaluation scenarios concerns the division of attributes over products (abstract concept of a product model, e.g. the Notec floor system), items (concrete instances of the product, e.g. a specific floor tile, or pedestal) and batches of items (sets of items, consisting of only one product, e.g. a pallet of floor tiles). It was not

always clear when representing the sample data, at what level the attributes should be tracked. For instance, one question concerned the identifiers of products, items and batches – how are they identified? Consumer products may have a unique ID at the item level, such as the GTIN, while this may not be the case for other products, such as building elements or materials. Additionally, in some systems, such as the CIRC traceability solution, the focus is on batches of items, which are identified with a unique but system-internal batch number, and items are only traced as “single-item-batches". In all use cases, the abstract product notion also plays a role, while at this level it is more unclear whether a globally unique identifier is always present, or whether the product name, or a company-internal identifier would be used. Based on these observations while modelling, a discussion was held with the use case partners in all three use cases, regarding how this manifested in their specific evaluation scenario, and beyond.

From the textile use case discussion we note that item level identifiers are rarely needed in the manufacturing process, neither when it comes to recycling. Individual items are rarely significantly different from the overall model or batch, e.g. there may be different shoe sizes, and different colours, but most often this has very little impact on the material content, recyclability etc. If a manufacturer runs out of materials while producing a certain batch, the material content may change even within a batch, but the overall specification should still stay the same. Hence, tracing such changes is most often not necessary from a circularity perspective. In some cases, the manufacturer would also generalise over a batch of products by using the “worst case” as the reported values. For instance, when reporting restricted substances from the RSL (Restricted Substances List), if one bill of material, as part of a batch, contains more restricted substances than the rest, this “worst case” content would be reported for the whole batch. As identifiers on the material level, usually CAS numbers are used (with HS codes), while identifiers at the product and component levels differ. Although not always implemented currently, it makes sense to create links between batches of components and the batches of products they are used in, to keep the material content traceability.

A similar situation seems to hold for the electronics use case, where the aim is to as far as possible have the specification of material content etc., on the product level. Sometimes, a batch may differ from another, even though they contain the same product, but the aim would be to have an overall specification of the product that always stays the same. However, that would entail a data gap, given the diversification of the supply chain and resulting different suppliers being involved in different batches of the same component. When a batch differs from another, an average is used for material content, since the system also focuses on mass balances. Material identifiers are usually CAS numbers, but different organisations may have different needs, so sometimes it can be other things. From the construction use case, it was noted that, while batches are not always explicit, there is a clear difference between products of the same model manufactured in different time periods, e.g. different years. For example, a floor tile manufactured in one year may consist of a specific blend of calcium sulphate, while in another year the blend was changed, still marketing it as the same product. Hence, tracing material content per batch is important, but batches may sometimes be implicit, e.g. based on manufacturing year. Another concern from this use case was that the notion of a batch is not always very strict, e.g. in terms of containing identical products. In fact, sometimes a batch may even contain products from different manufacturers, e.g. a batch of floor tiles may contain different kinds of floor tiles from different manufacturers, as long as they fulfil the same function and do not have to be distinguished in the construction process of a building. As concerns identifiers, most

tracking is done on the batch level, while usually also the items within the batch have their own identifiers (when it comes to the products in our use case, i.e. floor tile systems). Detailed chemical composition data is not collected, but some general material content data on the batch or product level is provided.

A second aspect that was discussed in relation to batches, items and products was compliance and certification. The question was whether certification is always on the product level, or sometimes on individual items (or batches). Even processes or entire organisations seems to be subject to certification in some cases. This was confirmed by the three use cases, and some details were discussed per use case domain. In the textile use case, testing and certification is most often used on the batch level, i.e. a set of products with known material content, where also the materials used come with certain certifications. The construction use case noted that usually testing happens on a random selection of items in a batch, and then the whole batch receives a quality certification based on those tests. In the electronics use case, most certifications are based on the mass balance approach, applied on batch-level to reduce the work of auditing.

For the construction use case, also the location notion was discussed, since this was part of their evaluation scenario specifically. The discussion concerned at what level of detail the location information needs to be captured. It is clear that the address of a construction or renovation site is needed, e.g. for locating items, but also for calculating transport costs etc. However, the location within a building was more unclear when representing this scenario. In the evaluation setup the BOT ontology was used to represent building topology, such as rooms and storeys, in order to express that a certain floor was installed at a certain storey, in a certain room. However, based on the discussion, we conclude that usually some codes are used to identify the location, e.g. a room number, rather than modelling the complete building topology, and information where such rooms are actually located would be outside the scope of the CEON-based data. Again, this data is mainly on batch level, i.e. a set of floor tiles are in the same location. However, when storing items then potentially some may need to instead have locations on individual item level.

Another aspect in the construction use case was the notion of “cost”, which should here be interpreted as an offer from an actor, rather than actual cost. This means that a cost published with the data is actually the price of an offer to, for instance, disassemble, move, or recycle, a certain construction component from a building. In this sense, the cost would be a parameter entered “manually” into the published data, based on a business decision, rather than something calculated based on some notion of value, or the parameters of the objects in question. Although the cost may be affected by the condition of the elements. Also, when marketing used construction materials, the current state and quality (condition) of the used parts is an essential parameter, which again may be tracked on batch or item level, depending on the type of product. For instance, doors and windows are potentially marketed and sold on-by-one, i.e. per item, while floor tiles would usually be sold in a batch with enough tiles to cover a certain floor area.

In the electronics use case, a discussion was also held around the detailed capture of rare earth content. In the sample data provided for this evaluation, attributes representing the amount (in grams) of rare earths in a product are present, however, this is not an exact measure. Rather it is an estimate, in order to allow a recycler to assess the feasibility and economic viability in retrieving those rare

earths. Concrete material amount required to make common blends of e.g. magnets form part of the competitive advantage.

An overall conclusion from the discussion with the textile use case concerned the reflection of current standards (such as PCDS and Circularity.ID) in the CEON ontologies, and in summary concluded that the current ontology network represents the standards well, but the alignment to the standards is not very transparent. For instance, while some "see also" statements are used on certain properties to refer to PCDS entries, it is not clearly visible which part of CEON actually represents PCDS, and similarly for Circularity.ID. Since both these standards are also frequently updated, and under development, it is important to provide the opportunity for easy maintenance of the links between CEON and the standards. Hence, the discussion concluded that potentially a different structure would be more beneficial, where PCDS and other standards constitute their own ontology modules, that are then used by CEON but can evolve and be maintained on their own, in parallel. Such a refactoring of the CEON network structure will be investigated further in the coming months.

Finally, the need for change tracking was discussed with all use cases, since none of the data samples contains any provenance information at the moment, while this is part of the project's overall requirements. It seems that this is something that the use cases agree is important, but where there is very little implemented so far. Hence, they see the need for provenance and change tracking of data, but this is still one step further into the future for most of the current systems.

2.3.4 Open circularity platform: consolidated requirements verification

Below, for each requirements category (Authenticate, Input, Interoperable Data, Reference, Query, Calculate, Notify, Share, Validate, View, Reproduce, Ethical, Performance), we detail how we adhere to this group of requirements.

Authenticate: Initiate a secure session with the OCP to interact with your and other actor's data

The Authenticate category covers requirements TUS11, NF3, NF4, ATM01, ATM02, ATM03, ATMF01, ATB01, ATR01, ATS03, ATRY01, ATRY02.
This is technically handled by WebID/Solid-OIDC and HTTPS and usable in the UI.

The OCP provides a secure layer by applying the Solid-OIDC specification that allows WebID accounts to securely log in and out of applications built on top of the OCP.

By making use of TLS encryption, all communication between client applications and server applications happens over HTTPS, making sure data remains secure even when in transit.

Input: Add, update, and delete information in the OCP

The Input category covers requirements CUS02, CUS05, EUS03, TUS01, TUS02, TUS03, TUS04, TUS05, TUS06, TUS13, CE04, CE05, CE07, CE08, CE11, ATM08, ATMF02, ATMF03, ATMF04, ATMF05, ATMF06, ATB11, ATB12, ATB13, ATB15, ATS02.
This is technically handled by RDF and LDP. Data coming from original data sources are ingested in the platform using an extension of RML. This also allows for data updates, and the extension takes VCs into account for managing trustworthy certificate data.

The OCP's Viewer is a read-only UI, although the OCP's APIs can store structured data and binary data such as PDF files and images. Solid makes use of the Linked Data Platform (LDP) API standard to provide access to data: a RESTful API that allows to add, read, update, and delete resources using the HTTP methods POST, GET, PATCH, and DELETE.

The RDF Mapping Language (RML) tooling was extended in two ways: handling direct connection to the OCP's APIs and allowing for automatic handling of Verifiably Credentials (VC).

Interoperable Data: Use FAIR data models such as WP3's CEON
The Interoperable Data category covers requirements NF1, NF2, F04, F05.
This is technically handled by CEON.

This category is covered by aligning where possible with WP3's CEON.

Reference: Allow permalinks to individual data pieces
The Reference category covers requirements TUS17.
This is technically handled by RDF and LDP, and the viewing application also allows for referenceable results.

The used data format (RDF) natively creates global URLs for each data entry, and Solid 's LDP allows to dereference all published resources if the actor has access to them.

Query: Retrieve specific data from one or more actors in the network
The Query category covers requirements CUS01, CUS02, CUS03, CUS04, CUS05, CUS06, CUS07, CUS08, CUS09, CUS10, CUS11, CUS12, CUS13, EUS01, EUS02, EUS03, EUS04, EUS05, EUS06, TUS01, TUS03, TUS04, TUS07, TUS08, TUS09, TUS10, TUS12, TUS14, TUS15, TUS16, TUS18, TUS19, TUS20, TUS21, TUS22, TUS23, CE01, CE02, CE03, CE04, CE05, CE06, CE07, CE08, CE09, CE10, CE11, CE12, CE13, ATM04, ATM07, ATMF07, ATMF08, ATB02, ATB03, ATB04, ATB06, ATB07, ATB08, ATB10, ATB16, ATR08, ATS01, ATS04, ATRY03, ATRY05, ATRY06, ATRY08, F01.
This is technically handled by using Comunica that queries the Solid pods using the SPARQL standard and is usable in the UI.

The OCP's UI provides a fixed set of queries that allows the actor to retrieve results from all information sources it has access to, and allows for customizing your own queries. This way, we showcase that the OCP is functionally capable of retrieving decentralized data in a standardized way. Query results are further downloadable in CSV.

In this evaluation, we however do not evaluate which individual data query can currently be performed within the OCP, and only evaluate whether the more high-level functionality is available in the OCP. Which data queries are covered depend on CEON as part of WP3. Aim of the OCP is to cover at least as many queries as those that are validated by WP3.

Calculate: "Calculate derived information from existing data in the OCP (e.g., for Lifecycle Assessment)"
The Calculate category covers requirements CUS02, CUS05, EUS03, TUS06, CE04, CE05, CE07, F02.
This is default behavior by using the SPARQL query language.

Notify: Receive notifications when data changes
The Notify category covers requirements CUS09, CUS10, CE07.

Deemed not a core functionality in scope of the OCP, but implementable as additional service, this category is not covered in the OCP.

Share: Request for and grant access to specific pieces of data
The Share category covers requirements TUS03, CE08, CE10, CE11, ATM05, ATM06, ATMF08, ATMF09, ATB02, ATB05, ATB09, ATB14, ATR02, ATR03, ATR04, ATR05, ATR06, ATR07, ATRY04, ATRY07, F07, F08.
This is technically handled by authorizing access to specific data resources using the ACL or ACP Solid standards.

The OCP's UI currently does not allow to manually configure which actor has access to which dataset. However, the Solid Access Control Lists (ACL) standard allows to authorize access to specific actors, and authorization rules can be dynamically configured using the RML mappings.

Validate: Validate that the retrieved data is genuine and has not been tampered with
The Validate category covers requirements EUS01, TUS09, CE13, ATM10, ATB06.
This is technically handled using the VC standards.

The OCP integrates the Verifiable Credentials (VC) standard to provide for this functionality.

View: Create custom views on top of existing data sources
The View category covers requirements ATMF09, F06.
This is technically handled using RML.

The OCP currently maps existing data sources using the RDF Mapping Language (RML). This allows to create and edit multiple views from existing data sources.

Reproduce: Provide well-documented open-source code and APIs
The Reproduce category covers requirements NF5, NF8, NF9, F03.

The code of the OCP and its UI are freely available on Github under the permissive MIT license, and APIs adhere to the current Solid standards.

Ethical: Align the OCP with ethical regulations such as GDPR
The Ethical category covers requirements NF6, NF7.

Adherence to legislation is out of scope of WP4.

Performance: Have a scalable system that can recover from calamities
The Performance category cover requirements CE07, CE09, NF10, NF11, NF12, NF13, ATM09.

Performance considerations are not considered in the current OCP demonstrator.

Functional validation results

We consolidated all requirements and IMEC (WP4 lead) validated manually which are functionally covered by the OCP and its UI: IMEC experts validated if the requirements were attainable via the OCP and its UI or not. For example, for CUS01 "to know which are the different EoL scenarios for building materials", we validated whether we were able to ask similar questions to the platform.

Out of all 131 consolidated requirements, we can functionally showcase 105 (16 partially) at iteration 2 (covering 92% of the current requirements, up from 55% at iteration 1). 2% of the requirements are deemed out of the OCP's scope, and 5% of the requirements are up for discussion for iteration 3.

3 Use-case focused evaluation

WP6 is tasked to demonstrate the data sharing platforms from the use-case partners (Circularise, Concular, circular.fashion/PositiveImpakt) and "*contribute requirements from the specific perspective of their industry domain, ...[and]... contribute research data, both for technical development as well as validation and evaluation of results.*"

WP6 is structured around the demonstration of data sharing in three use case industries (electronics, construction, textiles) by different data sharing platform/methodology providers (Circularise, Concular, CircularFashion/PositiveImpakt). In line with the general focus topics of ontology and data sharing functionalities of the Onto-DESIDE project, WP6 conducts three demonstrations (each representing a different tasks) of data sharing that each focus on a different methodology/technology as per the general practises of the data sharing practises of the task leads. In order to enable data sharing in the specific industry, each task implemented a data sharing demonstration with the project's industry partners. The three different approaches to data sharing result in

- three comparable demonstration practices of data sharing with industry partners depending on the methodology/ technology employed and
- input to WP3 and WP4 based on the different demonstration approaches. This involves for example, what do the three common methodologies/technologies of Circularise, Concular, Circular.Fashion/PositiveImpakt entail when it comes to data requirements and technical requirements for the prototypes developed in WP3 and WP4
- testing possibilities of the ontology and OCP in relation to the three different methodologies and technologies employed.

The work started in Deliverables 6.1-6.3 with the assessment of a) user needs when it comes to supply chain data communication (technology/methodology) and b) data needs (data sheets/DPP) for the circularity and c) concrete circularity practises and business cases the industry partners wanted to focus on e.g. recycling/repair. After assessing the needs of the industry partners when it comes to circularity, the three use case tasks focused on the mapping of the material flows along the use case supply chains. In line with the user needs, the data needs and prioritised circularity practises were identified in Deliverable 6.1. Each software/methodology provider defined the data structure needed for the communication of a) data that use case industry partners identified as relevant for circularity and b) the data that was identified as relevant during the circularity compass mapping. This section focuses on the evaluation of how the three software/methodology partners interacted with the industry partner to conduct data sharing, as well as the results and the evaluation and lessons learned from that data sharing demonstration.

3.1 First project iteration: Qualitative feedback on the open circularity platform demonstration in the use cases

To receive initial feedback on the Open Circularity Platform, we organized a first evaluation workshop during the September 2023 face-to-face meeting. According to the think-aloud principle, we noted all feedback. The results were consolidated in the "Qualitative feedback consortium meeting "Table added in Appendix 2 (Section 7.4). Below, the feedback is integrated into the deliverable.

For the first iteration of the test of the Open Circularity Platform, and related ontologies, the objective was to ensure that information can be shared between different actors and that there is actor-specific data access control. The basic functionalities of the platform to be tested in the first iteration were:

- Login
- Logout
- Forgot Password
- Creation of data in a data pod
- Query/search function connected to data
- View control: different content per actor/share data with specific actors
- Access control: different permissions per actor
- Data sharing between two actors

For the second iteration, the objective would be to ensure the ability to verify numeric data and claims in data pods by means of accessing associated uploaded certificates and other forms of verification. The third iteration consists of the testing of the final version of the decentralized digital platform for secure collaboration.

3.1.1 Textiles use case

Current process used by the actors: Brand asks its manufacturers for the percentage of recycled content, manufacturer asks its suppliers for the percentage over recycled content of the individual components, integrates the data, and returns the result to the brand.

Scenario to be demonstrated: the Brand can directly submit a query over the platform to retrieve the result, with no manual intervention of supplier nor manufacturer needed (given all access control is correctly configured).

For the test of the platform functionality, 3 actors were created: supplier of 3 footwear components (Texon), manufacturer of footwear products, and brand. Texon completed the data sheet for 3 product components, but the data access functionality was only tested for one data attribute (i.e. recycled content).

Methodology

The technical evaluation of the current iteration of the OCP entails a functional evaluation. This evaluation focuses not on the platform's capacity to operate in a production-like environment, but rather on two criteria: (i) the provision of functionalities, and (ii) alignment with expected requirements of the use case members.

To evaluate the OCP, detailed **test scenarios** were introduced, based on existing user stories. The Textile use case members (+ImpaKt, Circular.fashion, Texon) provided these detailed test scenarios (See appendix 2.3) to the WP4 member, guiding the platform development of the OCP. The selected user stories are from the list outlined in the deliverable D2.1 and include:

- TUS1: Access to production data
- TUS2: Access to editable and updatable content
- TUS3: Integrated product data

- TUS7: Circular materials catalogue
- TUS8: Component data
- TUS10: Materials composition

Detailed description of these stories and their evaluation can be found in **Error! Reference source not found.**. Selected user stories are related to the subset of actors that the first iteration is focused on: brand, supplier, manufacturer and the admin user. Actors like end users, transformation actors, retailers, sorters, and recyclers were left out for further iterations, as well as the stories related to certificates, verifications and sustainability scores.

However, the user stories are too general and do not specifically articulate main user actions to reach the expected functionality of the OCP. Subsequently, test case scenarios and questions are defined to test the implemented functionalities:

- Login into the platform as a specific actor - e.g. as a brand or a manufacturer (linked to TUS 1 and TUS2):
  - Can you log into the platform successfully?
  - Is the content displayed different for each actor?
  - Are permissions different for each actor?
  - Can I logout successfully?
  - Can I acquire a new password?
- Data available and data sharing (linked to TUS 2, TUS 7, TUS 8 and TUS 10)
  - As a brand I want to get information on recycled content of the component I want to use
    - Can the user easily identify where to access the information?
    - Do I get sufficient data on recycled content? Is data displayed correctly?
  - Am I able to share data with the actor I choose?
  - Can stakeholder upload data on the platform?

For the technical evaluation, the Textile Use Case members accessed the latest software version in the form of login credentials for the four kinds of users: admin, supplier (Texon), manufacturer, and brand. By acting as the different actors interacting with the platform (i.e. brand, supplier, manufacturer, and admin user) and clicking through the OCP's UI, the Textile use case members validated if the selected user stories can be successfully completed. Subsequently, the Textile use case members verified the alignment with user stories and validated the implemented test case scenarios and questions. The validation of platform viability involves a discussion about data presentation and usage. Additionally, it entails comparing the platform with the intended use by Textile case members.

Results

Technical evaluation

Error! Reference source not found. contains the evaluation of the platform based on user stories, while the evaluation of the test plan scenarios and questions is outlined in **Error! Reference source not found.**. The evaluation includes information if the implementation of functionality was observed, as well as general comments on the interface, user experience, and security concerns.

Table 5 Evaluation based on user stories

User story	Evaluation and Comments
TUS1: Access to production data As a Fiber Supplier I want a possibility to display the material content of my fibers requested by my customers	• As a supplier the available information includes the component URL, component name, material URL, material name, material percentage, recycled content percentage, and average recycled content percentage. The content can be further extended. • Above information is scattered into three different views. Our suggestion for the further iteration is displaying all of it in the one view (e.g. detailed view of the component)
TUS2: Access to editable and updatable content As a Fiber Supplier and Transformation actor I want a possibility to edit and update the material content of my fibers properties of my product displayed on the platform	Currently, it appears that this functionality has not been incorporated in the initial iteration. Users can view data but lack the options to edit or upload data.
TUS3: Integrated product data As a Fiber Manufacturer and Transformation actor I want an overview when I log into the platform to see all my materials including which materials have been viewed or where I have been contacted	It appears that this option has not been implemented fully. The user logged in as a manufacturer can see their materials but can't see which materials were viewed or if there were any request from other actors, to see data.
TUS7: Circular materials catalogue As a Brand I want to have access and explore freely a catalogue of available circular materials to improve the design phase of my products (eco-design).	This functionality is partially implemented. The user logged in as a brand can see products and components data as a list of available actors and their data. We recommend for the further iterations introducing search and/or mechanism, so the exploration is easier.
TUS8: Component data As a Brand I want to have access to data on properties, assembly methods and composition of components **TUS10: Materials composition** As a Brand I want: • To access data on manufacturing process on how fibers have been assembled AND/OR the quantity of resources used in the process.	• In the first iteration the decision was made to solely exhibit the recycled content for a component, excluding any additional data • As a brand the available information includes the product site URL, product name, component URL, component name, recycled content.

