Report on requirements on ontology tools and ontologies and criteria for selection of further cases

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Report on requirements on ontology tools and ontologies and criteria for selection of further cases

Work Package	Demonstration
Task	Definition of requirements upon tools and ontologies and specification of 11 initial cases
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Executive Summary

This report provides requirements on ontology tools and ontologies and criteria for selection of further cases. Specifically, we describe the state of the art of the initial demonstrators, addressing the relevant to the project needs, state of the affairs in the usage of ontologies and ontology tools, and the state of the FAIRness for the data in the demonstrators. We also describe how we collected the initial demonstrator descriptions and requirements, namely with surveys and through a dedicated demonstrator workshop. Further, we list the criteria for the selection of further demonstrators for the projects, and outline our future work.

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1. Introduction

As defined in the project plan: "The *OntoCommons* project's overall objective is to **bring together and coordinate activities of the most relevant EU stakeholders** for the development of an **Ontology Commons EcoSystem (OCES)**, consisting of ontologies and tools following specific standardization rules, that can be effectively used as **foundation for data documentation** in the industrial domain, in order to facilitate **data sharing and valorisation** and **overcome** the existing **interoperability bottlenecks**.

The OCES will target EU activities in the **domains** covered by the **H2020 NMBP Work Programme**, providing a way to **harmonise data documentation** through **ontologies** and **taxonomies**, making the data **FAIR** and enabling **intra-** and **cross-domain interoperability**. The range of domains includes **materials and manufacturing**, focusing in particular on nanotechnologies, materials characterisation, computational modelling, process industries, factories of the future, biotechnology (for materials and manufacturing), clean energy, regulatory and risk assessment.

The effectiveness of the OCES in accelerating data driven innovation will be proved at the end of the project by the delivery of **demonstrations cases**, covering several **application domains**."

One of our goals is to define requirements for demonstration cases and engage a wide range of stakeholders from different domains across academia and industry to deliver Demonstrators for different applications of ontology based data documentation and interoperability. Due to its wide stakeholder knowledge represented in the Consortium and via third parties, a first set is already predefined with further demonstrators from related projects and further stakeholder involvement during the project. Our work will lead to a validated set of cases of industrial importance demonstrating the expected impact of *OntoCommons* standardisation, operational, FAIR, practicality, userfriendliness, cross-domain nature, uptake of project results and software interoperability.

This report provides requirements on ontology tools and ontologies and criteria for selection of further cases, and also includes the background information on how these requirements and criteria are being defined, particularly outlining the work done in the workpackage up to now. Specifically, we describe the state of the art of the initial demonstrators, addressing the relevant to the project needs, state of the affairs in the usage of ontologies and ontology tools, and also the state of the FAIRness for the data in the demonstrators. To collect such input, we have conducted surveys with the demonstrators (see Appendix for the surveys and questions asked), and also analysed the discussions at the demonstrators workshop. The resulting input will be applied to other parts of the project and to the overall roadmap of the project.

The report is structured as follows. Section 2 discusses the initial demonstrators of the project. Section 3 describes the process of the collection of the requirements from the demonstrators, particularly, the surveys conducted and the first demonstrators-dedicated project workshop. Section 4 presents the requirements themselves, namely general requirements, requirements for ontologies and requirements for tools. Further, in Section 5, criteria and strategy for selection of further demonstrators are explained. Section 6 concludes the report.

2. Initial Demonstrators

The *OntoCommons* project has 11 initial demonstrators that allow the project partners to foster the development of initial guidelines and best practices driven by common requirements with regards to ontologies and tools. The initial demonstrators are mainly from Materials, Manufacturing and Procurement domains. Each demonstrator provides a use case. In this section, we briefly introduce each use case in terms of their goals and challenges. Finally, we analyse the use case in the context of FAIR data.

Each subsection is dedicated to one use case. The main content of a subsection provides an overview of the use case, introduces the company who owns the use case and their main goals. Finally, the current state of adherence to the FAIR (Findability, Accesibility, Interoperability, Reusability) principles with the metadata and data used in the use case. The radar charts presented for each dimension contain two information items: the current state of the use case in terms of individual principles (blue line) and the average state of all use cases for the given dimension (red line). The adherence to each principle is measured with a scale between 0-not applicable and 4-fully implemented. The principles in each dimension and to what they correspond to is given in the Appendix 7.2.

2.1 UC1: IRIS - IndustRIal Co-design Support

AIRBUS is a European aerospace corporation, registered in the Netherlands and trading shares in France, Germany and Spain. It designs, manufactures and sells large civil and military aerospace products worldwide, and manufactures in the European Union and various other countries. The company has three divisions: Commercial Aircraft, Defence and Space, Helicopters.