Table 6 Evaluation of test plan scenarios and questions

Question	Evaluation and Comments
Can you log into the platform successfully? Is the content displayed different for each stakeholder? Are permissions different for each stakeholder?	User can log in. The following issues are discovered though: • The necessity to log in with the WebID before reaching the actual login is not clear. • The invitation process to the platform and user onboarding details are yet to be clarified. • Security concern: visibility of the left-hand menu even when users are not logged in. This potentially exposes actor names and available data to unauthorized individuals.

	• Security concern: when a logged-in user lacks access to specific data, the entire menu remains visible. • Upon accessing forbidden content, users encounter a blank page without a message of access denial.
Can I logout successfully?	User can logout
Can I acquire a new password?	• The "Forgot password" feature is currently not operational. Upon attempting to use the "Forgot password" option and entering the email in the subsequent form, an error message is displayed: "501 - NotImplementedHttpError." • Furthermore, the length of the WebID link might make it challenging to remember. To enhance the login process, we suggest simplifying it by removing the WebID input step.
As a brand I want to get information on recycled content of the component I want to use? Can the user easily identify where to access the information? Do I get sufficient data on recycled content? Is data displayed correctly according to algorithm provided?	User can easily identify where to access data on recycled content. Data is displayed correctly according to the algorithm provided. For further iterations we advise adding information on how it's calculated to the platform.
Am I able to share data with the actor I choose?	This option has not been implemented
Can I upload data on the platform?	There is no option to upload data to the platform as the platform is meant to be only for displaying and sharing data. Actors are meant to integrate their data by creating integration layers, called data pods. Data pods are meant to translate the database schema that actor's database is using to the database schema used in the OCP (aligned with the ontology). For the further iterations we advise that this part is simplified/automated as much as possible, so onboarding new actors is not a bottle neck (e.g. we don't see a brand having IT budget to create and maintain data pod servers on their own).

For the next iteration, it's necessary to address the following requirements:

- **Improved login experience**: Simplify the login process by enabling direct login without requiring a WebID. Additionally, ensure that the dashboard accurately reflects the user's login status. Currently the dashboard constantly displays "Please login", even when the user is already logged in.
- **Inclusion of Headers**: Incorporate headers to pages to clearly indicate the user's current navigation location.
- **Enhanced Menu Readability**: Improve the user experience by making the menu more readable. Currently, long texts in the menu overlap the page content on hover
- **Implementation of search mechanism**: Introduce a search mechanism to facilitate data discovery instead of relying on a list of data providers in the menu. Relying on a long list for data exploration is not viable in the long run.
- **Evaluation of data source visibility**: while Data sources are visible, it's unclear how to add them. Evaluate the potential benefits of incorporating this feature.

- **Data overlapping and merging:** Address the question regarding data overlapping from different sources. Determine how such data overlaps are managed or merged within the system.
- **Visibility and Management of Data Access Levels:** Enable easy access to information about which data is available in each data access level and provide a user-friendly interface for its management.

Viability evaluation

The current platform setup does not adequately reflect the data granularity required for efficient data exchange and user-friendly navigation within the materials and components database. It is imperative to engage with the textile use case members to solicit their input on structuring the database and associated inventory of data attributes. The data name should align with a generic or commercial material name, and the simplified data attributes are elucidated in the updated user stories.

As mentioned in the technical evaluation, the OCP presents component-related information of Texon scattered into three different views. However, when a manufacturer sells a component and their client buys the same component, the information scattered into material composition becomes redundant. Data attributes, like identification details, material and chemical composition, recycled content, data on recycling, reuse, take-back schemes and other information, should be accessible by clicking on the component name and be visible as associated inventory. Therefore, the search function must operate at the level of data attributes.

To ensure the platform's success within the industry, it is important to empower stakeholders interested in accessing data by enabling self-service data retrieval. Presently, Texon is obligated to furnish data upon client requests, a process that proves time-consuming due to the diverse formats required by various brands. The platform should provide the capability to selectively share data attributes with other actors, safeguarding sensitive information and making it available only to designated parties.

The aim of this project is that circular.fashion will exploit parts of this project to upgrade the circularity.ID system for the textile industry. The developed ontology within this project will be used for the system to improve interoperability also with non-textile businesses. Furthermore, the own circularity.ID platform should be adapted so that it supports the decentralized network approach to publish and retrieve semantically annotated data, behind a layer of authentication and authorization. Also of interest will be the verification method, so that collaborating actors can trust the data, they are using to implement for the circularity.ID.

The primary objective of PositiveImpaKT for the platform is to enhance interoperability between the CP and the Product Circularity Data Sheet (PCDS). This poses a critical challenge that needs to be addressed to optimize the collaborative potential between PositiveImpaKT and the Open Circularity Platform, ensuring a more cohesive and effective integration with the PCDS.

As a component producer, Texon is keen on enhancing the visibility of their efforts in integrating recycled content, creating recyclable components, and efficiently managing information across various components. The platform's potential contribution to augment this visibility lies in the

incorporation of an advanced search function. Such a function would enable users to research suppliers based on diverse environmental indicators, thereby fostering transparency. In addition to this, to ensure access to and collection of trustworthy data from the supply chain, a mechanism for linking or uploading certificates is deemed necessary.

3.1.2 Electronics use case

For the electronics use case and the interaction with the data formats and Circularise software tool, the OCP must fulfil some basic functions ensuring interoperability of data and communication.

The electronics use case maps the production process of a speaker entailing a neodymium magnet and several more simplistic structural components constituting the speaker structure. For the user stories we are working with the OEM of the speaker and three different tier 1 suppliers from different parts of the world. Given the decentralised structure of the Circularise system and methodology used in the electronics use case, we are assessing the use case of suppliers personally reporting on their data within the data sharing system (in this case Circularise), rather than the central gathering of data by the tier 2 or tier 1 supplier for the OEM. Given the demonstration activities of data sharing between Circularise and the industry partner. Furthermore, the research scope must be very concrete, and we focus on the neodymium magnet specifically and a selection of engaged suppliers.

User stories and the feasibility of reflecting them on the OCPs current state of development:

Table 7 Electronics use case user stories

User story	**Evaluation of current feasibility**
As a speaker manufacturer, I would like to understand the origin of my components.	The system enables the OEM to receive information from their direct suppliers in an easily digestible way. Ontology and data input descriptions are clear and data sheet is comprehensively structured
As a speaker manufacturer, I would like to receive recycled material content information in a quantifiable manner	The system enables traceability according to the segregation model of traceability. This entails the step-by-step tracking of materials without any alternative features for simplification or data gap mitigation. Other additional options could be an additional option for supply chains where segregation is too expensive or difficult.
As a magnet manufacturer, I would like to be able to answer material questions from my OEM about the material content	Component suppliers are currently able to see material data from their direct supplier on the OCP. It is however not ensured yet that all previous supply chain steps are empowered to communicate material data beyond their direct customers.
As a material manufacturer for magnets, I would like to communicate quality criteria to the speaker manufacturer in order to achieve a higher price.	Verifiability of material quantities communicated and referenced by the data set is not fully clear yet. While core functionalities are all finalised, the indirect communication between partners is currently not possible yet.

The testing of the platform's user-friendly web application by Circularise via presentation and own assessment, still revealed some differences between the data and software used in the electronics use case and the OCP.

1. Material Data Classifications
Material data around the chemical composition on the OCP relies on material names e.g. inorganic filler, adhesive coating. The different data points within the material category are currently displaying different levels of detail e.g. it does not provide clear insights on the step of the supply chain (material, component or product level) addressed. This may cause some harmonization problems. A more detail description of materials that does not allow different names for the same material would improve interoperability. Another option might be drop down menus with pre-defined material codification to ensure correct classifications.

2. Anonymity of suppliers
Intermediaries in the supply chain are discouraged from engaging on a data sharing system while they perceive a risk of their customers receiving the identity of their suppliers. The OCP in its current version does not allow this anonymity, yet. This makes the likelihood of tier-1 suppliers to onboard their own suppliers low.

3. Verifiability
A mechanism of checks and balances or blockchain or verifiable claims would be important to ensure companies are not able to change previously made commitments about e.g. material composition. The existing idea is reflected by the OCP further implementation along the project timeline is expected.

4. Recycled material traceability
The level of traceability of materials could be improved by one of the standardised traceability mechanisms identified by the Ellen Macarthur foundation, segregation, book and claim, or mass balance. This would entail more monetizable options for the companies in proving the provenance of high quality of recycled material in cooperation with suppliers early in the supply chain.

5. Data format harmonization
Component names, recycled content, product names and other types of data points are clearly identified with unit information and therefore ensure a good level of interoperability for collaborating software partners.

6. Standardized output
The export functionality of the OCP fulfils the function of machine-readable data that can be imported into other platforms without ambiguity. As a further step, more options of data formats would be a possibility to ensure e.g. software integration becomes possible.

3.1.3 Construction use case

Offering a platform that makes decentralized data available has numerous advantages. Firstly, it mitigates risks associated with manual distribution of data, and it also ensures data integrity by ensuring that the ones owning the data are controlling it. Integrated access controls would ensure

that sensitive data is only accessible to authorized persons, bolstering security measures. Automated workflows streamline data distribution, approval processes, and notifications, reducing manual effort and enhancing operational efficiency. By integrating various data sources, including technical data sheets, EPDs, and LCA calculations, the platform provides users with a consolidated source of information, eliminating the need to navigate multiple databases or websites. Standardizing data formats facilitates easy retrieval and analysis, while robust search and retrieval functionalities improve user experience and productivity.

The use case demonstration was run through by Concular using both the underlying querying using the Comunica tool, as well as using the user interface developed in WP4. During the demonstration it was made clear the data gathered in the data gathering of D6.1 was made available through the OCP platform. At this stage of development in the project, the implementation of process, completeness and annotation of data are at an early stage and should be reviewed accordingly.

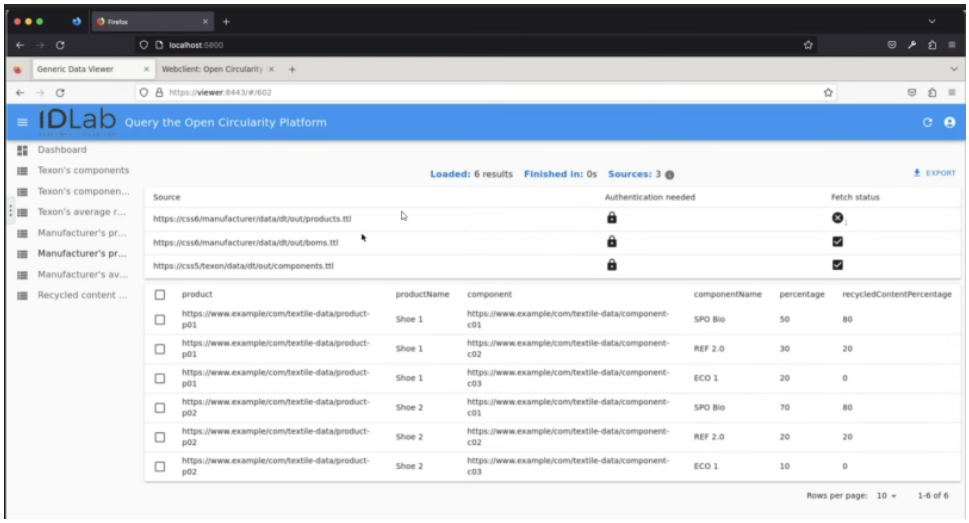

Figure 8 The interface of the OCP platform showing possible views used for querying data based on roles.

At this point it is hard to do an end-to-end assessment of the platform as not all requirements or data are available at this point. Nonetheless, as the platform stands today, and given the processes and tools setup in the project there is confidence in that it will be extended and more complete in later iterations of the project.

The OCP is supposed to enable data sharing to build up a circular economy. For the construction sector the evaluation of the platform revealed several areas require attention to enhance its utility and user-friendliness in real-world applications.

1. Diverse Application Scenarios:
One notable limitation of the current version of the platform is the lack of flexibility in displaying different application scenarios. To make the platform more versatile and adaptable to the construction sector's varied requirements, it is recommended that users be empowered to create their custom queries. This would allow users to configure queries based on specific needs and circumstances, facilitating more comprehensive data analysis.

2. Query Variability:
To accommodate the diverse and evolving use cases within the construction sector, the platform should incorporate query variation options. Users should have the ability to fine-tune their queries to cater to unique scenarios and specific requirements. This enhancement will ensure the platform's relevance and applicability in a dynamic environment.

3. Data Uploading:
A critical feature that could enhance the platform's user-friendliness is a clear and intuitive data uploading mechanism. Suggested improvements include providing predefined data entry fields to maintain data consistency and accuracy. This feature is especially important when considering the need for standardized data input within the construction sector.

4. Dynamic Data Integration:
An essential aspect that requires attention is the integration of dynamic data. For example, accommodating changes in classifications, locations, or quantities of reusable materials is crucial. The platform should support data modification with timestamps, allowing for historical tracking and auditing of changes. This feature is pivotal for monitoring long-term trends and ensuring data accuracy.

5. Ontology and Process Integration:
The platform's current version lacks the representation of processes, leaving questions about their integration and visualization unanswered. It is recommended that the platform incorporate a mechanism for integrating processes and provide clarity on how these processes can be effectively displayed on the platform's interface. This will facilitate a more comprehensive understanding of the circular economy within the construction sector.

6. User-Friendly Dashboard:
The platform's dashboard, while functional, could be significantly enhanced to improve the user experience. It is proposed to introduce a selection of queries as a dropdown menu, allowing users to quickly identify and select the queries they need. This user-friendly feature would streamline data access and improve overall platform efficiency.

7. Data Security and Sharing
The current stage of development doesn’t address the secure data sharing yet. It is necessary for the user to choose what data will be shared with others and what stays hidden or private. There is a necessity to share the data on different levels of detail.

In conclusion, the OCP, with its aim to revolutionize sustainability within the construction sector, shows promise. However, the feedback outlined in this report highlights critical areas of improvement necessary for the platform's success. These recommendations are intended to enhance the platform's adaptability and user-friendliness, ultimately contributing to its broader adoption and success within the circular economy.

3.2 Second project iteration: Qualitative feedback on the open circularity platform demonstration in the use-cases

3.2.1 Cross-use-case setup

Each actor can share data while maintaining control over who can access their data. These data can be heterogeneous in format (CSV, JSON, XML, SQL …) and schema. Each actor has its own mapping file to describe which data is shared and how this data is translated to RDF data and semantically annotated using the CEON ontology as Global Schema.
Each actor stores their RDF data, split over different resources, in his Solid Pod, and adds a Verifiable Credential (VC) to each resource. The Actor manages the access to these resources in a local file. The mapping file also describes how the data is split over different resources and stored on the actor's Solid Pod, and how the access rules are translated to RDF and added to the actor's Solid Pod.
We created one docker image to complete all needed process steps:

- generate RDF data
- split the RDF data into required subsets
- add a Verifiable Credential (VC) to the RDF subsets
- put the RDF subsets as resources on the Solid Pod
- add access rules to resources on the Solid Pod

Each actor announces their resources to the administrator of the (sub)network. The administrator adds these resources to an index file (stored locally in any format). The administrator adds this index file as RDF data in a dedicated resource on their solid pod. Every participant in the network gets read access to this index file. The administrator can use the same process as described above (with mapping file and docker image).

Each actor can log into the OCP to retrieve data shared in the network. The data is retrieved by executing queries. The OCP can store predefined queries and has an option to write additional custom queries. The index files of the administrator can be used as a source for the query. The list of consulted sources is displayed in the OCP and includes a check on the VC. Per query a dropdown list with parameters can be predefined. The query results can be exported as a CSV file.

The input data, mapping files and queries used to set up the demonstrators are available in Appendix 4. A screencast of each demonstrator is also available as a gif in Appendix 5.

3.2.2 Textiles use case

3.2.2.1 Actors and data

Based on the scenario as described in the previous section (see section 2.2.3 and Appendix 3, we set up following actors and data.

The demonstrator for the textile use case involves seven actors: four-component manufacturers (textile_user1 to textile_user4), one shoe manufacturer (textile_user6), one recycler (textile_user7), and one network administrator (textile_user9).

The component manufacturers share data about their products (including the matter composition of those products) with the shoe manufacturer and the recycler. In reality, the recycler refers to the company in charge of EoL treatment of shoe and preparation for recycling of shoe materials. The actual recycling process of materials from used shoes is done by a separate actor.

The shoe manufacturer shares data about its product called Super Shoe (including the product composition, a description of the manufacturing process and the dismantling methods) with the recycler. Generally, the shoe manufacturer and the brand are two separate actors, but for testing the platform we simplify the number of actors. Typically, brands do not have manufacturing capability but set up specifications for the manufacturing shoe company. Some luxury or very high-end brands may have their own factories or workshops, but this is rarer.

The recycler shares data about the dismantled and reusable components with the shoe manufacturer.

All actors have announced the address of their resources with data to the network administrator, who makes this information available to all actors included in the network.

3.2.2.2 Extensions

We have slightly adapted the data delivered for the evaluation.

- The input data delivered for the evaluation included only one component manufacturer (Texon). We decided to split this data over four component manufacturers to demonstrate the access restrictions and the combination of data from different data sources into one query result. In our demonstrator, the component manufacturers cannot read the data of any other component manufacturer. The shoe manufacturer has access to the data of all component manufacturers and sees the combination of multiple data sources as a result of the queries in the OCP.
- We have extended the data of the recycler with more dismantled and reusable products.

3.2.2.3 Reflections

This demonstrator was presented to the Textile use case group by WP4 representatives in an online meeting on Monday 24/06/2024.

As described in section 3.1.1 Textiles use case, scenarios in the first iteration were quite limited. Only 3 actors were created (a supplier of 3 footwear components, a manufacturer of footwear products, and a brand) and only one functionality was tested (data access) on a single data attribute. In the second iteration, we wanted to evaluate the real-life example of data flow, from the very beginning of the product life cycle (components manufacturer) to the very end (recycler). Our goal was also to test other functionalities such as allowing or restricting data access, adding or updating data, with much more data attributes, for the second iteration.
Table 8 shows the results of evaluation based on them. Additionally, we conducted evaluation based on views available in the platform as presented in Table 9.

Table 8 Evaluation based on use-case specific scenarios

Scenario	Evaluation and Comments
Scenario 1: As a component manufacturer, I want to allow our customers to see/retrieve relevant data about our components.	The four component manufacturers (textile_user1 to textile_user4) were tested and the results are identical for all of them. It was noticed that this functionality is implemented in the interface although there are some limitations: • There is no user interface to upload data. • The component manufacturer can choose which data to make accessible and with whom to share it, but this feature is not available in the interface yet, for now it is configured by Platform developers. • Some important data for recycling are missing (e.g. Print Method, Print Stuff, Material Construction, Is Industry Compostable, Is Home Compostable, Is Biodegradable). However, from our understanding, it should be feasible to add them at any point, without any technical challenges.
Scenario 2: As a shoe manufacturer, I want to produce a recyclable shoe and need to retrieve relevant data about available components. Shoe manufacturer S sends requests for details on the available components to their manufacturers.	The shoe manufacturer (textile_user6) was tested. In the "Products" view, the shoe manufacturer can see the component list that was shared with this user through the "Product overview" page. However, understanding which item can be chosen to build a shoe is challenging, as there is no clear distinction between product and component in the list. The case where component data is not shared with a product manufacturer cannot be tested, as there is only one product manufacturer, and they have access to all components data in the current scenario. Besides, no user interface for requesting data is available. Additionally, as mentioned above, some important for recycling data are missing.
Scenario 3: As a shoe product manufacturer, I want to allow customers, users and recyclers to see data on our product, including "modified" components. Shoe manufacturer S adds new data on the shoe as a whole and the 'modified' components to their Solid pod, once the shoe is manufactured. The data "points back" to component manufacturers data.	The shoe manufacturer (textile_user6) was tested. There is only one recycler (textile_user7) in the scenario and they have access to all components and product data. Additionally, there is no user interface for requesting data yet, so it cannot be tested whether product manufacturer can allow others to see their data if certain data has not been shared with them. Since there is no user interface to modify nor add components, it is not possible to test adding new data part of the feature, although that seems feasible. The link between modified and original component is not clearly seen or missing in the platform.
Scenario 4: As collector/treatment facility of used shoes I want to understand if a shoe can be disassembled and is intended for recycling.	The recycler (textile_user7) was tested. After choosing a product in the "Product disassembly" view, disassembly instructions are shown, although the table appears unclear.

Scenario	Evaluation and Comments
Collector/recycler C asks the manufacturer S for data and collects the related data from the component manufacturers.	For instance, a disassembly manual file can be made available in the "Disassembly method" column but it should not be the case if the value in the "hasDisasseblyMethod" column is false. It appears that not all components are displayed. For instance, for the 'Super Shoe' product, only 'Laces' and 'Soled and Insoled Shoe' are viewable, even though this product consists of several other components ('Verde', 'Vogue', 'Kabru', 'Ecostrobe', and 'Laces'). This list should be consistent with the list displayed in "Product components data" view. Moreover, it seems that there is no user interface for querying data yet.
Scenario 5: After having the shoe disassembled, I want to publish data on the new disassembled components/materials I am now selling/providing and their origin. Recycler C adds data about their new components/recycled materials into their Solid pod.	The recycler (textile_user7) was tested. Since there is no user interface to modify nor add components, it is not possible to test this feature, although that seems to be feasible. Furthermore, some components' "origin" in current data, is marked as "recycled" which suggests that a recycled component was added.

Table 9 Evaluation of available views

User	View	Evaluation and Comments
Component manufacturer (textile_user1)	Product overview	The view displays component data in a readable format. Available data is: • Product label • Type • Origin • Color • Dye Method • Dye Stuff • Finishing Steps • Water Property • Chemical Compliance • Includes Trims • Contains Metal • Product Designed For Recycling • REACH Certificate • MSDS Certificate • Biodegrability Test Some data, that we suggested to be important for the recyclability are missing (e.g. Print Method, Print Stuff, Material Construction, Is Industry Compostable, Is Home Compostable, Is Biodegradable). But from our understanding, it's easy to add at any point, without any technical challenges.

User	View	Evaluation and Comments
Component manufacturer (textile_user1)	Product components data	There is a list of components displayed, but no component data is shown after any component is chosen.
Component manufacturer (textile_user1)	Product matter composition	Materials composition related to the component selected from the list are viewable. For each material, there is mass percentage shown.
Component manufacturer (textile_user1)	Product disassembly	Two components ("Verde" and "Vogue") are available to choose from the list, although none of them have any disassembly data displayed, when chosen. It makes sense, as they are simple components, consisted of just materials, not other components, but it's not very intuitive to see empty screen there. You might wonder if it's empty by purpose, or because you don't have proper permissions to see those data. Our advice is to make the message clearer to the user if a component do not have disassembly method defined.
Shoe manufacturer (textile_user6) Recycler (textile_user7)	Product overview	These users have access to data from all other component manufacturers (textile_user1 to textile_user4). Hence, they can view all possible components and products data. However, indications on whether it is a component or product are not given. Additionally, the manufacturer or recycler cannot know which component/product belongs to which component/product manufacturer. Our recommendation would be to add functionality to create a link "is a constituent of" between product and its components, to clarify this hierarchy between a master product and components of this master product and component/product manufacturer information. Besides, data is missing for the components "Soled Shoe", "Soled and Insoled Shoe", "Textile A" and "Textile B".
Shoe manufacturer (textile_user6) Recycler (textile_user7)	Product components data	The 15 components and products are available and can be selected from the list and after this, its composition becomes available for viewing. However, components data are available only for the product "Super shoe" and are missing for all the other products/components in the list. Additionally, as mentioned for the "Product overview" for component manufacturer user - some data, that we suggested to be important for the recyclability are missing (e.g. Print Method, Print Stuff, Material Construction, Is Industry Compostable, Is Home Compostable, Is Biodegradable). But from our understanding, this should be feasible at any point, without any technical challenges. As improvement, a structured view of the product in the "Product components data" view could be added (see **Error! Reference source not found.**).
Shoe manufacturer (textile_user6) Recycler (textile_user7)	Product matter composition	In this view, the 15 components and products are available and can be selected from the list to query the product matter composition. Which should be the "mass percentage" of constituent components for products/compound components and "mass percentage" of specific material for simple components.

User	View	Evaluation and Comments
		Product matter composition is missing for all products i.e. for elements which are composed of components or other products. These are "Soled Shoe", "Soled and Insoled Shoe" and "Super Shoe". As improvement, we suggest that when viewing "Product matter composition" of a product, a list of its constituent components and products is presented. Upon selecting a component/product, the mass percentage of the components that product consists of, is shown. Apart from mass percentage, each component row displayed could have a link to component matter composition page, where mass percentage of materials that component consists of, could be viewed.
Shoe manufacturer (textile_user6) Recycler (textile_user7)	Product disassembly	In this view, the 15 components and products are viewable in the list although product disassembly is not relevant for some components. Additionally, the table appears unclear. See "Scenario 4" in Table 8 for details.
Shoe manufacturer (textile_user6) Recycler (textile_user7)	Product disassembly	As a usability suggestion, it would be convenient to have the selected product label on the result page after querying. For instance, for the product "Vogue", the result page could include the header "Product disassembly – Vogue" instead of just "Product disassembly".
All users	Product components data	As a usability suggestion, it would be convenient to have the selected product label displayed on the result page after querying. For instance, for the product "Vogue", the result page could include the header "Product components data – Vogue" instead of just "Product component data".
All users	Product matter composition	As a usability suggestion, it would be convenient to have the selected product label on the result page after querying. For instance, for the product "Vogue", the result page could include the header "Product matter composition – Vogue" instead of just "Product matter composition".
All users	All accessible data	This view does not appear clear. Indications on what is shown there are needed. Explanations on table headers ("s", "p", "o") are also needed.
All users	Sources in textile	This view does not appear clear. Indications on what is shown there are needed.

Figure 9 depicts an example of structured view of the "Super Shoe" that could be provided in the "Product components data" view to enhance the readability of the products.

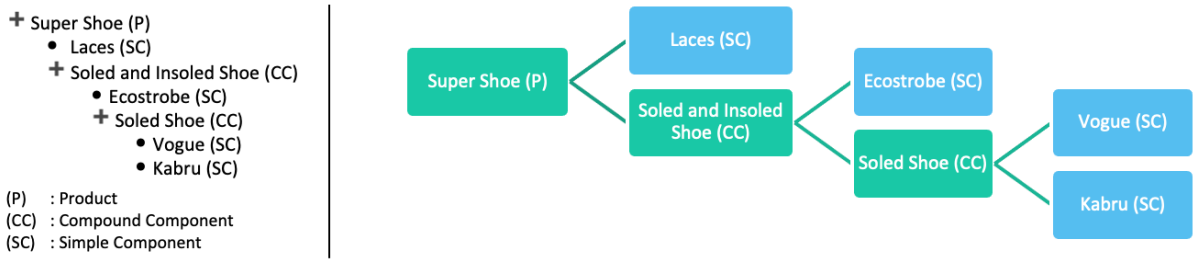

Figure 9 Examples of structured view of a product

For the second iteration, Textile use-case members, namely PositiveImpaKT and circular.fashion conducted the evaluation of the OCP based on new scenarios presented in section 3.2.2.1 Actors and data, Table 8 and Table 9. In comparison to the first iteration scenarios, those of the second iteration are more complex since they include more real-life scenarios, i.e. more supply chain actors and more data attributes to be tested. The expected data-sharing functionalities are nearly identical for both iterations, primarily involving the ability to add/remove and edit data in the platform, and secondly to allow/restrict selected users from accessing data from others.

Regarding the evaluation based on use-case specific scenarios (see Table 8 for further details), functionality for Scenario 1 is implemented in the interface although there are some limitations, in this instance the absence of user interface to add data and the possibility to allow or restrict some users to retrieve data. Besides, some important data for recycling are missing such as Print Method, Print Stuff, Material Construction and so on. For Scenario 2 and 3, since there is only one product manufacturer and one recycler, the case where component data is shared with other manufacturers or recycler but not with them cannot be tested. User interface for adding data is also unavailable for Scenario 3. For Scenario 4, collector or recycler can retrieve disassembly data from component or product manufacturers. And for Scenario 5, no user interface to modify nor add components is available yet.

Concerning the evaluation of available views, the product component data for some components following the example of “Vogue” is empty whereas this product is composed of two materials: leather and cellulose. In order to facilitate the selection of the variable for which the data is being queried, irrelevant variables should not be mentioned in the variables list, for instance, “Ecostrobe” component should not figure in the variables list for “Product disassembly” as it is not a product. Moreover, as improvement, we suggest that when viewing “Product matter composition” of a product, a list of its components (simple and compound) is presented, and upon selecting a component, the mass percentage of the components or materials that component consists of, is shown.

To conclude, at the end of the first iteration, some requirements were requested to be addressed in the second iteration. Based on our evaluation, the status of addressing these requirements is reported in the following table.

Table 10. Status of addressing the requirements requested at the end of the first iteration

Requirements	Addressed	Comments
Improved login experience	Partially	WebID is still required Dashboard reflects the user's login status
Inclusion of Headers	Yes	Headers are incorporated to pages but should give more precision on the name of queried item (see comments regarding all users in Table 9)
Enhanced Menu Readability	Yes	Menu is readable but could be improved for instance by providing a view indicating the structure composition of products (see **Error! Reference source not found.**)
Implementation of search mechanism	Partially	There is a search mechanism (Custom Query Editor), but it's not very user friendly – user needs to know SPARQL language to use it.
Evaluation of data source visibility	Partially	Still no user interface to add data on the platform
Data overlapping and merging	No	No data overlaps have been tested yet
Visibility and Management of Data Access Levels	Partially	Data are relatively easy to access through the "ProductLabel" query section Data management cannot be tested yet

3.2.3 Electronics use case

In the context of the electronics use case, Circularise leveraged the data gathering structure developed in deliverable 6.4 to comprehensively assess the supply chain specific to this application.

3.2.3.1 Actors and data

Based on the scenario as described in the previous section (see section 2.2.3 and Appendix 3), we set up the following actors and data. The demonstrator for the electronics use case involves eight actors: five component manufacturers (electronics_user1 to electronics_user5), one OEM (the speaker manufacturer, electronics_user6), one customer of the OEM (electronics_user7) and one network administrator (electronics_user9). The component manufacturers share data about their products with the OEM. The OEM shares data about its product called Speaker (including its product composition) with its customer. The customer is not contributing data to the OCP, but only retrieves data from the OCP. All actors have announced the address of their resources with data to the network administrator, who makes this information available to all actors included in the network.

3.2.3.2 Extensions

We have slightly adapted the data delivered for the evaluation.

- We have changed the excel file to a CSV file.
- We have split the CSV file into 6 CSV files (one per actor that delivers input to the OCP)
- We have uploaded the REACH and ROHS statements to the cloud and added links to these documents in the CSV files.
- We added a CSV file with the composition of the Speaker to the data of the OEM.

Through REIA's network and a meticulous selection process, it was possible to partner with a speaker manufacturer whose components utilize rare earth elements, enabling us to gain in-depth insights into the electronics and rare earth value chain, particularly focusing on upstream actors and

information. Once the partnership was established, the next crucial step involved determining the specific product to be traced within the platform. Through a series of interviews and collaborative discussions with the partner, Circularise successfully aligned project goals and explored the potential integration of the Circularise technology and platform into their day-to-day operations. Given the partner's need to comply with regulations, being able to trace the components upstream and getting more information on them seemed like the "solution to their problems". Now, through Circularise's platform, it is possible for the partner to "automatically" gather information required for audits, being it directly from the source (suppliers), and trustable (transactions verified by the system based on inventory and through public blockchain).

Considering current and prospective regulations and challenges associated with international value chains, the selection of the product to be traced was driven by the presence of components subject to, or poised for, regulation and the need for comprehensive information from upstream partners. As a result, the rare-earth-based magnet and steel plate of the speakers' motor, as well as the external steel assembly, were chosen as the focus components within the speaker. Subsequently, the speaker manufacturer contacted the respective suppliers to invite them to participate in the project and provide the necessary information to foster an informed and transparent value chain, thereby initiating the development of a DPP for the selected speaker model.

To further enhance the engagement and data-sharing process, a subsequent conversation took place with tier-1 suppliers of the industry partner. This interaction aimed to evaluate the feasibility of supplier involvement, gauge the extent of potential data sharing, ascertain the project's relevance to their own activities, and pinpoint the areas within the component tracing process where the greatest need and value exist. This approach enabled us to assess the practicality of onboarding suppliers into the data-sharing process, fostering collaboration and transparency throughout the value chain. In this case, suppliers showed their interest in being part of the project, as well as confirmed the usefulness of Circularise's platform in their activities. With the increasing pressure from suppliers' downstream clients on getting information about their components, and being able to certify and prove claims, having a tool that enables secure data sharing answer to their needs, to be able to satisfy customers' request for data, without sacrificing or risking their IP.

Having the partners onboard, it was time to determine the data needs of each stakeholder. This process focuses mainly on the requirements from the OEM, given the pressure from regulatory bodies to comply with regulations, for example, the Critical Raw Material Act (CRMA), a legal framework designed to secure the EU's supply of critical raw materials, essential for the green and digital transitions. This entails the need for reporting on different aspects, such as the recycled content and general traceability within the value chain. In this case, the main interest of the OEM was around the production date, invoice number, chemical composition, datasheets, some chemical properties of the OEM and certificates. The final demonstration of the OCP and the ontology, with the input on the multiple components was presented by WP3 and WP4 leaders to Circularise on 20/06/2024 to assess the viability and applicability of such results into a real use case scenario.

3.2.3.3 Reflections

Ontology and open circularity platform viability

The developments presented during the evaluation for the ontology and the circularity platform were mainly aligned with the needs of the electronics sector. Circularise was able to match the OCP's functionalities with requirements from the value chain actors, for example controlling access to data. Companies can determine who can have access to their information by their accounts to the OCP. Additionally, the possibility of making queries is key in value chains as companies need to prove their compliance with regulations and validate claims, through accessibility to data in the OCP. On the other hand, the ontology shows the complexity of the industry by incorporating multiple levels, such as product, batch and item. This provides a basis for setting a common understanding among partners in the electronics value chain, which includes a broad set of countries, as well as industries.

Stakeholders' needs

Ensuring compliance with both existing and forthcoming regulations is of paramount importance. Complying with regulations not only demonstrates responsible practices but also strengthens our ability to substantiate sustainability claims. This is crucial for maintaining a competitive advantage, meeting sustainability goals, and fulfilling commitments aligned with broader initiatives such as the Paris Agreement and the Circular Economy Action Plan.

Furthermore, access to pertinent data plays a pivotal role in driving internal improvements. It enables the evaluation of the status of processes, identifies areas for enhancement, and determines the associated developmental needs. Data access also empowers companies to propose new business models and optimize solutions. To achieve a comprehensive understanding of the value chain and obtain a broader perspective on data statistics, onboarding tier-1 suppliers becomes an initial critical step. With their input, traceability can go deeper into the value chain, analyse environmental and sustainability impacts (e.g. Life Cycle Assessments), assess the presence or absence of substances, evaluate the geographical origin of components, and consider factors such as recycled or biobased content. By doing so, companies can identify bottlenecks and uncover opportunities for enhancing sustainability practices while simultaneously improving supply chain resilience.

For the electronics use case, one of the partner's interests is to be able to trace the components accordingly to their existing system. For companies, it is crucial that any new platform connects/responds to the existing systems, to avoid double work and streamline its adoption. Consequently, for the partners, it is essential that the platform can include the coding used for the components and batches, to easily allocate the information. Additionally, information regarding the technical properties, performance and certificates on the composition, materials and processes are relevant to their operations.

Traceability value

Furthermore, the definition of the traceability of materials is influenced by the value companies see in tracing certain components. A high economic value of materials, a high fluctuation or scarcity of the materials on the market, and a lack of available standards that lead to material availability have been identified as drivers for the selection of components. In this case, the main components selected by the partners are those related to the rare earth industry (magnet from the speaker), given the regulations around critical raw materials and the need for traceability this entails. Additionally, those materials from the metal industry (e.g. steel, aluminium), where sustainability claims are being increasingly asked for, were also selected to trace by the use case.

Moreover, as mentioned before, there are multiple regulations that push for traceability. The recently approved CRMA aims to reduce dependency on imports, promoting domestic production, and recycling. For this, having a clear overview of how the value chain looks, what are the components from products, what is their composition (in terms of hazardous or critical substances) and where they come from, is a requirement. With this data, it is possible to understand whether changes are needed for more resilient value chains, as well as for meeting the guidelines from regulations. By having this overview, it is possible to identify critical raw materials, if mining and processing are under the approved practices, as well as plan for possible shortages and overall geopolitical issues that will strengthen international cooperation and supply chain resilience. These are all measures proposed by CMRA and its compliance will provide better positioning and reputation of companies, demonstrating a commitment to sustainable and responsible sourcing.

Feasibility

Establishing and nurturing strong relationships with suppliers is paramount in facilitating data sharing. In the electronics use case, the manufacturer has already cultivated positive dynamics with the selected suppliers, which streamlines communication and ensures a shared understanding of ontologies and data requirements. Trust is an essential factor, as suppliers are more likely to actively participate in initiatives spearheaded by OEMs. It is crucial for both the manufacturers and the suppliers to be aligned in recognizing the significance of compliance with regulations and the subsequent necessity for data availability and sharing. This alignment encourages stakeholders to play an active role in communicating data throughout the various processes and ensuring that all required downstream aspects are adequately addressed and continuously updated. As mentioned before, the partner and its suppliers are aligned regarding the need for traceability of their components. Both parties agree on the importance and positive outcomes that using Circularise's platform could bring, to first ensure certifications and proving of claim for the partner, and improving customer relationships for the suppliers, as well as internal documentation. By providing information on their materials and processes, suppliers support their customers to achieve their goals in terms of achieving standards and complying with regulations, that give them competitive advantage and thus positioning in the market. This information sharing is translated into trust and strengthening of their supplier-OEM relationship and can also support supplier to achieve certifications and increase their value. These are all benefits that the electronics' use case will bring in the long term to the stakeholders involved.

Data transparency and validity

Through the platform, stakeholders are now able to have trustworthy data from their supply chain, as they can now see the flow of components, and corroborate that there are no "double expenditures" or wrong claims. The Circularise's system is based in public blockchain, which means that there is not one particular entity that has all the data or that can validate if it is correct. On the other contrary, for a transaction (sharing components in the platform) to happen, it needs to be approved by multiple users, providing a solution to false claims and greenwashing. Additionally, Circularise provides analytics such as the Sankey diagram, which shows components' flow. As mentioned before, having clarity of the components that are required to make a product helps companies have a better understanding of their value chains, and thus take actions accordingly. For example, if a substance, part of one of their components, is classified as hazardous, they can inform

their suppliers and together look for solutions. Also, knowing where these components are sourced can help foresee shortages, driven by possible geopolitical situations.

As mentioned before, in this use case the OEM's focus was on knowing certifications, as well as composition (for possible hazardous substances) that will enable their compliance with for example REACH and RoHS. For this use case, the suppliers created the components they are responsible for in the platform, with the required information. These were later sent to the OEM via the system and used for the creation of the final speaker. Through Circularise, it is possible to get the Sankey diagram of this process, showing each of the steps and components before with their relevant information, as seen in the images below. Now the OEM has no need to send emails to its suppliers asking for different details, but rather click on the different components and get this information, which, as mentioned before, is validated and trustworthy.

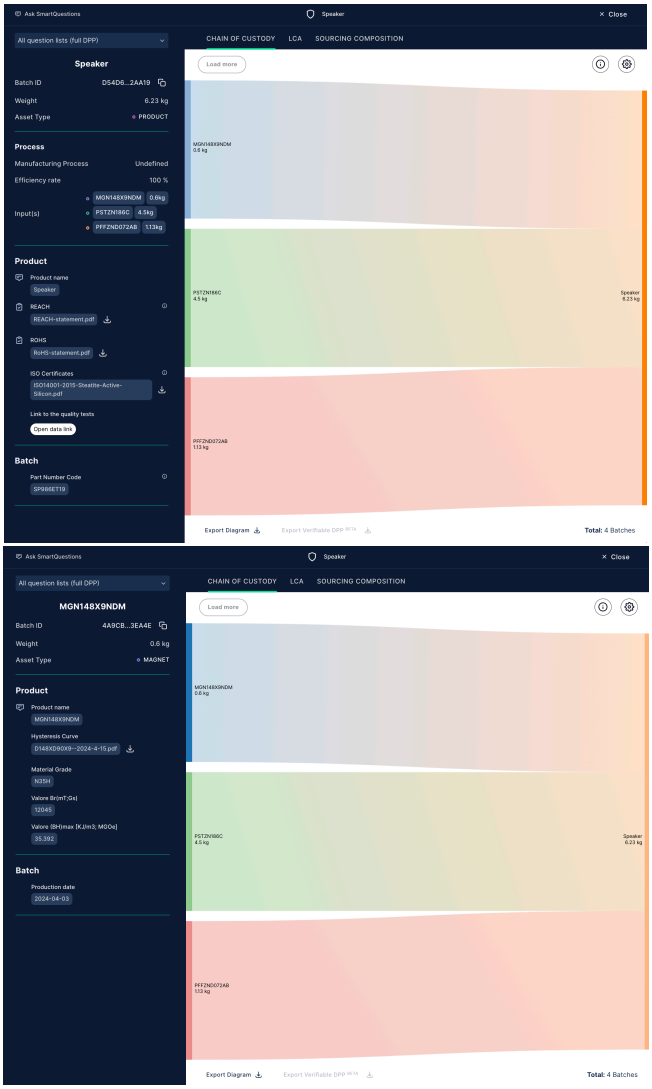

Figure 10 – Screenshot of the Circularise's platform, showing the Sankey diagram of a speaker.

As seen in the image, it is possible to only show certain data, which in turn maintains the confidentiality of companies' data, protecting their IP. The data doesn't necessarily involve the companies' names, which also protects the "middleman" (some suppliers don't share their suppliers'

information in fear of their customers going directly to the source, and thus taking them out of business). Additionally, multiple files (and file types) can be shared, which facilitates the sharing of for example datasheets, but also product models (CAD, png, jpg,...), and even links to repositories where more data is already stored. Moreover, there is the possibility of disclosure levels within the Circularise's system, where instead of sharing the actual value, a range or "validation" is presented. For example, in the figure we can see that the exact values of some properties were shared, however, these can have also been shared as "> 30" or "< 50". This is useful for companies, especially regarding the chemical composition, as most of the times they do not require exact values but rather if they are under a certain threshold (in case of hazardous substances) and in turn protects IP and motivates suppliers to share information, as their "recipes" will not be disclosed. These values can even be fine-tuned per stakeholder, so the laboratory can the different validations than the customer (the laboratory might need more tight ranges than the customer for the precision of their trials).

3.2.4 Construction use case

For the construction use case the following simplified validation cases were described for the purpose of the evaluation in the second project iteration (see also section 2.2.3 and Appendix 3).