Table 2.1: Overview of UC1

Use case owner:	Airbus
Involved partner:	University of Oslo
Technology Readiness Level:	TRL4
Data sources used:	Historical system design data Design requirements and KPIs
Ontologies considered:	IOF Core QU4LITY Ontology GRACE Ontology Z-BRE4K Ontology

Main Challenges:	• High-complexity of the system makes it hard to model and populate a comprehensive ontology • Lack of process-oriented ontologies to be reused • Lack of unified tools to integrate design requirements to process data for simulation

The primary goal of the use case is to increase the interoperability and improve the communication between aircraft assembly and the industrial system design. Airbus aims to use ontologies to support trade-off decision making, represent domain and process knowledge explicitly and improve traceability of the decisions made during the design and assembly processes. The use case aims to demonstrate:

- decreased development time via automatized decision making and improved re-usability,
- improved reliability via traceability,
- improved communication between assembly and design experts via data integration and increased domain knowledge interoperability.

on the design of an Airbus A321 orbital joint process design.

For summarized further details, see Table 2.1, Figure 2.1.1 and Figure 2.1.2.

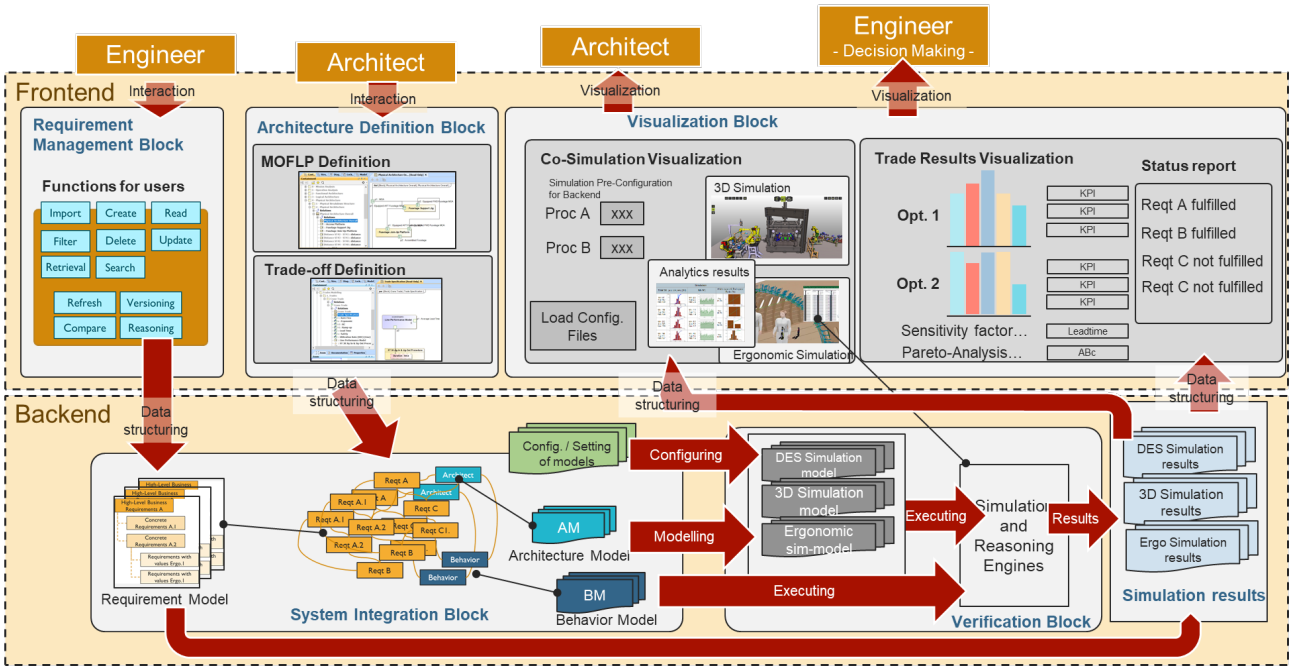


Figure 2.1.1 Overview of UC1

FAIRness of the Demonstrator

In the Findability dimension the use case is close to the average of the initial use cases. All dimensions are deemed to be applicable, and one principle (rich metadata is provided to allow discovery) is already in the implementation phase. The principles regarding persistent identifiers for metadata and data are also in the planning phase.

Almost all principles for the Accessibility dimension are applicable. There are already principles regarding manual access to the data and metadata being implemented. Publication of data and metadata over a standardised protocol is in the planning phase.

Interoperability is arguably the strongest dimension in this use case with four principles already in the implementation phase. This situation indicates that both metadata and data are represented with standardised and machine-understandable metadata formats.

At the Reusability front, the use case is still at an early stage as none of the principles have not even been considered yet.

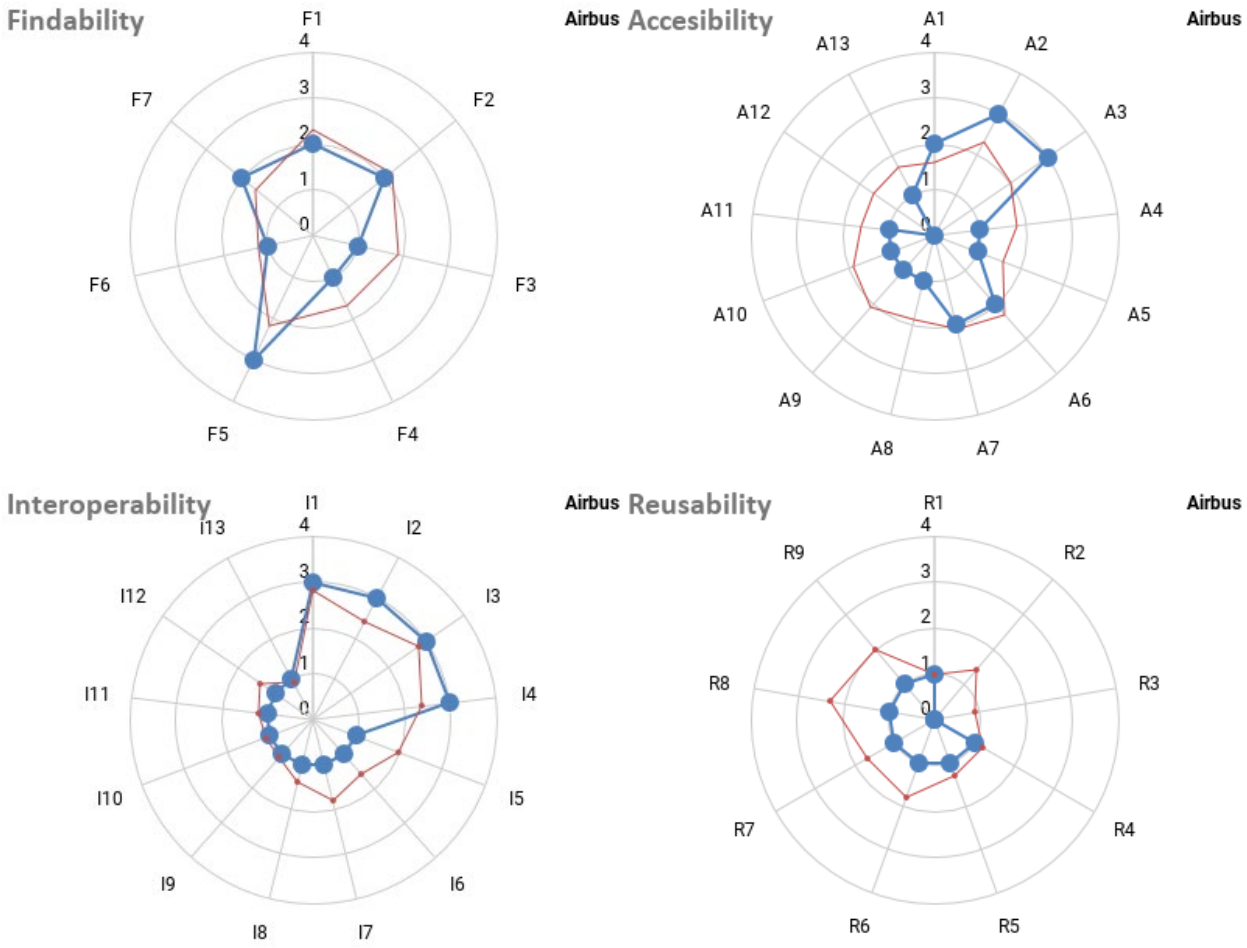


Figure 2.1.2: FAIR charts of UC1

2.2 UC2: SeDIM: Semantic Data Integration for Manufacturing

The Bosch Group is a leading global supplier of technology and services with 394,500 associates worldwide (as of December 31, 2020). Its operations are divided into four business sectors: Mobility Solutions, Industrial Technology, Consumer Goods, Energy and Building Technology. As a leading IoT provider, Bosch offers innovative solutions for smart homes, Industry 4.0, and connected mobility. Bosch is pursuing a vision of mobility that is sustainable, safe, and exciting. It uses its expertise in sensor technology, software, and services, as well as its own IoT cloud, to offer its customers connected, cross-domain solutions from a single source. The Bosch Group's strategic objective is to facilitate connected living with products and solutions that either contain artificial intelligence (AI) or have been developed or manufactured with its help.

Table 2.2: Overview of UC2

Use case owner:	Bosch
Involved partner:	Bosch, University of Oslo
Technology Readiness Level:	TRL5
Data sources used:	• Manufacturing • Simulated laboratory data
Ontologies considered:	Bosch Ontology (developed in-house)
Main Challenges:	• Cost of ontology development • Lack of standards and guidelines

The main goal of this use case is to foster scalable development of Machine Learning (ML) pipelines for condition monitoring of industrial equipment. The use case aims to improve the reusability of existing ML pipelines for similar processes of tasks. The company aims to achieve the adaptation of ML pipelines with affordable, minimal modifications in the existing pipelines.