3.2.4.1 Actors and data

Based on the scenario as described in the previous section (Technical Evaluation > Combined Platform Evaluation Methods), we set up the following actors and data. The demonstrator for the construction use case involves seven actors: one manufacturer (construction_user1), one building owner (construction_user2), one potential buyer of reusable products (construction_user3), one dismantler (construction_user4), one recycler (construction_user5), one transporter (construction_user6) and one network administrator (construction_user9). The manufacturer shares data about its products (including the product and matter composition) with all involved actors. The building owner shares data about its building with the dismantler, recycler, transporter and with the potential buyer of reusable products. The dismantler, recycler and transporter share their price for resp. dismantling, recycling and transporting a batch of specific products from a building with the building owner. The potential buyer of reusable products is only sharing their company details with the building owner, dismantler, recycler and transport. All actors have announced the address of their resources with data to the network administrator, who makes this information available to all actors included in the network.

3.2.4.2 Extensions

We have slightly adapted the data delivered for the evaluation.

- We have changed the excel file to a CSV format.
- We have added extra lines for the components of the Nortec floor system.
- We added additional CSV files to capture the information about the component and matter composition.
- We added CSV files with building information and information about a batch of Nortec floor systems in this building.
- We added CSV files that hold the costs for processes related to the end-of-life scenario of the batch.

Validation cases:
These validation cases come from the initial user stories defined as requirements for the project, as in deliverable 2.2 through 2.4. To ease the readability some rewordings and additional text have been added but in essence these correspond to what is expressed in the user stories. Not all user stories are verified in this evaluation but rather a subset. The stories to be verified in this evaluation were agreed upon by the partners participating in the construction use case.

Case 1
As a building owner (and possibly also as a deconstruction company), I can ask the platform for the EoL scenarios for a specific type of floor tile. This will require that actors, capabilities and data are present through the ontology for validating such a question.

Case 2
As a dismantler, I can ask the platform for dismantling instructions and logistics information related to a specific type of floor tile. This will require that the different EoL scenarios are defined and that data for dismantling and logistics planning are available through the ontology.

Case 3
As a building owner, I can ask the platform if a specific floor tile can be refurbished.

Case 4
As a building owner, I can ask the platform if a specific floor tile can be reused as raw material.

The following list contains descriptions of the various actors:
Building owner
- The owner of real estate, for example Vasakronan (Swedish real estate owner). Note: This role is quite high-level and would most likely have to be more granular/split in to more specialized roles to be really useful later on.

Manufacturer
- The manufacturer of construction products, for this use case, this would be Lindner Group as the manufacturer of floor tiles of the Nortec product line.

Dismantler
- The actor that does the physical dismantling of building components. For this use case, this would be an actor that dismantles the Nortec floor tiles. This could for example be done by Ragn-Sells or by Lindner Group themselves.

Recycler
- The actor that is responsible for managing the recycling of dismantled building components. For this use case, this would be recycling of Nortec floor tiles from Lindner Group. This could for example be Ragn-Sells.

Deconstructor (deconstruction company)
- The actor responsible for deconstructing parts of, or the whole building. This actor would act on behalf of the building owner on a contract.

Marketplace
- The actor responsible for selling the reused products. For this use case, this could be done by Concular.

3.2.4.3 Reflections

This evaluation was demonstrated by IMEC to the use case partners in an online session on Monday 1/07/2024.

Methodology:

The approach taken in the evaluation of use case demonstrations within the construction industry was methodically designed to capture the intricacies of real-world scenarios. The initiation of this process involved a systematic identification and exploration of user stories, serving as foundational narratives within the construction domain. Subsequently, a collaborative data collection initiative unfolded, drawing upon the combined expertise of Concular and Lindner, with a focused inquiry into the domain of floor panels.

Upon the accumulation of this comprehensive dataset (see Deliverable 6.4), a rigorous analysis ensued, with a meticulous emphasis on qualifying the data based on key criteria—namely, relevance, realism, and the value it contributed to an enriched understanding of the construction use case (Deliverable 6.1 and 6.7). This methodological precision aimed to ensure that the insights derived from the use case demonstrations resonated authentically with the dynamic realities of the construction industry and, concurrently, delivered tangible value for stakeholders and decision-makers.

Information:

Exploration into the information landscape within the construction industry revealed a spectrum of challenges, prominently featuring the discernible reluctance of companies to share specific information such as material recipes or supplier identities. This reluctance underscored a pivotal consideration for the evaluation process: the imperative for a secure and controllable access system. Acknowledging that certain data might be classified as sensitive or proprietary, the evaluation emphasized the necessity of establishing a system that not only respects the confidentiality concerns of companies but also ensures that the appropriate stakeholders possess access to pertinent information. This strategic approach aimed to address the nuances of information sharing within the construction domain, thereby enhancing both the security and efficacy of the use case demonstrations.

Furthermore, the dynamic nature of information emerged as a significant factor in this context. The fluidity of data, coupled with the involvement of multiple actors across the construction ecosystem, introduced intricacies in aligning diverse perspectives. For instance, information concerning the toxicity of certain materials is subject to change as ongoing research in health and environmental risks progresses. This dynamism introduces complexities in harmonizing evolving perspectives, as stakeholders must navigate changing insights to construct a cohesive narrative. Complex new legislation and standards for sustainability are a good example and enhanced by different priorities in the field of sustainability e.g. waste avoidance vs. carbon emission reduction vs. Resource-depletion awareness.

Additionally, the condition of construction materials can evolve over time due to usage, wear, or damage. The necessity to track and incorporate these changes into use case demonstrations adds

a layer of intricacy. Coordinating disparate viewpoints demands not only a technical understanding of the materials but also a keen awareness of how their conditions evolve, impacting the overall construction process. This nuanced interplay underscores the necessity for adaptable and responsive information systems in the construction domain.

Tracking:
In the realm of tracking material and product properties, challenges emerged that extended beyond conventional notions of monitoring and management. The delineation of the scope and granularity of product and material tracking became a pivotal facet of the evaluation process. Determining the appropriate level of detail transcended technical considerations, delving into strategic dimensions. Determining the level of detail aimed to ensure that the use case demonstrations encapsulated the nuances of construction processes without inundating stakeholders with unnecessary intricacies.

Moreover, comprehending the journey of raw materials from their inception to their integration within the final structure demanded a holistic perspective of the construction supply chain. This encompassing viewpoint was essential not solely for tracking the physical movement of materials but also for gaining insights into broader implications such as sustainability, resource optimization, and project efficiency.

Additionally, the intricate task of managing the interplay of numerous small modular parts in construction projects demanded heightened clarity within the use case demonstrations. The challenges extended beyond mere tracking, delving into the domain of visual representation and communication. Effectively showcasing the relationships and dependencies among these components required not only a profound understanding of the technical aspects but also a keen sense of how information is consumed and interpreted by diverse stakeholders.

Result
From the point of view of the use case partners, the selected subset of user stories in the validation cases for this second evaluation can be verified in the demonstration presented by IMEC. By assigning different rights to view data, users have freedom of choice and control over their own data. The various stakeholders can submit their requests centrally via the OCP.

3.2.5 Cross-use-case reflections

When it comes to the assessment of the Open Circularity Platform, clear similarities between the three use cases were found around the topics of usability, interoperability, verifiability and safety. We will guide the final iteration of the OCP based on the validation of the platform and the qualitative feedback of the different use case members during their evaluations. For iteration 3, besides improving stability and minor feature enhancements, we will focus on management of access requesting and granting, to further complete the Share category of functional requirements as presented in the category groupings under “Request for and grant access to specific pieces of data" in Section 2.2.2 document.

4 Conclusion

WP6 is structured around the demonstration of three use case scenarios (electronics, construction, textiles) by three different software providers (Concular, Circularise, CircularFashion) and an ontology expert (PositiveImpakt). Through this interdisciplinary collaboration between technical and industrial expertise, the three use case examples developed unique ways of identifying the market needs of industrial partners (Deliverable 6.1-6.3) and turned these identified needs into a needs-guided data gathering and data communication approach (Deliverable 6.7-6.9) that has been used as a practical testing exercise for the Ontology Network and OCP created in WP3 and WP4. The collaboration process entailed the definition of stakeholders in the data sharing example, the setup of a consultation process to define the data to be communicated via Circularise, Concular, circular.fashion, PositiveImpakt platforms respectively), as well as a process of gathering this data. Throughout this process of supply chain stakeholder engagement and onboarding to the concept and tools for data sharing, the task leaders employed their common practises of engaging with demonstrating industry partners or customers in data-sharing activities with their ontology and software. The demonstrations revealed interesting similarities, related to the OCP and overall digital tools, between the three use case approaches that are detailed below.

Needs assessment: In light of previously identified user needs in D2.2-2.3 & 6.1-6.3, the use case demonstrations run by IMEC in this second evaluation raised additional emphasis on end-user need in terms of graphical interfaces to interact with data. End user interfaces have not been the focus in validating the platform, rather the approach of "just enough interface" to be able to verify a specific platform functionality has been applied.

Analog starting point: Despite the software-focus of the three software providers, all demonstrations were started with data gathering and exchange via Excel spreadsheets to onboard industrial partners on the difficult functionalities of platform-based sharing.

Difficulties: Two of the use cases clearly revealed mitigation activities developed by the software providers in order to tackle a) the fact of data gaps due to data sensitivity and b) the frequent inaccessibility of the tier-2 to tier-x level suppliers who would naturally take the role of data communicator for the material-specific questions. Some of these involved technologies around cryptography, as well as customised access, controlled by the data provider (so the one providing the information remains responsible for its rights and validity).

Regarding the ontologies, it can be concluded that the technical quality is certainly sufficient, although we were able to identify minor points of improvement. For the use case related evaluation, we have shown that it is possible to extend the core ontology network to three separate (and quite different) industry domains, with the addition of modules for capturing statements and provenance, as well as quantities and units. This was the main conclusion already from the first iteration, regarding the ontologies, i.e. that we are able to find a level of generality that sufficiently captures the cross-domain notions of the CE. We have then more in detail sought feedback on specific modelling choices, as well as evaluated the coverage and understandability of the ontologies. While understandability is important, it is still not crucial to the success of the ontologies, since the ontologies are not supposed to be the “front end” of a data sharing platform. Still, the feedback also

shows that the modelling choices made are overall sound and sufficient for the use cases, while minor details still require improvement, such as a possibility to more in detail specify the roles of actors in certain contexts. Overall, the main points of extensions and improvement of the ontology network for the final project iteration includes: (i) to improve the coverage of CEON, but lifting parts of the additional and/or domain-specific ontologies to the core CEON modules, and by providing alignments to existing ontologies, (ii) to include more concrete alignments to standards, such as the new ISO 59004 and the PCDS, and (iii) to prepare a final release, which also fulfils the last few FAIR criteria that are still remaining, such as registering the ontologies in online catalogues, and ensuring their maintenance after the project lifetime.

Finally, on the evaluation of the use cases themselves, the work of the use case partners to test the tools started with the assessment of user needs when it comes to supply chain data communication for circularity. After assessing the needs of the industry partners when it comes to circularity, the three use case tasks focused on the mapping of the material flows along the use case supply chains. In line with the user needs and circularity possibilities identified in Deliverable 6.1, each software provider defined the data structure needed for the communication of a) data that use case industry partners identified as relevant for circularity and b) the data that was identified as relevant during the circularity compass mapping. All use cases demonstrated the value of the tools for ensuring circularity practices. Having information on the different stages of the value chain, regarding the materials, composition, technical properties, and others, ensures adequate resource handling throughout the entire lifecycle, as well as at EoL, facilitating the subsequent use of components in new cycles (either for the same or different application, depending on for example, their quality and performance).

5 References

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[2] Garijo, Daniel and Corcho, Oscar and Poveda-Villal{\'o}n, Mar{\i}a. “FOOPS!: An Ontology Pitfall Scanner for the FAIR Principles” International Semantic Web Conference (ISWC) 2021: Posters, Demos, and Industry Tracks, (2021) CEUR-WS.org, Vol 2980.

[3] Blomqvist, E., Seil Sepour, A., Presutti, V. (2012). Ontology Testing - Methodology and Tool. In: ten Teije, A., et al. Knowledge Engineering and Knowledge Management. EKAW 2012. Lecture Notes in Computer Science(), vol 7603. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-33876-2_20

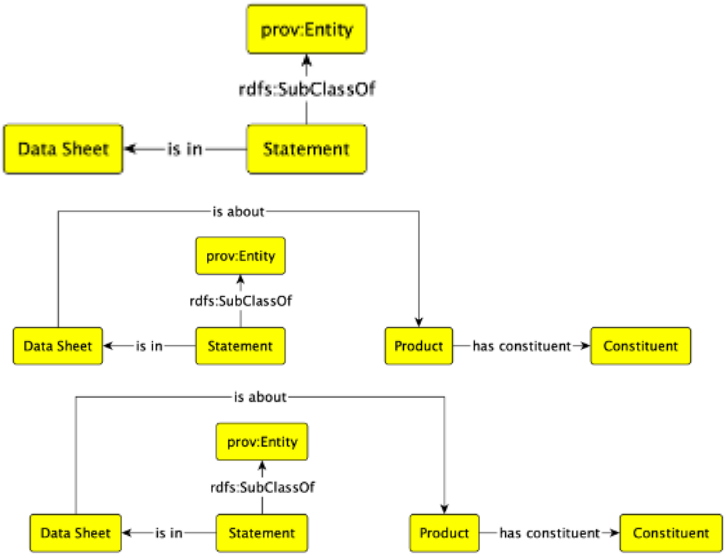
[4] Peroni, S. (2013) Grafoo Specification. Available at: https://essepuntato.it/graffoo/specification/ (Accessed: 2023-11-27)

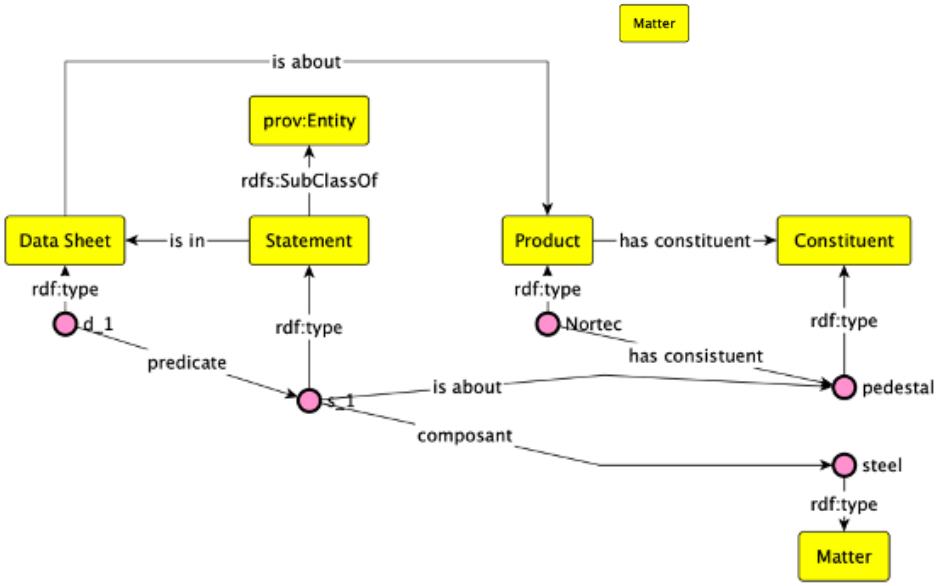
6 Appendix 1 – Ontology Network Evaluation (first iteration)

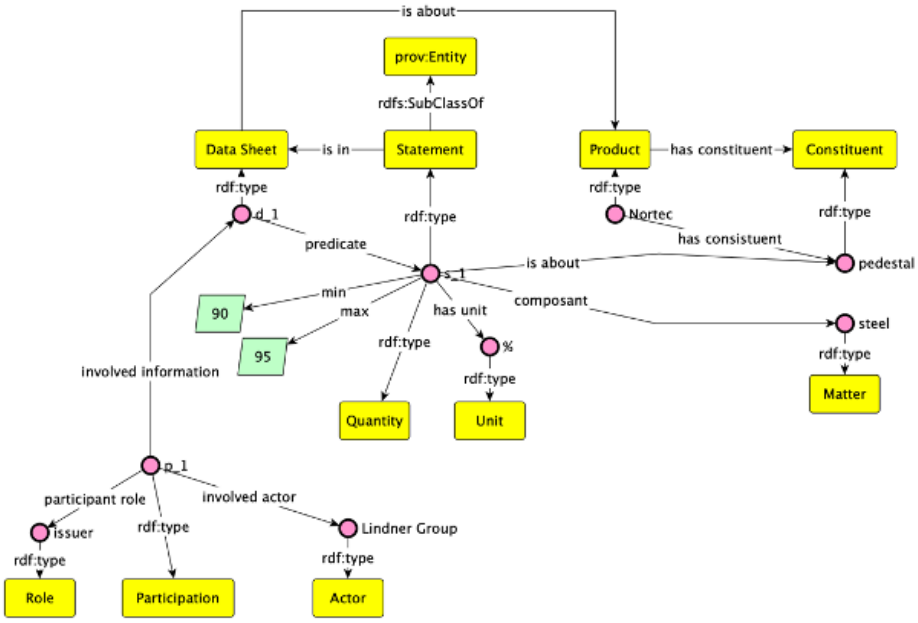
In this appendix, we provide the details of the ontology evaluation setup in the first project iteration, including the survey sent to the participants of the use case evaluation.

6.1 Ontology evaluation workshop material

For the ontology evaluation workshop in the consortium meeting, the following examples were presented (built up step by step in a series of slides):







6.2 Ontology survey

In this section the three versions of the survey, sent out to the three project use cases are presented in detail.

Textile ontology survey

Textile Use Case Ontology Evaluation Form

This form is used to gather feedback on the ontologies created so far, in relation to the evaluation scenarios and data sheets described in WP6 for the first iteration evaluation. The form consists of a number of examples of how data has been modelled so far, and you are asked to provide an opinion on how correct and easy to understand you find the models to be, as well as answering specific questions on modelling choices, and provide general suggestions or feedback.

* Required

Notation

In this first section we will try to make you familiar with the notation used in the later parts of the evaluation. Remember that you can always go back in the survey if you become unsure about the notation later on!

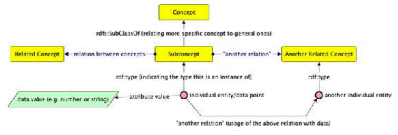
1

First you need to be familiar with the notation of the example illustrations. The image below shows the notation used in the example illustrations. It is the same notation used in the consortium meeting workshop.

Yellow boxes represent concepts, i.e. classes of instances or you can think of them as types or categories of things. Concepts can be organised in hierarchies using rdfs:SubClassOf, meaning that everything that is of the subtype is also of the supertype, e.g. given that "dog" would be a subclass of "animal" that means that all individual dogs are also animals. Concepts are the main things defined in an ontology. The ontology also defines relations that may hold between individuals, i.e. instances of the concepts. These can be shown as the dark blue arrows between the yellow concepts. This top part of the diagram shows the ontology.

The bottom part of the image then shows an example of data expressed, or documented, using the ontology. The pink dots represent individuals, i.e. instances of the concepts, where the rdf:type relation points to the concept that is their type (can be more than one). For instance, an individual of the "dog" class might be a specific dog we have collected data about. Such data can be relations to other individuals, such as a relation to the person owning the dog, or relations representing attribute values, such as the name of the dog, its age, or any other data we have about it. Relations to other individuals are represented as black arrows between the pink dots, with the same name as a relation specified in the ontology part of the picture with a blue arrow (sometimes omitted in the examples to not clutter the image), and attribute values are represented using light green parallelograms.

Just for our reference, please rate below how confident you feel in interpreting this notation. 1 meaning "not very confident at all" and 5 meaning "completely confident". This will help us assess the confidence of your answers later on, but remember, this is not an exam so answer as honestly as possible. *



1	2	3	4	5

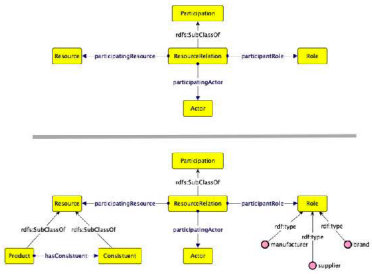
Actors and their relations to products

In this section we will show some examples expressing the relations of actors to resources, and product break-down into components.

2

The basic pattern:
In order to be able to express information abut the relation between an actor and a specific resource, such as the role(s) that the actor has in relation to the resource, and perhaps also temporal and spatial context (which is however not shown here), we need to represent the relation as a specific concept (yellow box) rather than as a simple relation (arrow) in the ontology. In the image below you can see the general pattern how this is expressed for relations between actors and resources, above the grey line. This pattern is quite abstract, but will occur later on in the examples.

Below the grey line you can see an extension of the pattern, more specific to our CE context, showing some of the subclasses of resource, i.e. indicating that Product and Consistuent (components of products) are two (non-mutually exclusive) kinds of resources. The illustration also shows three example instances of the role concept, i.e. manufacturer, supplier and brand. *



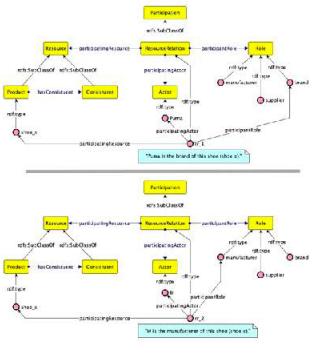
	Very poorly	Quite poorly	Neither poor nor good	Mostly clear	Completely clear
Does the principle of this pattern make sense to you?	○	○	○	○	○
How well do you feel that you understand this pattern?	○	○	○	○	○

3

Do you have any comments or suggestions regarding the basic pattern in question 2?