The core of the use case relies on the semantic technologies by representing domain knowledge both for manufacturing processes and ML pipelines explicitly with ontologies. A reasoner is then able to derive feature groups from the annotated data and selects the suitable ML algorithms. This knowledge-based approach also improves explainability as both the selected features and ML models are explicitly annotated.

For summarized further details, see Table 2.2, Figure 2.2.1 and Figure 2.2.2.

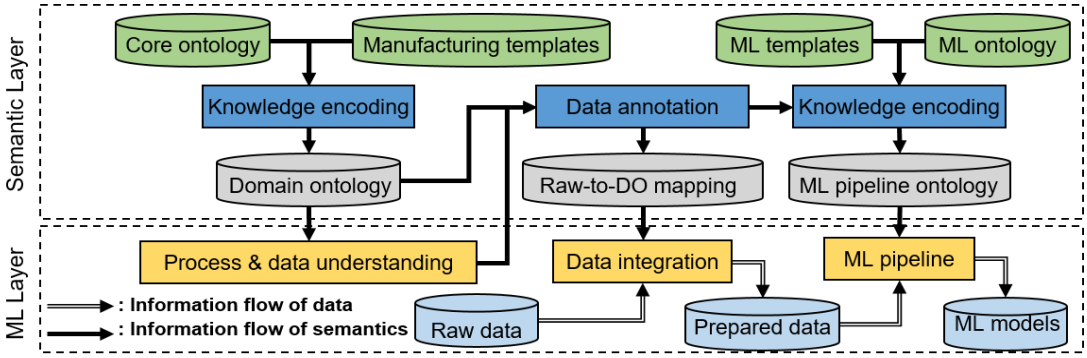


Figure 2.2.1: Overview of UC2

FAIRness of the Demonstrator

In terms of adherence to FAIR principles, the use case is more mature than the average of the initial demonstrators. Most of the principles in each dimension are either in the implementation phase or in the planning phase, which creates an opportunity for *OntoCommons* best practices for ontologies and tools to influence the developments towards the implementation of these principles.

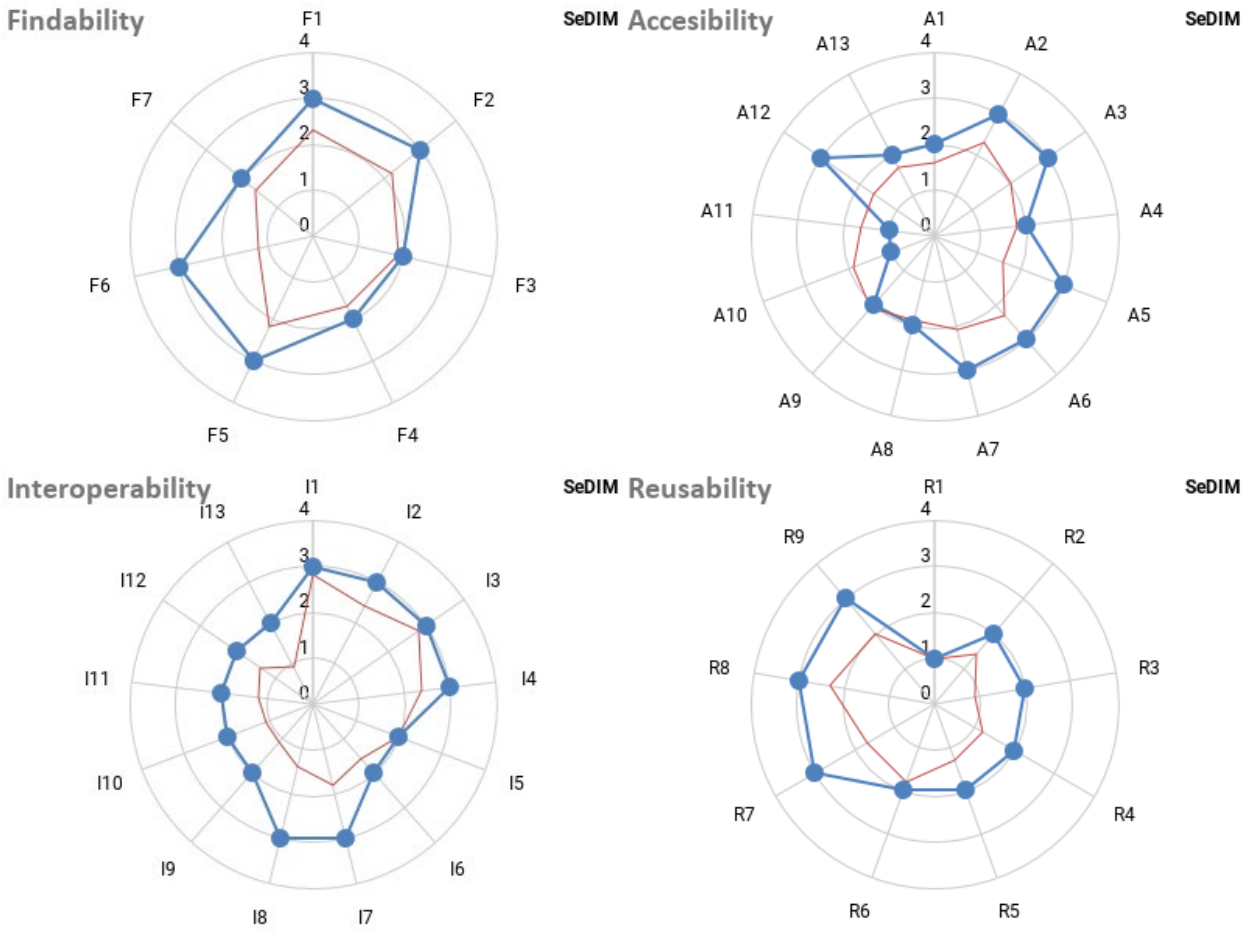


Figure 2.2.2: FAIR Charts of UC2

2.3 UC3: Engineering for Procurement

Aibel is a service company within the oil, gas and offshore wind industries. The company has 4000 employees and uses semantic technologies in their data-driven solutions since 2015.

Table 2.3: Overview of UC3

Use case owner:	Aibel
Involved partner:	University of Oslo
Technology Readiness Level:	TRL5
Data sources used:	• Regulatory requirements • Product/Material specification • Production or purchase orders • Product certificate • Design codes • Material standards
Ontologies considered:	ISO 15926-14 Material-Core (In-house development) Standards Ontology (In-house development) ChEBI SKOS
Main Challenges	• Scalability of ontology development • Overcoming the learning barriers for semantic technologies in the industry • Dealing with Intellectual Property (IP) protected content

The main goal of the use case is to describe data from various sources within the Aibel organisation, semantically, in order to

- improve the reusability of data and processes,
- find inconsistencies via reasoning in terms of specific requirements,
- improve interoperability between departments/organisations, and
- improve interoperability between applications.

The use case will be built on top of the existing ontologies used in the company. The ontologies will be extended in the scope of the use case. The ontologies will be used for semantic modelling of material properties and chemical composition. Existing standards will be converted into ontologies via OTTR templates.

For summarized further details, see Table 2.3, Figure 2.3.1 and Figure 2.3.2.