4

Brands, manufacturers and products:
Now we shall use the basic pattern to express some example data, related to the evaluation scenario drafted in WP6, where a manufacturer manufactures a product for a specific brand. In the illustration below, you can see two examples, one expressing the relation between a specific shoe and the brand, and the other between the manufacturer and the same shoe. Both of these can of course be in our data at the same time, but have been broken into two separate illustrations here simply for clarity of the illustration. For the sake of clarity we also include a textual description of the data expressed (in the blue box below each image). *



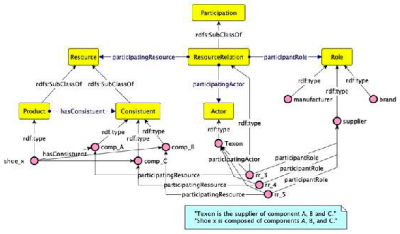
	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Do these two examples make sense to you in the context of the evaluation scenario?	◯	◯	◯	◯	◯
How well do you feel that you understand the examples?	◯	◯	◯	◯	◯

5

Do you have any comments or suggestions regarding the examples in question 4?

6

Products and components:
Now lets look at an example that is a bit more complex, where a product has been broken down into three components (constituents) which are supplied by the same supplier in this case. Similarly to the examples above, we provide a textual representation of the data expressed in the image in the blue box. And this data could of course be combined with the other information about the shoe illustrated above, but has been broken out to a separate example here for clarity. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	◯	◯	◯	◯	◯
How well do you feel you understand the example?	◯	◯	◯	◯	◯

7

Do you have any comments or suggestions regarding the example in question 6?

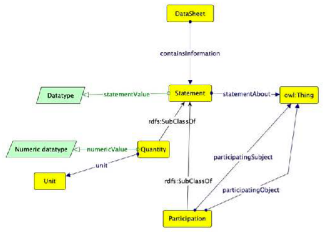
Data sheets and statements

In this section we will show some examples expressing both metadata about data sheets and statements, as well as how information inside a data sheet can be expressed.

8

The basic pattern:
In order to be able to express information about various data sheets, which in turn are collections of statements expressing facts about a product, component, or something else, we need to model the general concept of a data sheet. Below you can see an illustration of this part of the ontologies. There is a concept of DataSheet that contains information, which are some Statements. A Statement in turn is "about" something (owl:Thing is the most general concept in an ontology, i.e. this means "anything") and can have a content that is a literal, e.g. a text string, a number or some other value. Although not shown in the illustration, this also means we can express other metadata about a data sheet and a statement, e.g. the time of issuing or validity, the version, the location of the sheet in a file etc.

To further detail the kinds of statements we have in our data sheets we have modelled two more specific kinds of statements; Quantity and Participation. A quantity expresses a relation between some thing, and a numeric value, with an associate unit of measure, e.g. the weight of a product in grams. The participation you have actually already seen in previous examples, such as the role of an actor in relation to a resource, e.g. this could represent the statement about who has issued the data sheet, or who is the manufacturer of the product the data sheet represents. Remember that things can also be of both types, i.e. both a participation AND a quantity, if one wishes to express for instance that a product is composed of a certain amount of material. *



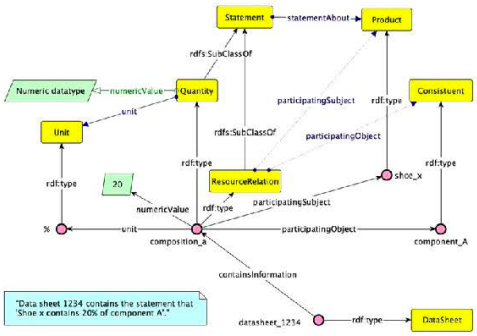
	Very poorly	Quite poorly	Neither poor nor good	Mostly clear	Completely clear
Does the principle of this pattern make sense to you?	○	○	○	○	○
How well do you feel that you understand this pattern?	○	○	○	○	○

9

Do you have any comments or suggestions regarding the general pattern in question 8?

12

Statements in sheets:
Data sheets are collections of statements. Hence, in this example you can see an example data sheet instance (called datasheet_1234) which contains the statement from the previous example. More information about the data sheet could of course be added, and we will look at that in further examples below, as well as many more statements (rather than just one statement, as in the illustration). As before, we have included a textual description of this information in the blue box at the bottom, for increased clarity. *

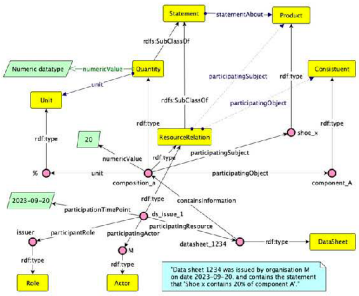


	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

13

Do you have any comments or suggestions regarding the example in question 12?

Issuing of data sheets:
Now let's add some more information about the data sheet, i.e. the information about which organisation has issued it. This is again a relation between an organisation (Actor) and a data sheet (which is actually a Resource, but this is omitted in the illustration for readability reasons), where the role of the actor is "issuer". To illustrate the fact that any additional information about the issuing of the sheet can be added to this relation, we take the example of adding an issuing date (using the relation participationTimePoint). As before, we have included a textual description of this information in the blue box at the bottom, for increased clarity. *



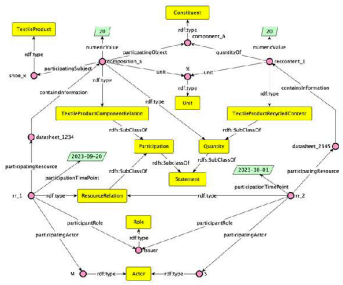
	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

15

Do you have any comments or suggestions regarding the example in question 14?

Different sources:
Continuing on the example above, the information about the product would be held by the manufacturer or the brand, while the information of the content of the component is held by the supplier of the component. In the example below, we illustrate how this can be expressed using the current ontologies. We first add the information that composition_a is in datasheet_1234 and that the statement reccontent_1 is in another data sheet, datasheet_2345. Note that this does not say where this data is actually stored, which could be in two separate Solid pods, for instance, but this is not part of the example. We are just saying that the sources are different.

Next, we can again express information about the data sheets, i.e. who issued them and when, which is illustrated at the bottom of the image. In this example datasheet_1234 is issued by the actor M, and datasheet_2345 is issued by the actor S, and at a different date. This example aims to illustrate how data from different sources can be integrated, based on that they refer to the same components and products, and use the same ontology. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

19

Do you have any comments or suggestions regarding the example in question 18?

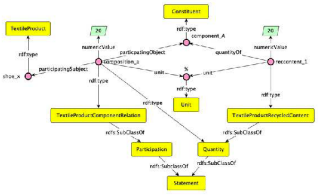
Product breakdown and content

In this section, we will illustrate some examples of data about a product breakdown, its content and other data.

16

Product components and their content:
Earlier we have already seen how to express the components of a product, as a statement and quantity of a product. The example below shows an example that is a bit more detailed, where we have also specialised some of the concepts, for the textile use case, i.e. such as the TextileProduct (which is a subclass of Product, but this is omitted in the illustration), and the specific participation and quantity concepts. These are not essential for the functionality of the ontologies as such, but increases the human usability of the ontologies, i.e. hopefully increases the understanding of how to use the ontologies. Hence, we have included some concepts like this in the use case specific ontologies of Onto-DESIDE, but we are happy to receive feedback on this.

Otherwise, the example shows first the same statement on product composition that we have seen before (to the left), i.e. that the shoe x contains 20% of component A. Now this is complemented with a second statement (to the right) that mentions the amount of recycled content of component A, which is also 20%. The example shows the amount of recycled content, but similar statements can be made also about the actual chemical composition of the product etc., although this was not currently detailed in the initial evaluation scenario and hence not illustrated here. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

17

Do you have any comments or suggestions regarding the example in question 16?

Final comments

Please share any additional comments and thoughts you have.

20

Overall, how well do you think that the above examples cover the content and intention of the evaluation scenario of the textile use case for the first project iteration? Let 1 mean "not at all" and 5 "completely". *

1 2 3 4 5

21

Do you have any final comments, questions or suggestions based on the examples you have seen in this evaluation survey?

Construction ontology survey

Construction Use Case Ontology Evaluation Form

This form is used to gather feedback on the ontologies created so far, in relation to the evaluation scenarios and data sheets described in WP6 for the first iteration evaluation. The form consists of a number of examples of how data has been modelled so far, and you are asked to provide an opinion on how correct and easy to understand you find the models to be, as well as answering specific questions on modelling choices, and provide general suggestions or feedback.

* Required

Notation

In this first section we will try to make you familiar with the notation used in the later parts of the evaluation. Remember that you can always go back in the survey if you become unsure about the notation later on!

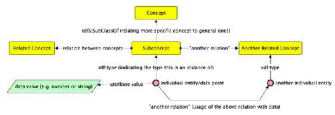
1

First you need to be familiar with the notation of the example illustrations. The image below shows the notation used in the example illustrations. It is the same notation used in the consortium meeting workshop.

Yellow boxes represent concepts, i.e. classes of instances or you can think of them as types or categories of things. Concepts can be organised in hierarchies using rdfs:SubClassOf, meaning that everything that is of the subtype is also of the supertype, e.g. given that "dog" would be a subclass of "animal" that means that all individual dogs are also animals. Concepts are the main things defined in an ontology. The ontology also defines relations that may hold between individuals, i.e. instances of the concepts. These can be shown as the dark blue arrows between the yellow concepts. This top part of the diagram shows the ontology.

The bottom part of the image then shows an example of data expressed, or documented, using the ontology. The pink dots represent individuals, i.e. instances of the concepts, where the rdf:type relation points to the concept that is their type (can be more than one). For instance, an individual of the "dog" class might be a specific dog we have collected data about. Such data can be relations to other individuals, such as a relation to the person owning the dog, or relations representing attribute values, such as the name of the dog, its age, or any other data we have about it. Relations to other individuals are represented as black arrows between the pink dots, with the same name as a relation specified in the ontology part of the picture with a blue arrow (sometimes omitted in the examples to not clutter the image), and attribute values are represented using light green parallelograms.

Just for our reference, please rate below how confident you feel in interpreting this notation. 1 meaning "not very confident at all" and 5 meaning "completely confident". This will help us assess the confidence of your answers later on, but remember, this is not an exam so answer as honestly as possible. *



1	2	3	4	5

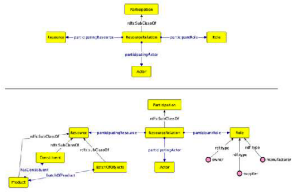
Actors and their relations to products

In this section we will show some examples expressing the relations of actors to resources, and product break-down into components

2

The basic pattern:
In order to be able to express information abut the relation between an actor and a specific resource, such as the role(s) that the actor has in relation to the resource, and perhaps also temporal and spatial context (which is however not shown here), we need to represent the relation as a specific concept (yellow box) rather than as a simple relation (arrow) in the ontology. In the image below you can see the general pattern how this is expressed for relations between actors and resources, above the grey line. This pattern is quite abstract, but will occur later on in the examples.

Below the grey line you can see an extension of the pattern, more specific to our CE context, showing some of the subclasses of resource, i.e. indicating that Product, Constituent (components of products), BatchOfObjects are three kinds of resources. The relationship (link) from BatchOfObjects intends to represent that a specific batch consists of objects that are all of a certain product. The illustration also shows three example instances of the role concept, i.e. owner, supplier, and manufacturer. *



	Very poorly	Quite poorly	Neither poor nor good	Mostly clear	Completely clear
Does the principle of this pattern make sense to you?	○	○	○	○	○
How well do you feel that you understand this pattern?	○	○	○	○	○

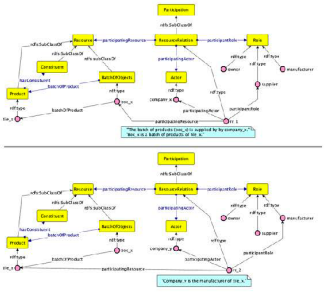
3

Do you have any comments or suggestions regarding the basic pattern in question 2?

4

Manufacturers, suppliers, batches of products and products:
Now we shall use the basic pattern to express some example data, where a supplier supplies a batch of products, and a manufacturer manufactures a product. In the illustration below, you can see two examples, one expressing a batch of tiles and the supplier of the batch, the other expressing the relation between a specific tile and the manufacturer. Both of these can of course be in our data at the same time, but have been broken it into two separate illustrations here simply for clarity of the illustration. For the sake of clarity, we also include a textual description of the data expressed (in the blue box below each image).

*



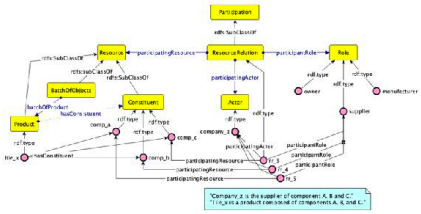
	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Do these two examples make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel that you understand the examples?	○	○	○	○	○

5

Do you have any comments or suggestions regarding the examples in question 4?

6

Products and components:
Now lets look at an example that is a bit more complex, where a product has been broken down into three components (constituents) which are supplied by the same supplier in this case. Similarly to the examples above, we provide a textual representation of the data expressed in the image in the blue box. And this data could of course be combined with the other information about the tile illustrated above, but has been broken out to a separate example here for clarity. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

7

Do you have any comments or suggestions regarding the example in question 6?

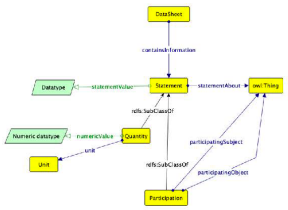
Data sheets and statements

In this section we will show some examples expressing both metadata about data sheets and statements, as well as how information inside a data sheet can be expressed.

8

The basic pattern:
In order to be able to express information about various data sheets, which in turn are collections of statements expressing facts about a product, component, or something else, we need to model the general concept of a data sheet. Below you can see an illustration of this part of the ontologies.
There is a concept of DataSheet that contains information, which are some Statements. A Statement in turn is "about" something (owl:Thing is the most general concept in an ontology, i.e. this means "anything") and can have a content that is a literal, e.g. a text string, a number or some other value. Although not shown in the illustration, this also means we can express other metadata about a data sheet and a statement, e.g. the time of issuing or validity, the version, the location of the sheet in a file etc.

To further detail the kinds of statements we have in our data sheets we have modelled two more specific kinds of statements; Quantity and Participation. A quantity expresses a relation between some thing, and a numeric value, with an associated unit of measure, e.g. the weight of a product in grams. The participation you have actually already seen in previous examples, such as the role of an actor in relation to a resource, e.g. this could represent the statement about who has issued the data sheet, or who is the manufacturer of the product the data sheet represents. Remember that things can also be of both types, i.e. both a participation AND a quantity, if one wishes to express for instance that a product is composed of a certain amount of material. *



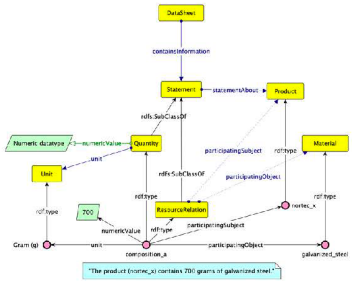
	Very poorly	Quite poorly	Neither poor nor good	Mostly clear	Completely clear
Does the principle of this pattern make sense to you?	○	○	○	○	○
How well do you feel that you understand this pattern?	○	○	○	○	○

9

Do you have any comments or suggestions regarding the general pattern in question 8?

10

A basic statement:
Now lets look at an example of a basic statement that can be found in a data sheet, e.g. you could view it as a row in an Excel sheet. In this example we are expressing a fact about a product, e.g. a specific product (nortec_x), which contains 700 grams of galvanized steel. This statement expresses information about the relation between the product and its components, hence it is a relation between resources (ResourceRelation), but it also expresses a concrete quantity, i.e. the numeric value 700 and its associated unit (grams). Like before, we have included a textual description of this information in the blue box at the bottom, for increased clarity. *



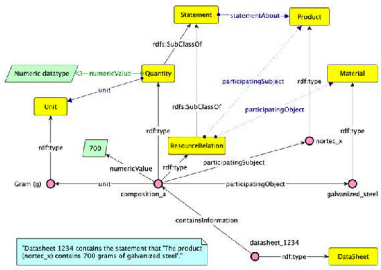
	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

11

Do you have any comments or suggestions regarding the example in question 10?

12

Statements in sheets:
Data sheets are collections of statements. Hence, in this example you can see an example datasheet instance (datasheet_1234), which contains the statement from the previous example. More information about the data sheet could of course be added, and we will look at that in further examples below, as well as more statements (rather than just one statement, as in the illustration). As before, we have included a textual description of this information in the blue box at the bottom, for increased clarity. *



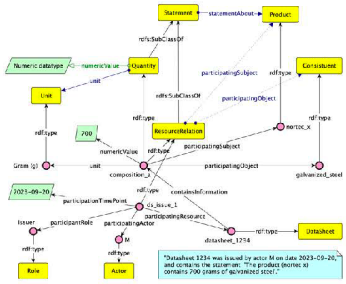
	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

13

Do you have any comments or suggestions regarding the example in question 12?

14

Issuing of data sheets:
Now let's add some more information about the datasheet, i.e. the information about which organisation has issued it. This is again a relation between an organisation (Actor) and a datasheet (which is actually a Resource, but this is omitted in the illustration for readability reasons), where the role of the actor is "issuer". To illustrate the fact that any additional information about the issuing of the sheet can be added to this relation, we take the example of adding an issuing date (using the relation participationTimePoint). As before, we have included a textual description of this information in the blue box at the bottom, for increased clarity. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

15

Do you have any comments or suggestions regarding the example in question 14?

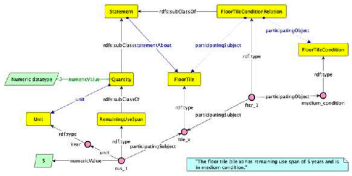
Product breakdown and content

In this section, we will illustrate some examples of data about a product breakdown, its content and other data.

16

Products and their content:
Earlier we have seen how to express the components of a product, as a statement and quantity of a product. The example below shows an example that is a bit more detailed, where we have specialised some of the concepts for the construction use case, such as the FloorTileProduct (which is a subclass of Product), FloorTileConditionRelation (which is a subclass of ResourceRelation) and RemainingUseSpan (which is a subclass of Quantity). The concepts Product and ResourceRelation have been left out of simply for the clarity of the illustration. Note that these subclasses are not essential for the functionality of the ontologies as such, but increases the human usability of the ontologies, i.e. hopefully increases the understanding of how to use the ontologies. Hence, we have included some concepts like this in the use case specific ontologies of Onto-DESIDE, but we are happy to receive feedback on this.

The example below shows two statements regarding the remaining use span of a floor tile and its condition. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

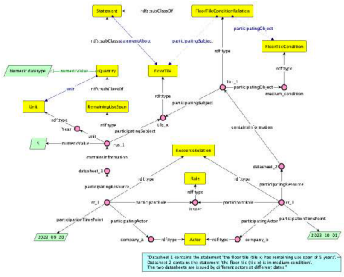
17

Do you have any comments or suggestions regarding the example in question 16?

18

Different sources:
Continuing on the example above, the information about the product could be held by different actors. In the example below, we illustrate how this can be expressed using the current ontologies. We first add the information that rus_1 is in datasheet_1 and that ftrc_1 is in datasheet_2. Note that this does not say where this data is actually stored, which could be in two separate Solid pods, for instance, but this is not part of the example. We are just saying that the sources are different.

Next, we can again express information about the datasheets, i.e. who issued them and when. In the example, datasheet_1 is issued by company_a, and datasheet_2 is issued by the company_b. The datasheets are issued at a different dates. This example aims to illustrate how data from different sources can be integrated, based on that they refer to the same components and products, and use the same ontology. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Does this example make sense to you in the context of the evaluation scenario?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

19

Do you have any comments or suggestions regarding the example in question 18?

Final comments

Please share any additional comments and thoughts you have.

20

Overall, how well do you think that the above examples cover the content and intention of the evaluation scenario of the construction use case for the first project iteration? Let 1 mean "not at all" and 5 "completely". *

1	2	3	4	5

21

Do you have any final comments, questions or suggestions based on the examples you have seen in this evaluation survey?

Electronics ontology survey

Electronics Use case Ontology Evaluation Form

This form is used to gather feedback on the ontologies created so far, in relation to the evaluation scenarios and data sheets described in WP6 for the first iteration evaluation. The form consists of a number of examples of how data has been modelled so far, and you are asked to provide an opinion on how correct and understandable you find the models to be, as well as answering specific questions on modelling choices, and provide general suggestions or feedback.

* Required

Notation

In this first section we will try to make you familiar with the notation used in the later parts of the evaluation. Remember that you can always go back in the survey if you become unsure about the notation later on!

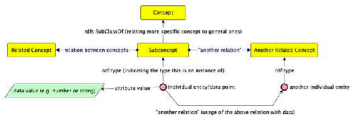
1

First you need to be familiar with the notation of the example illustrations. The image below shows the notation used in the example illustrations. It is the same notation used in the consortium meeting workshop.

Yellow boxes represent concepts, i.e. classes of instances or you can think of them as types or categories of things. Concepts can be organised in hierarchies using rdfs:SubClassOf, meaning that everything that is of the subtype is also of the supertype, e.g. given that "dog" would be a subclass of "animal" that means that all individual dogs are also animals. Concepts are the main things defined in an ontology. The ontology also defines relations that may hold between individuals, i.e. instances of the concepts. These can be shown as the dark blue arrows between the yellow concepts. This top part of the diagram shows the ontology.