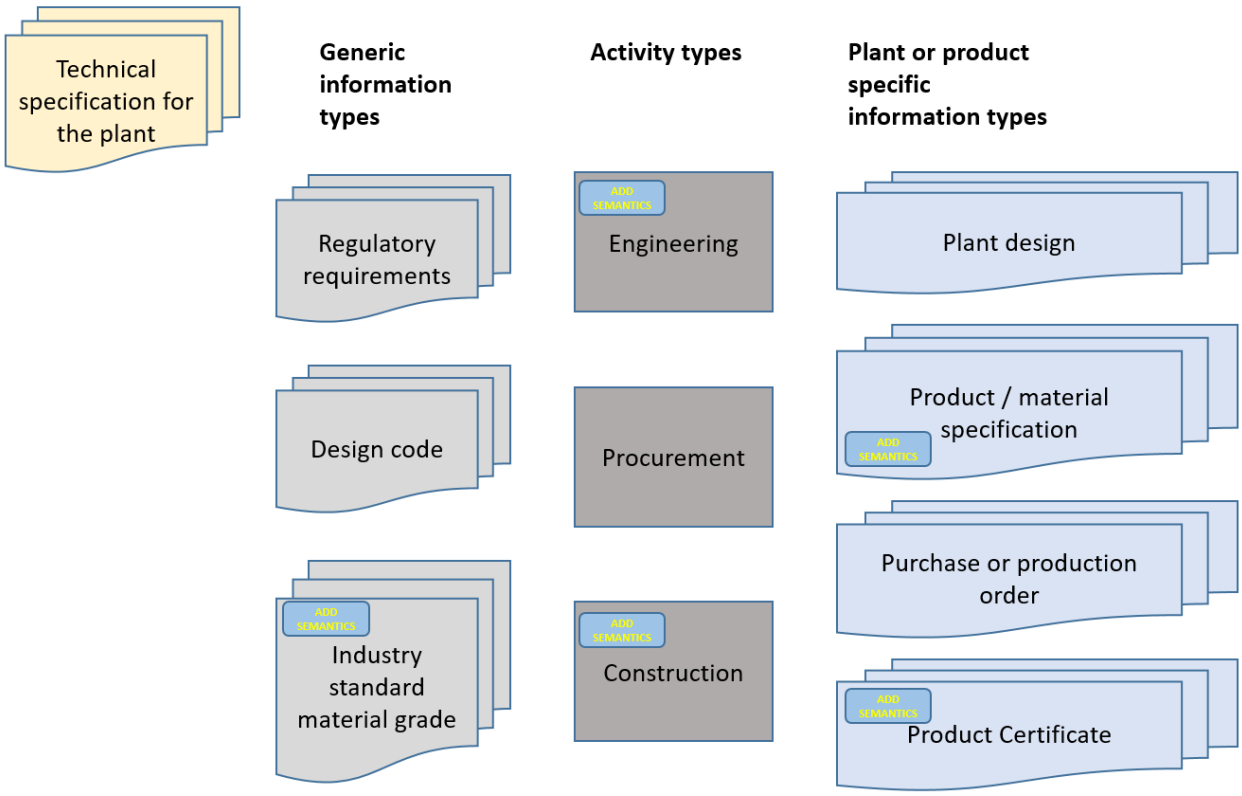


Figure 2.3.1: Overview of UC3

FAIRness of the Demonstrator

Although there are many non-applicable principles, Aibel has already implemented many principles in every FAIR dimensions. *OntoCommons* can benefit from the experience gained from Aibel's use case while developing its best practices and the developed best practices can influence the adoption of further principles that are in the planning or implementation phase.

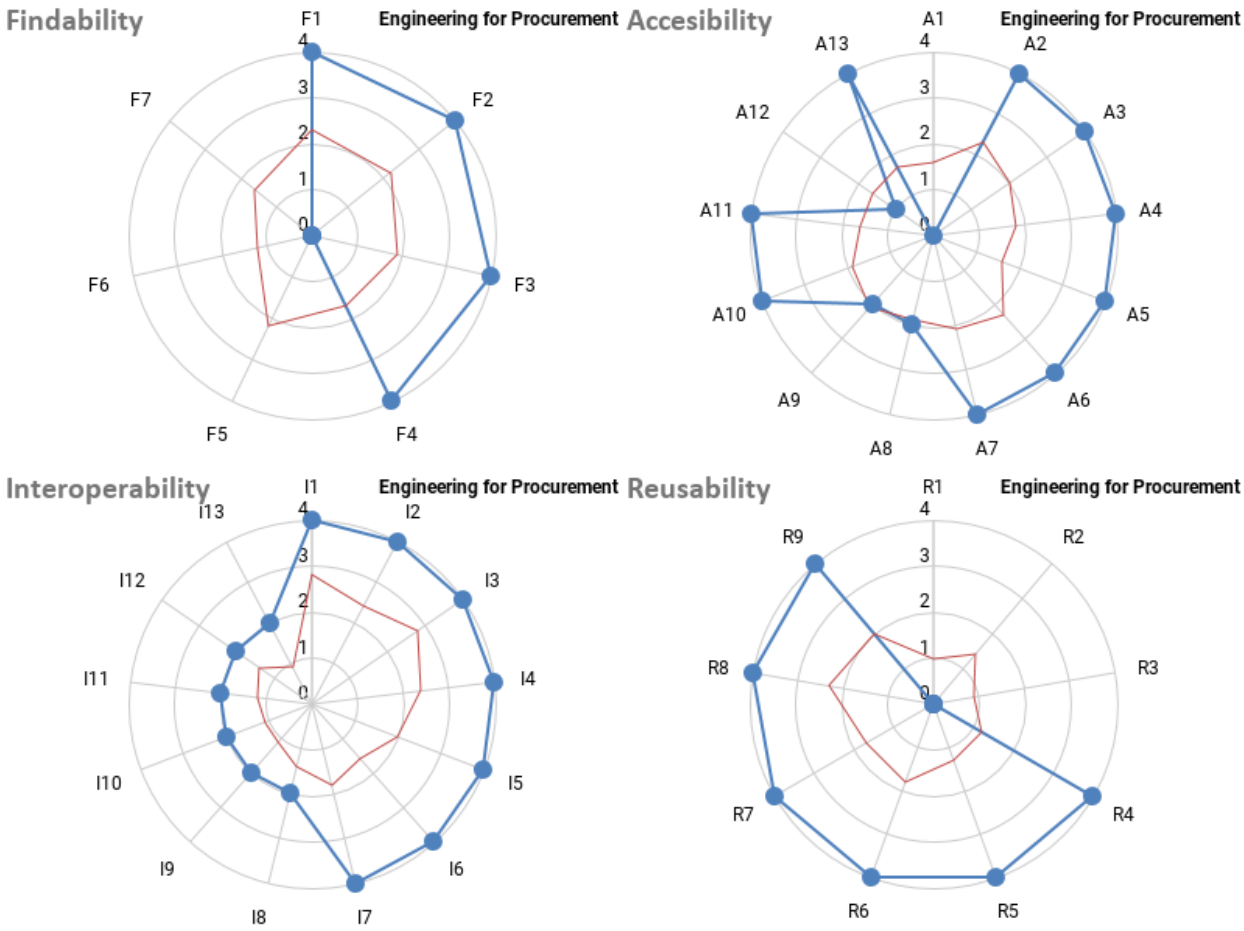


Figure 2.3.2: FAIR Charts of UC3

2.4 UC4: Materials' Tribological Characterisation

Tekniker is a research and development centre located in Spain. They have over 40 years of experience in applied research, especially in manufacturing.