The bottom part of the image then shows an example of data expressed, or documented, using the ontology. The pink dots represent individuals, i.e. instances of the concepts, where the rdf:type relation points to the concept that is their type (can be more than one). For instance, an individual of the "dog" class might be a specific dog we have collected data about. Such data can be relations to other individuals, such as a relation to the person owning the dog, or relations representing attribute values, such as the name of the dog, its age, or any other data we have about it. Relations to other individuals are represented as black arrows between the pink dots, with the same name as a relation specified in the ontology part of the picture with a blue arrow (sometimes omitted in the examples to not clutter the image), and attribute values are represented using light green parallelograms.

Just for our reference, please rate below how confident you feel in interpreting this notation. 1 meaning "not very confident at all" and 5 meaning "completely confident". This will help us assess the confidence of your answers later on, but remember, this is not an exam so answer as honestly as possible. *



1	2	3	4	5

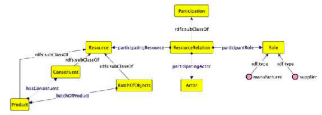
Actors and their relations to products

In this section we will show some examples expressing the relations of actors to resources, and product break-down into components.

2

The basic pattern:
In order to be able to express information abut the relation between an actor and a specific resource, such as the role(s) that the actor has in relation to the resource, and perhaps also temporal and spatial context (which is however not shown here), we need to represent the relation as a specific concept (yellow box) rather than as a simple relation (arrow) in the ontology. In the image below you can see the general pattern how this is expressed for relations between actors and resources, above the grey line. This pattern is quite abstract, but will occur later on in the examples.

Below the grey line you can see an extension of the pattern, more specific to our CE context, showing some of the subclasses of resource, i.e. indicating that Product, Consistuent (components of products), BatchOfObjects are three kinds of resources. The relationship (link) from BatchOfObjects intends to represent that a specific batch consists of objects that are all a certain product. The illustration also shows two example instances of the role concept, i.e. manufacturer, and supplier. *



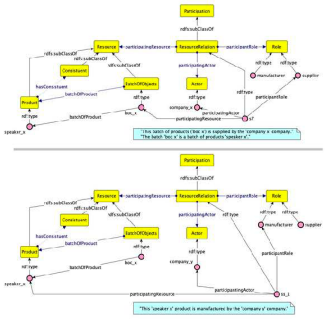
	Very poorly	Quite poorly	Neither poor nor good	Mostly clear	Completely clear
Does the principle of this pattern make sense to you?	○	○	○	○	○
How well do you feel that you understand this pattern?	○	○	○	○	○

3

Do you have any comments or suggestions regarding the basic pattern in question 2?

4

Manufacturers, Suppliers, batches of products and products:
Now we shall use the basic pattern to express some example data, where a supplier supplies a batch of products, and a manufacturer manufactures a product. In the illustration below, you can see two examples, one expressing a batch of speakers and the supplier of the batch, the other expressing the relation between a specific speaker and the manufacturer. Both of these can of course be in our data at the same time, but have been broken into two separate illustrations here simply for clarity of the illustration. For the sake of clarity we also include a textual description of the data expressed (in the blue box below each image). *



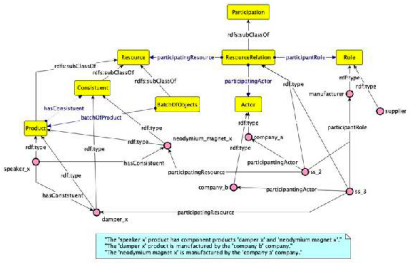
	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Do these two examples make sense to you in the context of the use case?	○	○	○	○	○
How well do you feel that you understand the examples?	○	○	○	○	○

5

Do you have any comments or suggestions regarding the examples in question 4?

6

Products and components:
Now lets look at an example that is a bit more complex, where a product has been broken down into three components (constituents) which are supplied by the same supplier in this case. Similarly to the examples above, we provide a textual representation of the data expressed in the image in the blue box. And this data could of course be combined with the other information about the speaker illustrated above, but has been broken out to a separate example here for clarity. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Do these two examples make sense to you in the context of the use case?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

7

Do you have any comments or suggestions regarding the example in question 6?

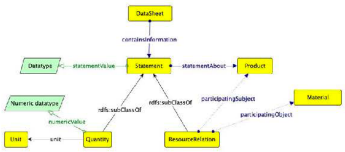
Data sheets and statements

In this section we will show some examples expressing both metadata about data sheets and statements, as well as how information inside a data sheet can be expressed.

8

The basic pattern:
In order to be able to express information about various data sheets, which in turn are collections of statements expressing facts about a product, component, or something else, we need to model the general concept of a data sheet. Below you can see an illustration of this part of the ontologies.
There is a concept of DataSheet that contains information, which are some Statements. A Statement in turn is "about" something (owl:Thing is the most general concept in an ontology, i.e. this means "anything") and can have a content that is a literal, e.g. a text string, a number or some other value. Although not shown in the illustration, this also means we can express other metadata about a data sheet and a statement, e.g. the time of issuing or validity, the version, the location of the sheet in a file etc.

To further detail the kinds of statements we have in our data sheets we have modelled two more specific kinds of statements; Quantity and Participation. A quantity expresses a relation between some thing, and a numeric value, with an associate unit of measure, e.g. the weight of a product in grams. The participation you have actually already seen in previous examples, such as the role of an actor in relation to a resource, e.g. this could represent the statement about who has issued the data sheet, or who is the manufacturer of a product. Remember that things can also be of both types, i.e. both a participation AND a quantity, if one wishes to express for instance that a product is composed of a certain amount of material. *



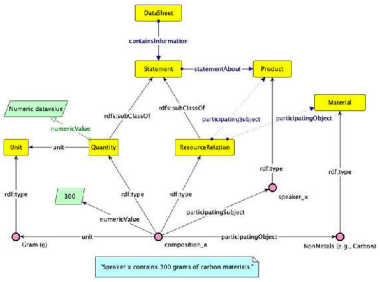
	Very poorly	Quite poorly	Neither poor nor good	Mostly clear	Completely clear
Does the principle of this pattern make sense to you?	○	○	○	○	○
How well do you feel that you understand this pattern?	○	○	○	○	○

9

Do you have any comments or suggestions regarding the general pattern in question 8?

10

A basic statement:
Now lets look at an example of a basic statement that can be found in a data sheet, e.g. you could view it as a row in an Excel sheet. In this example we are expressing a fact about a product, e.g. a specific speaker product, which overall contains 300 grams of a nonmetal materials (e.g., carbon). This statement expresses information about the relation between the speaker and the component, hence it is a relation between resources (ResourceRelation), but it also expresses a concrete quantity, i.e. the numeric value 300 and its associated unit (gram). Like before, we have included a textual description of this information in the blue box at the bottom, for increased clarity. *



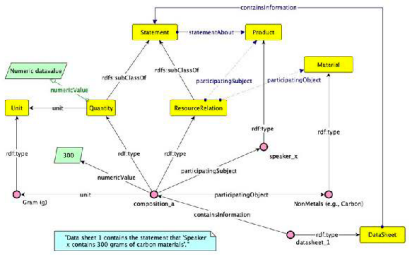
	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Do these two examples make sense to you in the context of the use case?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

11

Do you have any comments or suggestions regarding the example in question 10?

12

Statements in sheets:
Data sheets are collections of statements. Hence, in this example you can see an example data sheet instance (called datasheet_1) which contains the statement from the previous example. More information about the data sheet could of course be added, and we will look at that in further examples below, as well as many more statements. As before, we have included a textual description of this information in the blue box at the bottom, for increased clarity. *



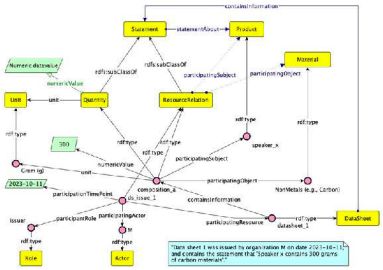
	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Do these two examples make sense to you in the context of the use case?	◯	◯	◯	◯	◯
How well do you feel you understand the example?	◯	◯	◯	◯	◯

13

Do you have any comments or suggestions regarding the example in question 12?

14

Issuing of data sheets:
Now let's add some more information about the data sheet, i.e. the information about which organisation has issued it. This is again a relation between an organisation (Actor) and a data sheet (which is actually a Resource, but this is omitted in the illustration for readability reasons), where the role of the actor is "issuer". To illustrate the fact that any additional information about the issuing of the sheet can be added to this relation, we take the example of adding an issuing date (using the relation participationTimePoint). As before, we have included a textual description of this information in the blue box at the bottom, for increased clarity. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Do these two examples make sense to you in the context of the use case?	◯	◯	◯	◯	◯
How well do you feel you understand the example?	◯	◯	◯	◯	◯

15

Do you have any comments or suggestions regarding the example in question 14?

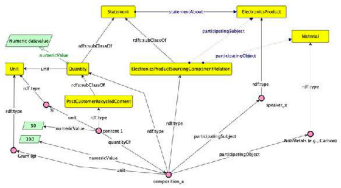
Product breakdown and content

In this section, we will illustrate some examples of data about a product breakdown, its content and other data.

16

Product components and their content:
Earlier we have already seen how to express the components of a product, as a statement and quantity of a product. The example below shows an example that is a bit more detailed, where we have also specialised some of the concepts, for the electronics use case, i.e. such as the ElectronicsProduct, and the specific participation and quantity concepts. These are not essential for the functionality of the ontologies as such, but increases the human usability of the ontologies, i.e. hopefully increases the understanding of how to use the ontologies. Hence, we have included some concepts like this in the use case specific ontologies of Onto-DESIDE, but we are happy to receive feedback on this.

Otherwise, the example shows first the same statement on product composition that we have seen before (at the bottom), i.e. that the speaker x contains 300 grams of a carbon material. Now this is complemented with a second statement (above to the left) that mentions the amount of post-customer recycled content of this material, which is 50%. The example shows the amount of post-customer recycled content, but similar statements can be made also about the actual chemical composition of the product etc. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Do these two examples make sense to you in the context of the use case?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

17

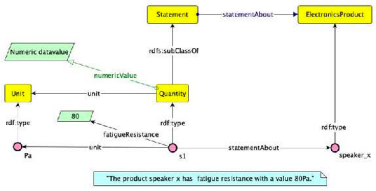
Do you have any comments or suggestions regarding the example in question 16?

Product Properties and Statements

In this section, we will illustrate some examples of properties about a product and their statements.

18

Product properties and statements:
Earlier we have already seen how to express the components of a product, as a statement and quantity of a product. The example below shows an example of properties (mechanical, physical) of a specific product and statements about such properties. In the below example, we specialize numericValue with fatigueResistance as a sub-relationship from Quantity to numeric data value. Then of course, we can use more such relationships to represent different quantity properties of products. As before, we have included a textual description of this information in the blue box at the bottom, for increased clarity. *



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Do these two examples make sense to you in the context of the use case?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

19

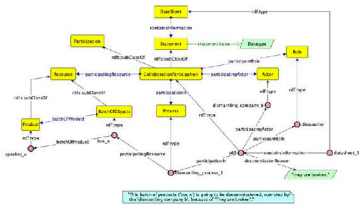
Do you have any comments or suggestions regarding the example in question 18?

Batch Recycling/Dismantling Process and Statements

In this final section, we will illustrate some examples of processes about a batch of products and their statements.

20

Processes, batches and statements:
Earlier we have already seen how to express a batch of products, the relationships to express suppliers and manufacturers of batch of products and products, respectively. In the below example, we are going to show how CE-related processes can be represented. We first illustrate the Participation with a CollaborationParticipation sub-concept which can participate in a process. The CollaborationParticipation is similar to ResourceRelation introduced in previous examples, which has participantRole and participatingActor relations. We also specialize statementValue with decommissionReason as a sub-relationship from statement to data value. As before, we have included a textual description of this information in the blue box at the bottom, for increased clarity.
*



	Very poorly	Quite poorly	Neither poor nor good	Quite clear	Completely clear
Do these two examples make sense to you in the context of the use case?	○	○	○	○	○
How well do you feel you understand the example?	○	○	○	○	○

21

Do you have any comments or suggestions regarding the example in question 20?

Final comments

Please share any final comments and thoughts you have.

22

Overall, how well do you think that the above examples cover the content and intention of the electronics use case in the first project iteration? Let 1 mean "not at all" and 5 "completely".

1	2	3	4	5

23

Do you have any final comments, questions or suggestions based on the examples you have seen in this evaluation survey?

7 Appendix 2 – Requirements validation

This appendix aligns the given requirements with the OCP functional categories as introduced in Section 2.2.2.

7.1 User stories

ID	AS A	I WANT	Platform Requirements
CUS01	Building owner	I want to know which are the different EoL scenarios for building materials.	Query
CUS02	Building owner	I want to obtain economic and environmental costs of different EoL scenarios for building material.	Query,Calculate
CUS03	Manufacturer	I want to obtain information on quantities and locations of my products that will be dismantled.	Query
CUS04	Manufacturer	I want to find out if the rest material from my production could be used in other production processes.	Query
CUS05	Manufacturer	I want to know the costs of dismantling and refurbishing my products.	Query,Calculate
CUS06	Manufacturer	I want to know the market demand for a refurbished product.	Query
CUS07	Dismantler	I want to find out where there are needs of dismantling of products for a certain building and what these products are.	Query
CUS08	Tenderer	I want to retrieve product information from the manufacturer.	Query
CUS09	Recycler	I want to be informed on buildings where deconstruction and retrieval of certain secondary raw materials is planned and for what products it is planned.	Query,Notify
CUS10	Deconstruction company	I want to be informed on buildings where the deconstruction is planned and for what products.	Query,Notify
CUS11	Marketplace	I want to retrieve product information such as composition, dimensions, quantities, and pricing.	Query
CUS12	Planner	I want to retrieve product information such as measurements, qualities, and quantities.	Query
CUS13	Manufacturer, Dismantler, Tenderer, Recycler, Deconstruction company, Planner, Marketplace	I want to retrieve product information such as measurements, composition, qualities, quantities, and location. I also need to be able to access the process and handling information that are related to these products.	Query
EUS01	Supplier	To be able to proof the quality characteristics of the material I supply to the Brand, End-user, and Legislator	Query,Validate

EUS02	Manufacturer	To understand the origin of the materials and the production processes	Query
EUS03	Manufacturer/ Brand	To assess the sustainability performance of my production.	Query,Calculate
EUS04	User	To find information on how sustainable my product is and how to recycle or refurbish my product.	Query
EUS05	Recycler	To understand the composition of the product.	Query
EUS06	Recycler	To find out if a product contains hazardous materials.	Query
TUS01	Fiber Supplier	a possibility to display the material content of my fibers requested by my customers.	Query,Input (Data,Certificate,Image)
TUS02	Fibre supplier, Transformation actor	A possibility to edit and Notify the material content of my fibers/properties of my product displayed on the platform	Input(Data,Certificate)
TUS03	Fiber Manufacturer and Transformation actor	An overview when I log into the platform to see all my materials including which materials have been viewed or where I have been contacted.	Query,Share,Input(Certificate)
TUS04	Transformation actor	Access trustful data of the fibers and other materials I used in my transformation process (properties, origin of materials/fibers and the conditions in which they have been produced/ cultivated)	Query,Input(Data)
TUS05	Fiber supplier and Transformation actor	A platform that can generate material inventories (based on imported data from my ERP system or from digital document such as excel, json, etc.) and upload certificate.	Input(Data,Certificate)
TUS06	Transformation actor	A visible and transparent score on my product sustainability/circularity performance	Calculate
TUS07	Brand	To have access and explore freely a catalogue of available circular materials. To improve the design phase of my products (eco-design).	Query
TUS08	Brand	To have access to data on properties, assembly methods and composition of components	Query
TUS09	Brand	Recognition of recycled material though certificates, labels, etc.	Query,Validate
TUS10	Brand	• To access data on manufacturing process on how fibers have been assembled AND/OR the quantity of resources used in the process. • To create waste minimization strategies • To find eco-friendly alternatives.	Query
TUS11	Brand	To access to secure and validated data (i.e., composition of material) through the platform.	Authenticate
TUS12	Brand	Mechanisms boosting visibility of sustainability & circularity efforts.	Query

TUS13	Brand	Display my circular and sustainable products in the platform including all product details.	Input (Data,Image)
TUS14	Retailer	To access information on brands that offer product that can be remanufactured AND ways to sell them the products back.	Query
TUS15	Retailer	To access guidance on how to repair or reuse product.	Query
TUS16	Retailer	To access sustainable data on the product from the brands	Query
TUS17	User	To access trustful and understandable data on circularity and sustainability aspects of the shoes	Reference
TUS18	User	To access information on the appropriate treatment to my shoes (e.g., wash, care for)	Query
TUS19	User	To access guidance on how to replace shoes elements (i.e., inner sole, outer sole, laces)	Query
TUS20	User	To access guidance on how to dispose my shoes after I don't want them anymore.	Query
TUS21	Collector and sorter	To access product information	Query
TUS22	Collector, Sorter	• To access to material inventory • To build knowledge about mechanical and chemical recycling destinations	Query
TUS23	Recycler	To access guidance on how to disassemble the components. To access material inventory	Query
CE01		Energy implementation actions: • The ability to understand all parts of energy (i.e., exergy and anergy). Value implementation actions: • The ability to consider a diverse variety of value forms (incl. economic, environmental, and social)	Query
CE02		Material implementation actions: • The ability to identify connections by analysing (large amounts of) supply chain data.	Query
CE03		Material implementation actions: • The ability to collect data along entire supply chain. • The ability to observe and track materials (in real time) throughout all life cycle phases. Energy implementation actions: • The ability to collect and analyse large amount of data fast. • The ability to visualise and simulate all processes.	Query
CE04		Material implementation actions: • The ability to identify connections by analysing (large amounts of) supply chain data.	Query,Calculate

		Energy implementation actions: • The ability to understand carbon intensity and sustainability of energy sources. • The ability to visualise and simulate all processes.	
CE05		Material implementation actions: • The ability to analyse the feasibility of resource exchange. • The ability to record material specifications and activities in central and standardised unit. • The ability to understand the connection of the quality and quantity of flows. • The ability to incorporate data from various sources. • The ability to visually capture processes. Energy implementation actions: • The ability to trace materials back to their origin to evaluate energy consumption. • The ability to identify energy requirements of rebound effects from material flows. • The ability to consider alternatives for achieving efficiency. • The ability to forecast energy demand and supply. • The ability to assess technical feasibility. Value implementation actions: • The ability to evaluate the economic feasibility of material and energy strategies. • The ability to account for social and environmental externalities. • The ability to develop holistic value proposition. • The ability to identify activities for value creation, capture, and delivery. • The ability to develop core objectives. • The ability to understand value created, value destroyed, value missed.	Query,Calculate
CE06		Energy implementation actions: • The ability to consider macro level energy infrastructure and legislature.	Query
CE07		Material implementation actions: • The ability to understand success factors of exchanges. • The ability to measure and compare material flows. • The ability to evaluate direct and indirect effects. Energy implementation actions: • The ability to evaluate energy consumption and carbon emissions. • The ability to analyse large amount of data fast. • The ability to manage the dynamic and complexity of energy data. • The ability to measure rebound effects.	Query,Calculate,Performance,Notify

		• The ability to establish (prompt) feedback structures. Value implementation actions: • The ability to measure economic, environmental and social value each. • The ability to combine all dimensions of value for a comprehensive evaluation. • The ability to assess value created, missed, destroyed.	
CE08		Material implementation actions: • The ability to track actions and decisions made by system actors. Energy implementation actions: • The ability to collect data during all life cycle phases. • The ability to incentivize the sharing of data.	Query,Input(Data),Share
CE09		Material implementation actions: • The ability to understand the qualities and characteristics of a material. Energy implementation actions: • The ability to collect and process dynamic and complex energy data quickly. • The ability to simulate processes to identify efficiency potential. Value implementation actions: • The ability to define different types of value. • The ability to understand underlying needs and wants.	Query,Performance
CE10		Material implementation actions: • The ability to share infrastructure (Hardware and software). • The ability to align processes. Energy implementation actions: • The ability to share infrastructure (Hardware and software). • The ability to collaborate for energy recovery. • The ability to bring together all energy sector stakeholders. • The ability to share information on energy demand and surplus. Value implementation actions: • The ability to collaborate for value (co)creation, value transfer and value capture.	Query,Share
CE11		Material implementation actions: • The ability to incentivize cooperation. • The ability to establish reciprocal information exchange. Energy implementation actions: • The ability to allow and encourage active engagement by users (i.e., prosumers).	Share,Query,Input(Data)

		• The ability to collect and provide consumption data during use phase. Value implementation actions: • The ability to include stakeholders during identification of value. • The ability to integrate stakeholders in evaluation processes.	
CE12		Material implementation actions: • The ability to manage risk in case of exchange failure. Energy implementation actions: • The ability to manage energy exchanges decentralised. • The ability to make decisions automatically. Value implementation actions: • The ability to establish shared vision and align objectives. • The ability to ensure that responsibilities and obligations are met.	Query
CE13		Material implementation actions: • The ability to share information transparently and traceably. • The ability to standardise material information. Energy implementation actions: • The ability to share information transparently and traceably. Value implementation actions: • The ability to verify value creation.	Query,Validate

7.2 Non-functional requirements

ID	Categorie	Description	Platform Requirements
NF1	Interoperability	Interoperability of data needs to be done using shared vocabularies and languages for knowledge representation.	Interoperable Data
NF2	Interoperability	Vocabularies and languages for knowledge representation needs to adhere to the FAIR principles for scientific data.	Interoperable Data
NF3	Security	It should not be possible to manipulate source data by an unauthorized actor.	Authenticate
NF4	Security	It should not be possible to manipulate data in transit by an unauthorized actor.	Authenticate
NF5	Security	The source code of the circularity platform can be uploaded to a publicly accessible online software repository (e.g., GitHub, Bitbucket), under an opensource license.	Reproduce
NF6	Privacy	Storage and handling of data related to individuals and organizations need to adhere to the standards of the European General Data Protection Regulation (GDPR).	Ethical

NF7	Privacy	Interoperable data needs to be managed in a privacy preserving manner.	Ethical
NF8	Usability	Clear guidance and instructions on how to use the solutions developed needs to be provided.	Reproduce
NF9	Usability	Code should be clearly documented.	Reproduce
NF10	Scalability & Performance	All solutions developed needs to scale with performance given an increase of utilization.	Performance
NF11	Scalability & Performance	As a user that is using the solutions developed, they should not get the perception that the solutions have poor performance.	Performance
NF12	Availability	Data needs to be recoverable from accidental and malicious deletion.	Performance
NF13	Availability	Operations needs to be recoverable from disasters as well as malicious attacks.	Performance

7.3 Application Testing Scenario – Textile

Category	**ID**	**Main user action**	**Platform Requirement**
Main	ATM01	Login	Authenticate
Main	ATM02	Logout	Authenticate
Main	ATM03	Forgot Password	Authenticate
Main	ATM04	Different content per actor	Query
Main	ATM05	Different permissions per actor	Share
Main	ATM06	Data sharing between 2 actors- Textile team needs to define use case eg supplier sharing with brand on high level	Share
Main	ATM07	Ontology testing: See eg whats a fiber -> The right content is displayed Check if all data we have provided are displayed correctly -> All info we receive is defined and setup within ontology framework	Query
Main	ATM08	POC API connection (raw API responses) but on a very basic level or uploading excel/ csv	Input
Main	ATM09	Scalability	Performance
Main	ATM10	Verifiying data -> certificates etc eg Verify recycled content eg by certificates -> Verify functionality to check if certificate is valid	Validate
Manufactorer	ATMF01	As a manufacturer I can log in with my credentials	Authenticate
Manufactorer	ATMF02	As a manufacturer I have the possibility to display the material content of my fibers requested by my customers by clicking "Add material" (?)	Input
Manufactorer	ATMF03		Input
Manufactorer	ATMF04		Input

Manufactor er	ATMF05		Input
Manufactor er	ATMF06		Input
Manufactor er	ATMF07	As a manufacturer I see an overview when I log into the platform with all my materials and can share those with different stakeholders	Query
Manufactor er	ATMF08		Query,Share
Manufactor er	ATMF09		Share,View
Brand	ATB01	As a brand I can log in with my credentials	Authenticate
Brand	ATB02	As a brand I want to have access to data on properties, assembly methods and composition of components so that I can assure the quality and the sustainability of the material	Query,Share
Brand	ATB03		Query
Brand	ATB04	As a brand I want to have access and explore freely a catalogue of available circular materials to improve the design phase of my products (eco-design) and am able to improve the circularity of my products	Query
Brand	ATB05		Share
Brand	ATB06		Query,Validate
Brand	ATB07		Query
Brand	ATB08	In order to know the composition of the material I use to make my products I want to access data on manufacturing process on how fibers have been assembled AND/OR the quantity of resources used in the process • To create waste minimization strategies • To find eco-friendly alternatives.	Query
Brand	ATB09		Share
Brand	ATB10	As a brand I want to display and promote my circular and sustainable products in the platform including all product details and even cross-link to materials uploaded by manufacturers	Query
Brand	ATB11		Input(data)
Brand	ATB12		Input(image)
Brand	ATB13		Input
Brand	ATB14		Share
Brand	ATB15		Input
Brand	ATB16		Query
Retailer	ATR01	As a retailer I can log in with my credentials	Authenticate
Retailer	ATR02	"As a retailer I want to check if brands have an existing ""take back"" program with information on which footwear product can be send back to the brand, reduce or even minimize waste and ensure circularity.	Share
Retailer	ATR03		Share

Retailer	ATR04	As a retailer I want to access guidance on how to repair or reuse product. So that either I can reintroduce them on the market or display this to potential customers bying shoes.	Share
Retailer	ATR05		Share
Retailer	ATR06		Share
Retailer	ATR07	As a retailer I want to make sure that I empower the purchase of sustainable products by displaying all information for my customers. To access sustainable data on the product from the brands	Share
Retailer	ATR08		Query
Sorter	ATS01	In order to successfully sort the footwear product into the right fraction for either recycling or reuse/ resell I need to see all data of the footwear product such as • Valorization methods and actors • Information on legal restrictions regarding resale, repair, sorting and recycling of already used footwear products • Material composition with data such as: • Product with name, type, category & country code (ISO country list) • Brand name • Variation with name, description (consumer facing description provided by brand), year of sale, price, images, color, size, country of origin • Material with name and composition, content, percentage, is recycled • Material component steps with step type (Origin of raw material e.g. Production, Spinning • Tanning, Pre-Tanning, Dyeing, Finishing, Printing), country, color, category (trim, yarn, fabric, leather etc.) and country	Query
Sorter	ATS02	As a sorter Im able to add information on how product was sorted by eg using an API connection to the platform or the brand/ retailer	Input(Data)
Sorter	ATS03	As a sorter I can log in with my credentials	Authenticate
Sorter	ATS04	As a sorter Im able to see information about recyclers and their recycling methods	Query
Recycler	ATRY01	As a recycler I can log in with my credentials	Authenticate
Recycler	ATRY02	As a recycler I log into the platform to access guidance on how to disassemble the components of the footwear product	Authenticate
Recycler	ATRY03		Query
Recycler	ATRY04		Share
Recycler	ATRY05		Query
Recycler	ATRY06	As a recycler Im also able to to access material inventory	Query
Recycler	ATRY07		Share

Recycler	ATRY08		Query

7.4 Qualitative feedback consortium members – iteration 1

ID	DESC	Requirement
F01	Being able to manage custom queries, maybe with query templates	Query
F02	Process data, e.g. to perform LifeCycle Assesment	Calculate
F03	API documentation	Reproduce
F04	Align with the CEON ontology	Interoperable Data
F05	Describe the process in the CEON ontology	Interoperable Data
F06	Create subsets of the data	View
F07	Configure the authorization	Share
F08	Overview: where do I have access to?	Share

7.5 Coverage

Covered from: 1 means iteration 1, 2 means iteration 2, P means partially at iteration 2, 3 means foreseen in iteration 3, x means out of scope

ID	Covered from	Comment
CUS01	1	
CUS02	1	
CUS03	1	
CUS04	1	
CUS05	1	
CUS06	1	
CUS07	1	
CUS08	1	
CUS09	P	Query can be redone, but not automatic
CUS10	P	Query can be redone, but not automatic
CUS11	1	
CUS12	1	
CUS13	1	
EUS01	2	
EUS02	1	
EUS03	1	
EUS04	1	
EUS05	1	
EUS06	1	
TUS01	P	No image (yet)
TUS02	2	
TUS03	2	
TUS04	2	

TUS05	2	
TUS06	1	
TUS07	1	
TUS08	1	
TUS09	2	
TUS10	1	
TUS11	2	
TUS12	1	
TUS13	P	No image (yet)
TUS14	1	
TUS15	1	
TUS16	1	
TUS17	P	QR out of scope
TUS18	1	
TUS19	1	
TUS20	1	
TUS21	1	
TUS22	1	
TUS23	1	
CE01	1	
CE02	1	
CE03	1	
CE04	1	
CE05	1	
CE06	1	
CE07	P	
CE08	P	
CE09	P	
CE10	P	
CE11	P	
CE12	1	
CE13	2	
ATM01	1	
ATM02	1	
ATM03	1	
ATM04	1	

ATM05	2	
ATM06	2	
ATM07	1	
ATM08	2	
ATM09	x	
ATM10	2	
ATMF01	1	
ATMF02	P	Data upload
ATMF03	P	Data upload
ATMF04	2	
ATMF05	2	
ATMF06	3	
ATMF07	1	
ATMF08	2	
ATMF09	P	Views via data upload
ATB01	1	
ATB02	2	
ATB03	1	
ATB04	1	
ATB05	3	
ATB06	3	
ATB07	1	
ATB08	1	
ATB09	2	
ATB10	1	
ATB11	2	
ATB12	3	
ATB13	2	
ATB14	2	
ATB15	2	
ATB16	1	
ATR01	1	
ATR02	2	
ATR03	2	
ATR04	P	Only via Data Upload
ATR05	2	

ATR06	2	
ATR07	2	
ATR08	1	
ATS01	1	
ATS02	2	
ATS03	1	
ATS04	1	
ATRY01	1	
ATRY02	1	
ATRY03	1	
ATRY04	3	
ATRY05	1	
ATRY06	1	
ATRY07	3	
ATRY08	1	
NF1	2	
NF2	2	
NF3	1	
NF4	1	
NF5	1	
NF6	1	
NF7	1	
NF8	1	
NF9	1	
NF10	x	
NF11	x	
NF12	P	Original data uses existing systems
NF13	P	Original data uses existing systems
F01	2	
F02	1	
F03	1	
F04	2	
F05	2	
F06	2	
F07	2	
F08	3	

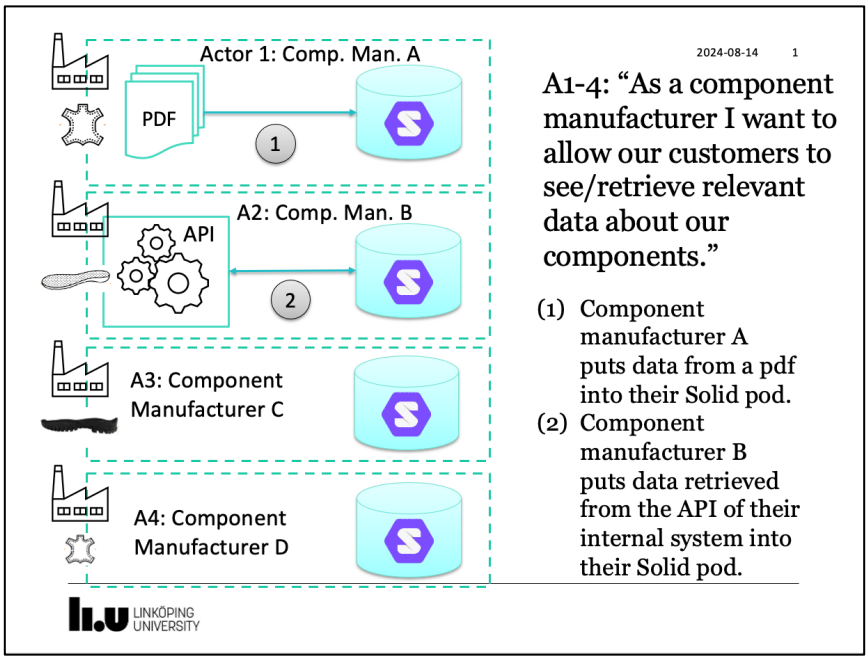
Above, all requirements are consolidated and annotated with which iterations will cover them. Requirements deemed out of scope are marked with “x”, Requirements to be further discussed are marked with “?”.

8 Appendix 3 – Use case scenarios (2nd project iteration)

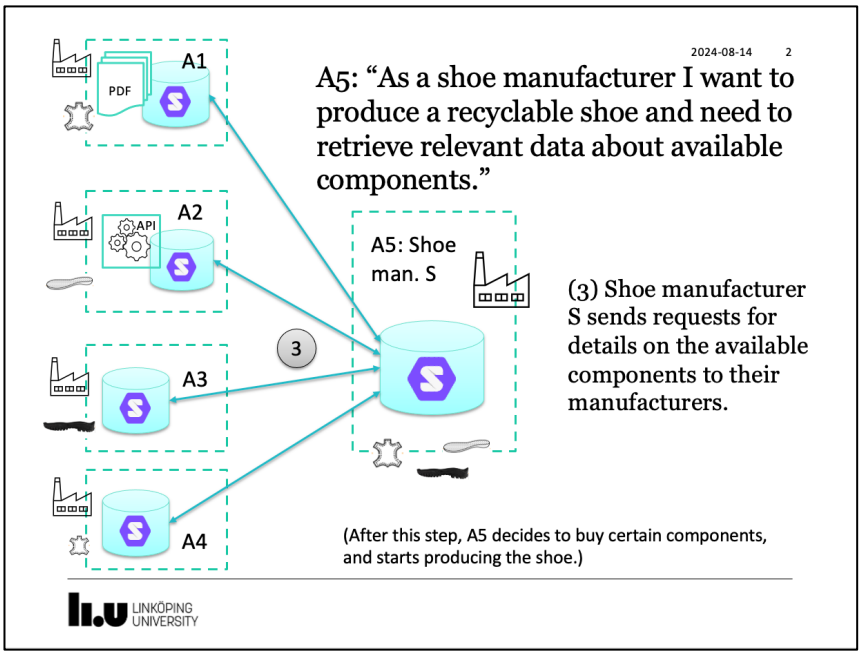
PowerPoint slides for the evaluation scenarios.

Textile use-case

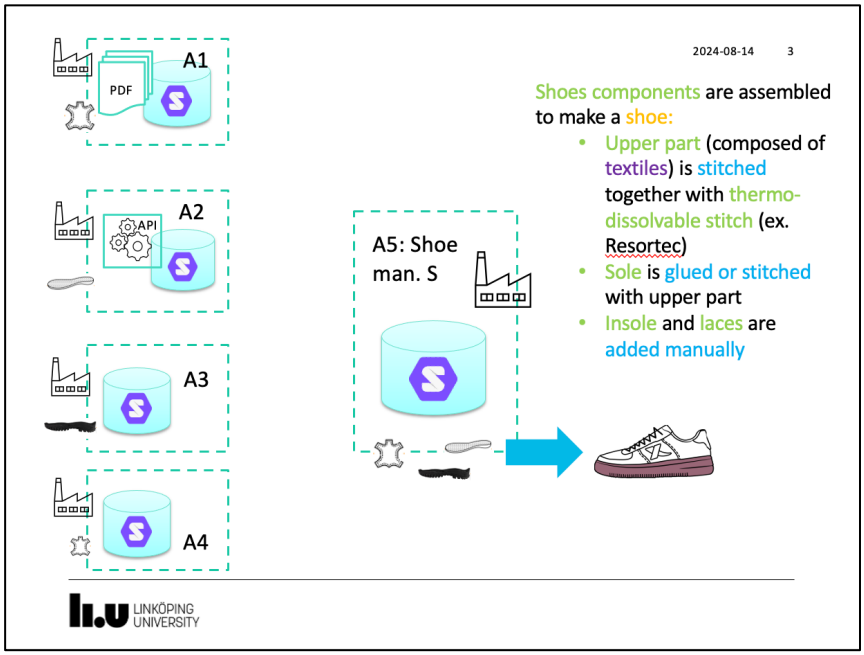
Step 1



Step 2



Step 3


A1
PDF
A2
API
A3
A4
A5: Shoe man. S
2024-08-14 3
Shoes components are assembled to make a shoe:
Upper part (composed of textiles) is stitched together with thermo-dissolvable stitch (ex. Resortec)
Sole is glued or stitched with upper part
Insole and laces are added manually
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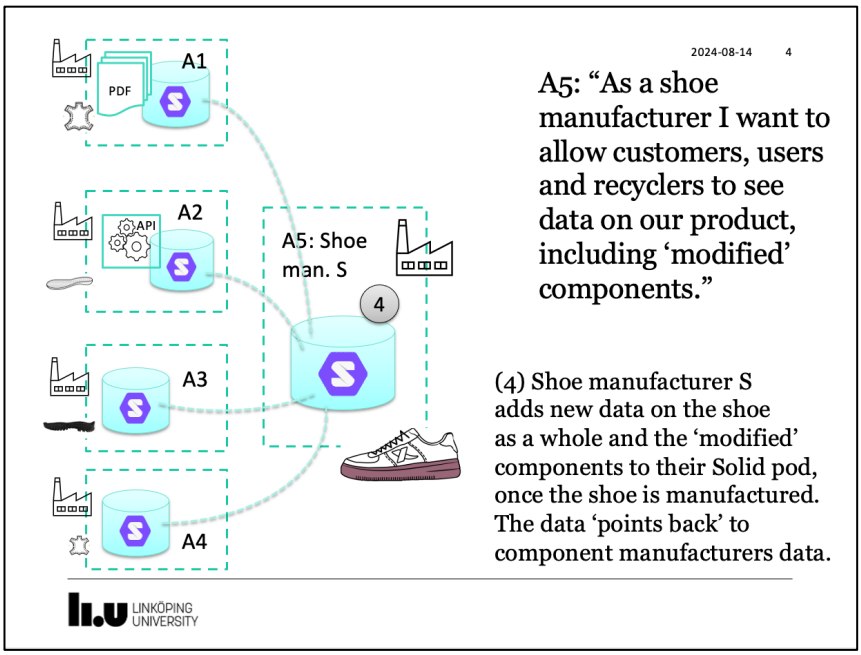
Step 4


A1
PDF
A2
API
A3
A4
A5: Shoe man. S
4
2024-08-14 4
A5: "As a shoe manufacturer I want to allow customers, users and recyclers to see data on our product, including 'modified' components."
(4) Shoe manufacturer S adds new data on the shoe as a whole and the 'modified' components to their Solid pod, once the shoe is manufactured. The data 'points back' to component manufacturers data.
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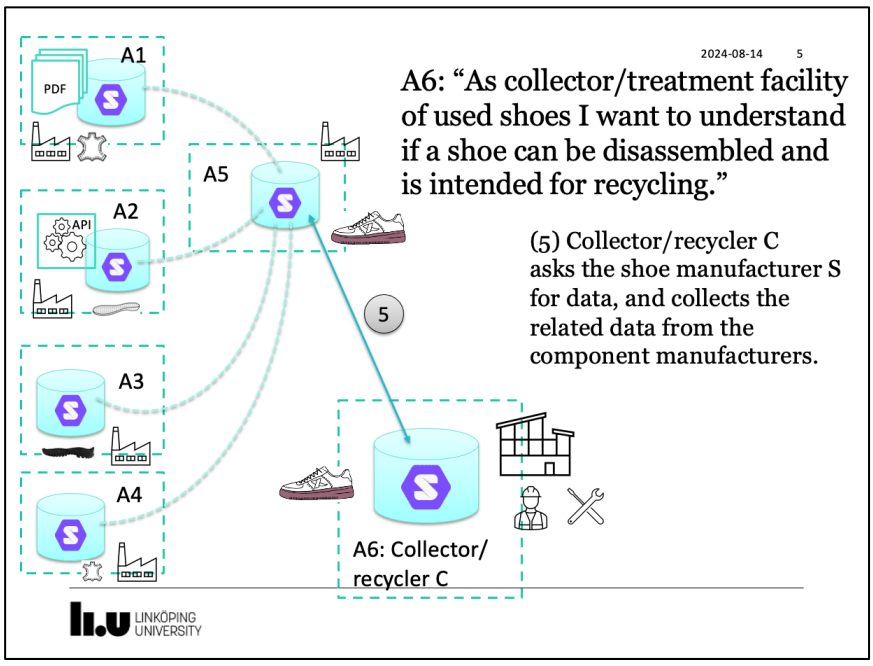
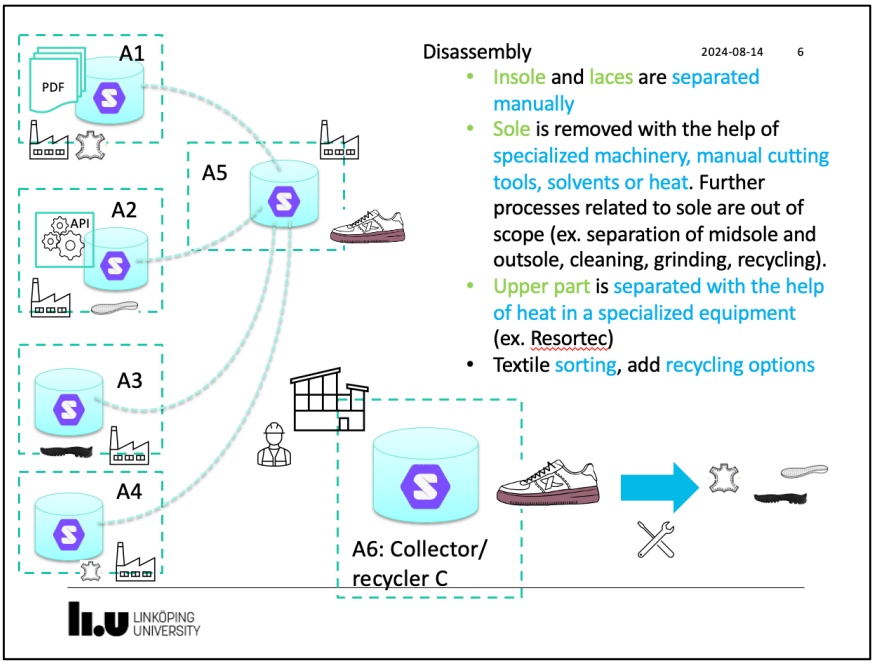
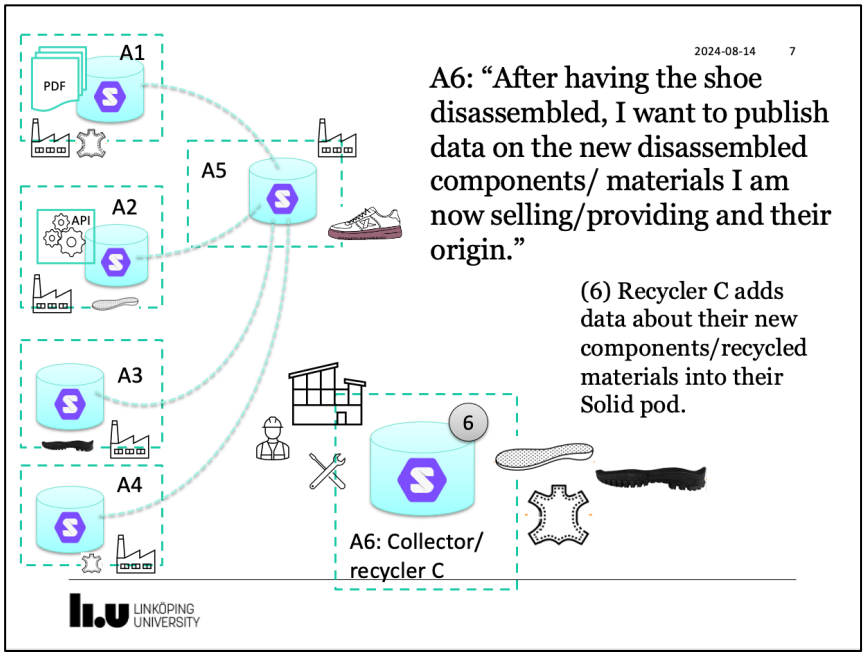
Step 5