Table 2.4: Overview of UC4

Use case owner:	Tekniker
Involved partner:	Tekniker
Technology Readiness Level:	TRL4
Data sources used:	i-Tribomat DB
Ontologies considered:	EMMO / EMMC

	TribAIn[1] VAR Ontology
Main Challenges:	• Uncertainty regarding whether currently used ontologies cover all the use case requirements

The primary goal of the use case is to reduce the number and size of, and time required for experiments, for identifying the behaviour of a material or combination of them (e.g. metal, coating, lubricant) with respect to specific operation conditions. The goal is planned to be achieved via

- better representation of material experiments,
- enriching existing data with additional background knowledge,
- easing data retrieval and navigation through related resources.

The use case will provide ontology-based access to materials' tribological[2] related information in order to abstract from underlying data structures.

For summarized further details, see Table 2.4, Figure 2.4.1 and Figure 2.4.2.

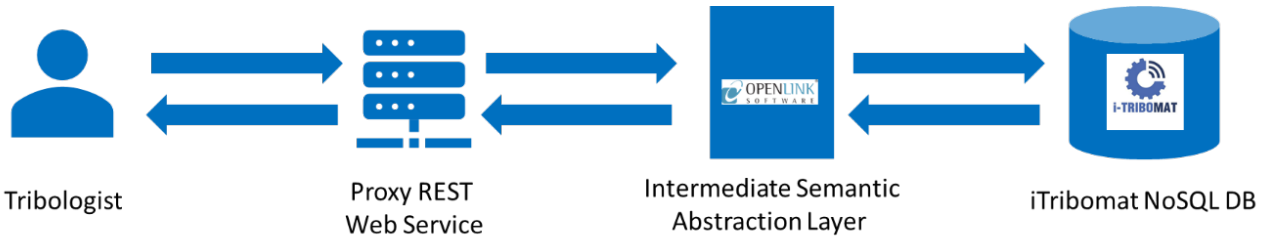


Figure 2.4.1: Overview of UC4

FAIRness of the Demonstrator

The use case is overall well-rounded in all dimensions comparing to the average adherence to FAIR principles. In the Findability dimension, the majority of the principles are in planning phase which has a good potential to be improved with the outcomes of *OntoCommons*. Same goes for the Accessibility dimension, as 7 out of 13 principles are in the planning phase. Interoperability and Reusability dimensions are less mature than the other two. But the overall large number of principles in the planning or implementation phase indicate a good potential for application of best practices produced by *OntoCommons* to improve their adherence to the FAIR principles.

[1] Kügler P, Marian M, Schleich B, Tremmel S, Wartzack S. tribAIn—Towards an Explicit Specification of Shared Tribological Understanding. *Applied Sciences*. 2020; 10(13):4421. https://doi.org/10.3390/app10134421