2024-08-14 5
A6: "As collector/treatment facility of used shoes I want to understand if a shoe can be disassembled and is intended for recycling."
(5) Collector/recycler C asks the shoe manufacturer S for data, and collects the related data from the component manufacturers.
A1
PDF
A2
API
A3
A4
A5
5
A6: Collector/ recycler C
LINKÖPING UNIVERSITY

Step 6

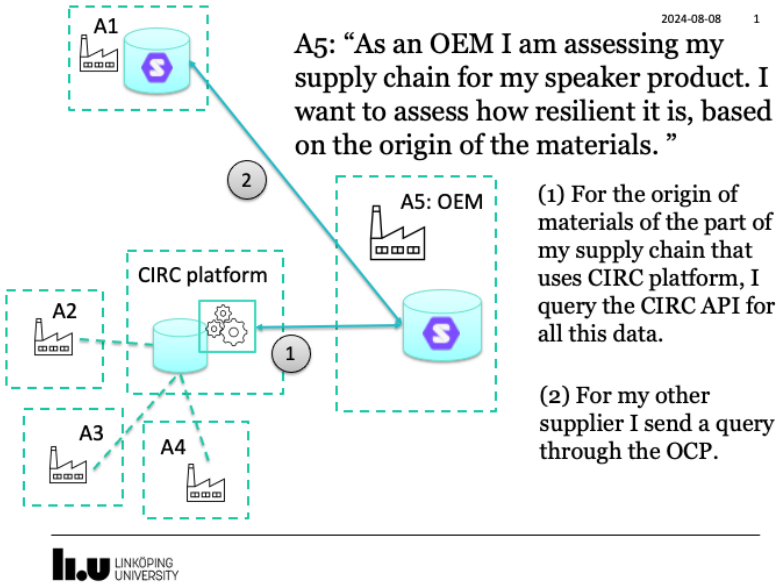

Disassembly
2024-08-14 6
Insole and laces are separated manually
Sole is removed with the help of specialized machinery, manual cutting tools, solvents or heat. Further processes related to sole are out of scope (ex. separation of midsole and outsole, cleaning, grinding, recycling).
Upper part is separated with the help of heat in a specialized equipment (ex. Resortec)
Textile sorting, add recycling options
A1
PDF
A2
API
A3
A4
A5
A6: Collector/ recycler C
LINKÖPING UNIVERSITY

Step 7

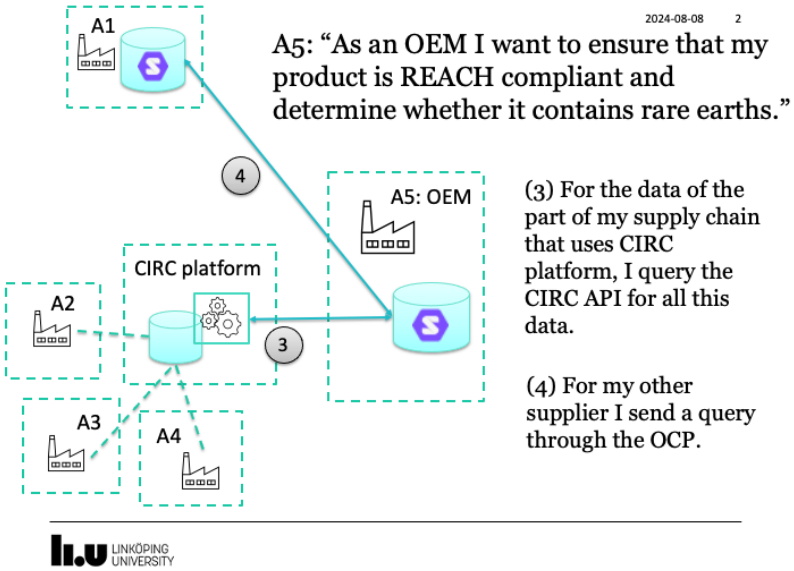


Electronics use-case

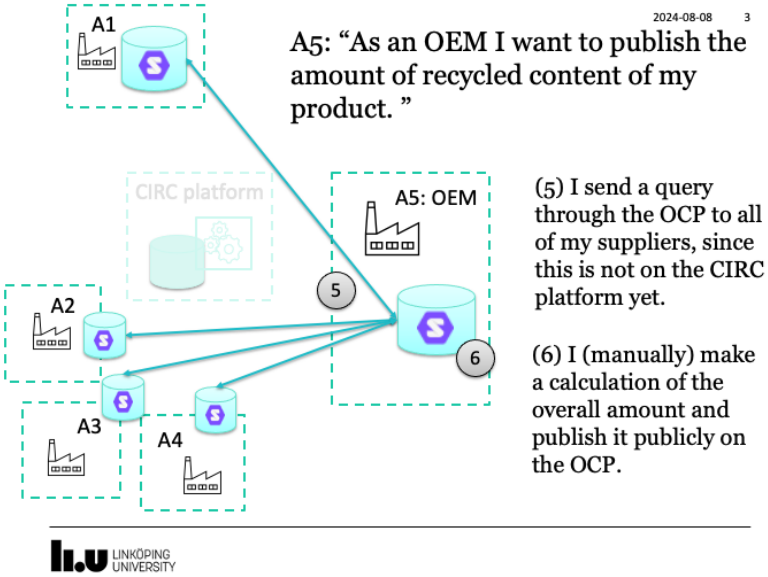
Step 1



Step 2


2024-08-08 2
A1
A5: "As an OEM I want to ensure that my product is REACH compliant and determine whether it contains rare earths."
4
A5: OEM
(3) For the data of the part of my supply chain that uses CIRC platform, I query the CIRC API for all this data.
CIRC platform
A2
3
(4) For my other supplier I send a query through the OCP.
A3
A4
LINKÖPING UNIVERSITY

Step 3


2024-08-08 3
A1
A5: "As an OEM I want to publish the amount of recycled content of my product. "
CIRC platform
A5: OEM
(5) I send a query through the OCP to all of my suppliers, since this is not on the CIRC platform yet.
5
A2
6
(6) I (manually) make a calculation of the overall amount and publish it publicly on the OCP.
A3
A4
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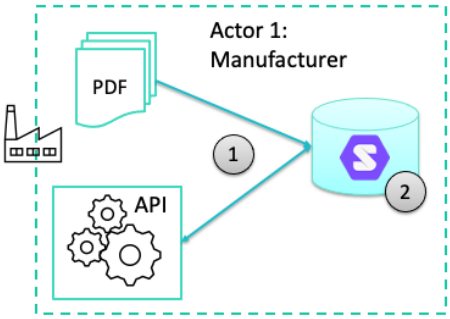
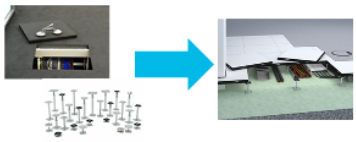
Construction use case

Step 1



2024-08-08 1

"As a manufacturer I want to share (public and confidential) data with my customers and other actors."



(1) Manufacturer puts data from a pdf or an API of their internal system into their Solid pod.

(2) Manufacturer sets access rights on the different data for different actors.

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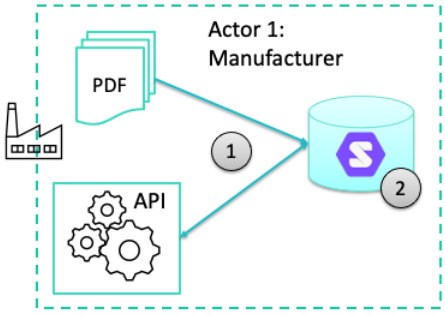
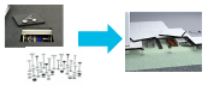
Step 2



2024-08-08 2

"As a manufacturer I want to share (public and confidential) data with my customers and other actors."

Legend
Green: component
Yellow: product
Purple: material
Blue: process



The Nortec floor panel system is made up of panels and pedestals.

Manufacturing and processing the calcium sulphate panel:

- the REA gypsum and cellulose fibre raw materials are combined and after adding water, they are pressed under high pressure to form stable panels, then dried and milled to the requisite sizes. The edge trims are processed in additional manufacturing steps.

Manufacturing the pedestals:

- Pedestals are manufactured through resistance welding or pressing the individual pipe, threaded rod and sheet steel components
- Zinc coating is applied to the supports by means of electroplating (electro-galvanising)

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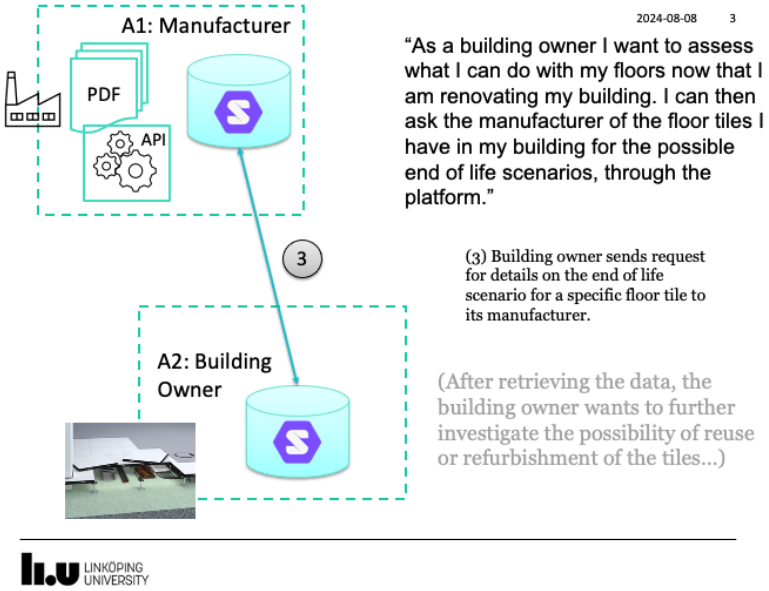
Step 3


A1: Manufacturer
PDF
API
3
A2: Building Owner
2024-08-08 3
"As a building owner I want to assess what I can do with my floors now that I am renovating my building. I can then ask the manufacturer of the floor tiles I have in my building for the possible end of life scenarios, through the platform."
(3) Building owner sends request for details on the end of life scenario for a specific floor tile to its manufacturer.
(After retrieving the data, the building owner wants to further investigate the possibility of reuse or refurbishment of the tiles...)
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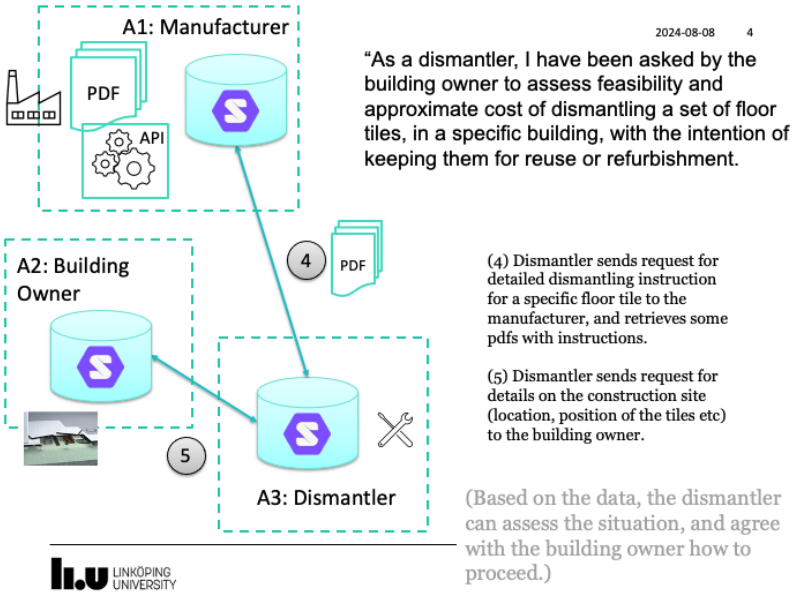
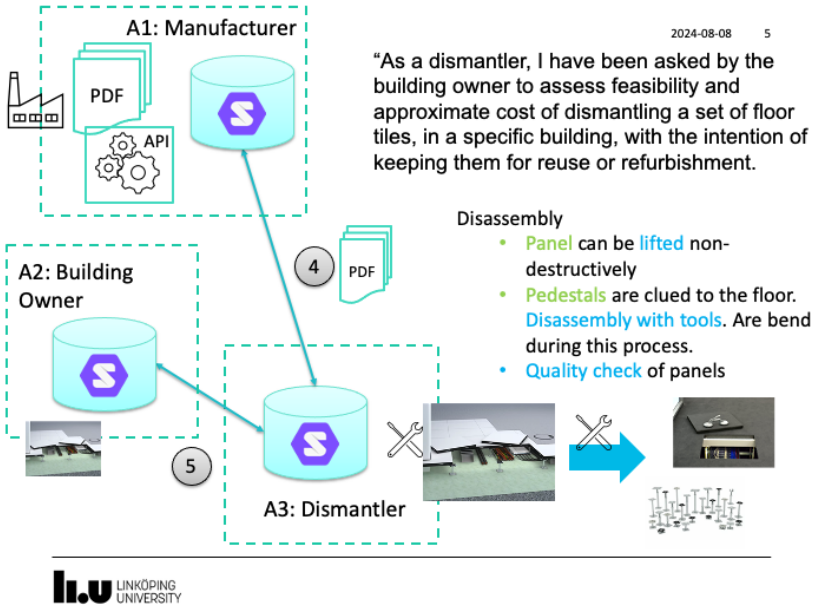
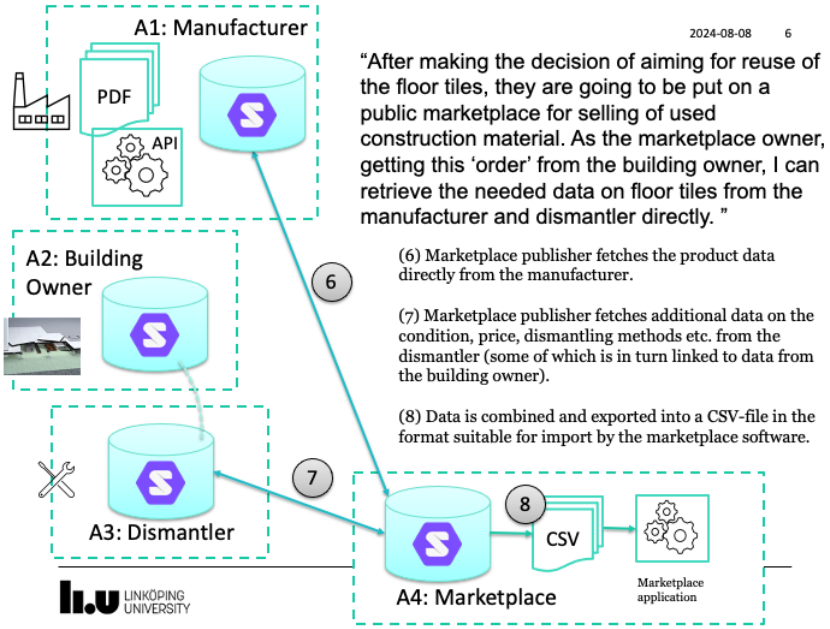
Step 4


A1: Manufacturer
PDF
API
4
PDF
A2: Building Owner
5
A3: Dismantler
2024-08-08 4
"As a dismantler, I have been asked by the building owner to assess feasibility and approximate cost of dismantling a set of floor tiles, in a specific building, with the intention of keeping them for reuse or refurbishment.
(4) Dismantler sends request for detailed dismantling instruction for a specific floor tile to the manufacturer, and retrieves some pdfs with instructions.
(5) Dismantler sends request for details on the construction site (location, position of the tiles etc) to the building owner.
(Based on the data, the dismantler can assess the situation, and agree with the building owner how to proceed.)
LINKÖPING UNIVERSITY

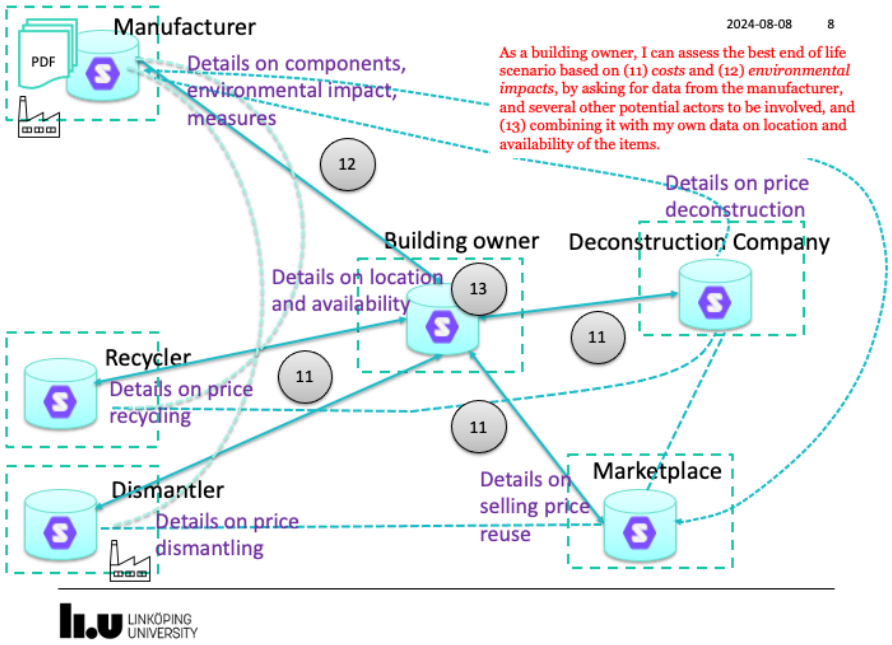
Step 5


A1: Manufacturer
PDF
API
2024-08-08 5
"As a dismantler, I have been asked by the building owner to assess feasibility and approximate cost of dismantling a set of floor tiles, in a specific building, with the intention of keeping them for reuse or refurbishment.
Disassembly
Panel can be lifted non-destructively
Pedestals are clued to the floor. Disassembly with tools. Are bend during this process.
Quality check of panels
4
PDF
A2: Building Owner
5
A3: Dismantler
LINKÖPING UNIVERSITY

Step 6


A1: Manufacturer
PDF
API
2024-08-08 6
"After making the decision of aiming for reuse of the floor tiles, they are going to be put on a public marketplace for selling of used construction material. As the marketplace owner, getting this 'order' from the building owner, I can retrieve the needed data on floor tiles from the manufacturer and dismantler directly. "
(6) Marketplace publisher fetches the product data directly from the manufacturer.
(7) Marketplace publisher fetches additional data on the condition, price, dismantling methods etc. from the dismantler (some of which is in turn linked to data from the building owner).
(8) Data is combined and exported into a CSV-file in the format suitable for import by the marketplace software.
A2: Building Owner
6
7
8
CSV
A3: Dismantler
A4: Marketplace
Marketplace application
LINKÖPING UNIVERSITY

Step 7


2024-08-08 8
As a building owner, I can assess the best end of life scenario based on (11) *costs* and (12) *environmental impacts*, by asking for data from the manufacturer, and several other potential actors to be involved, and (13) combining it with my own data on location and availability of the items.
Manufacturer
PDF
Details on components, environmental impact, measures
12
Details on price deconstruction
Building owner
Deconstruction Company
Details on location and availability
13
11
Recycler
Details on price recycling
11
11
Dismantler
Details on price dismantling
Details on selling price reuse
Marketplace
LINKÖPING UNIVERSITY

9 Appendix 4 – Input data, mapping files and queries (2nd project iteration)

See attached folder with additional material. Folder includes files used to map example schema to OCP schema (the ones with *.yml extension) and files used to import example data (the ones with *.csv extension).

10 Appendix 5 – Screencast of the demonstrator (2nd project iteration)

See attached folder with additional material – gif files containing video of the demonstration of the current features grouped by use case.