[2] https://en.wikipedia.org/wiki/Tribology

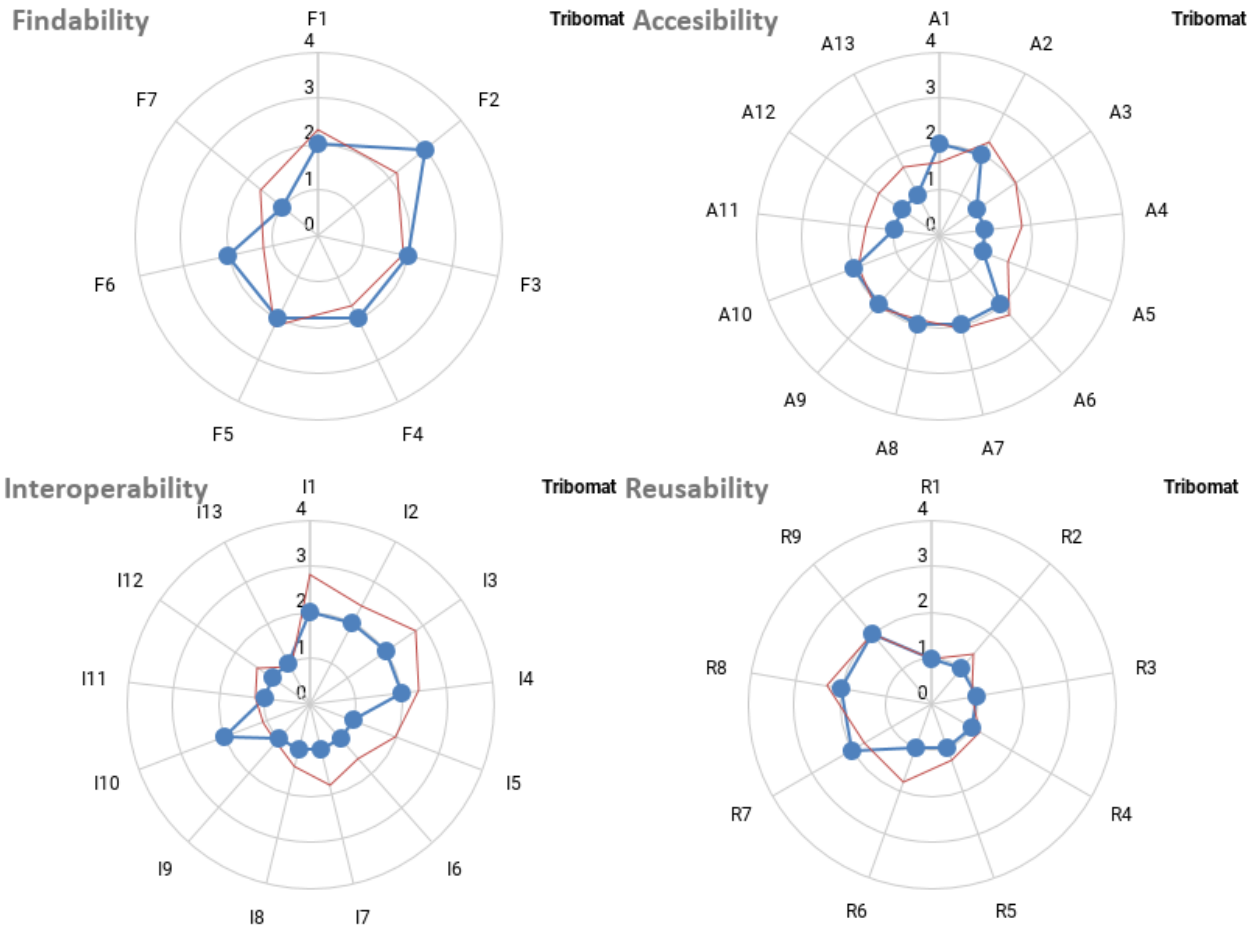


Figure 2.4.2: FAIR Charts of UC4

2.5 UC5: EVMF - European Virtual Marketplace Framework

The UK Research and Innovation (UKRI) agency is a non-departmental public body. It brings together the seven disciplinary research councils, Research England, and Innovate UK. The Science and Technology Facilities Council (STFC) is a multi-disciplinary science institution whose field of activity includes astronomy, particle physics, space science, nuclear physics, as well as the provision and operation of research facilities for all areas of activity of UKRI.

Goldbeck Consulting Ltd (GCL), based in Cambridge (UK), aims to bridge existing gaps in the materials modelling ecosystem, connecting communities, supporting the validation and technology transfer of academic developments to industry, translating industrial needs into impactful materials modelling projects and researching the pathways and barriers to economic impact.

For summarized further details, see Table 2.5 and Figure 2.5.1

Table 2.5: Overview of UC5

Use case owner:	UKRI/STFC and GCL
Involved partner:	UKRI/STFC and GCL
Technology Readiness Level:	TRL3-TRL4
Data sources used:	RoMM[3], MODA[4], knowledge and services from VIMMP partners and perspective marketplace providers/users
Ontologies considered:	VIMMP Ontologies EMMO SWO

The main goal of this use case is to extend and improve the VIMMP (Virtual Materials Marketplace Project) Ontologies[5] [6] which are in the core of the VIMMP platform that aims to support interoperability between different services and marketplaces in NMBP domains.

The use case will provide a concrete implementation for the VIMMP platform and will improve it based on the input from the *OntoCommons* ecosystem and a wider community. It will also create a basis for alignment of EMMO top-level ontology with various domain ontologies in materials domain.

FAIRness of the Demonstrator

The use case has many non-applicable principles at this stage, because there are still some Intellectual Property (IP) issues to be resolved. Nevertheless, it is already mature from the perspective of Interoperability (which is expected due to the nature of the use case) and the other dimensions are mostly in the planning phase, which opens up a nice path for *OntoCommons* project results to influence the FAIR compatibility of the data and metadata of the use case.

[3] A.F. De Baas (ed.), What makes a material function?, EU Publications Office, Luxembourg, Let me compute the ways, 2017.

[4] CEN-CENELEC Management Centre, Materials modelling: terminology, classification and metadata. CEN workshop agreement 17284, Brussels, Belgium, 2018.

[5] M.T. Horsch *et al*, Introduction to the VIMMP ontologies (Technical report), 2020. doi:10.5281/zenodo.3936795."
[6] Horsch, M.T., Chiacchiera, S., Seaton, M.A. *et al.* Ontologies for the Virtual Materials Marketplace. *Künstl Intell* **34,** 423–428 (2020). https://doi.org/10.1007/s13218-020-00648-9

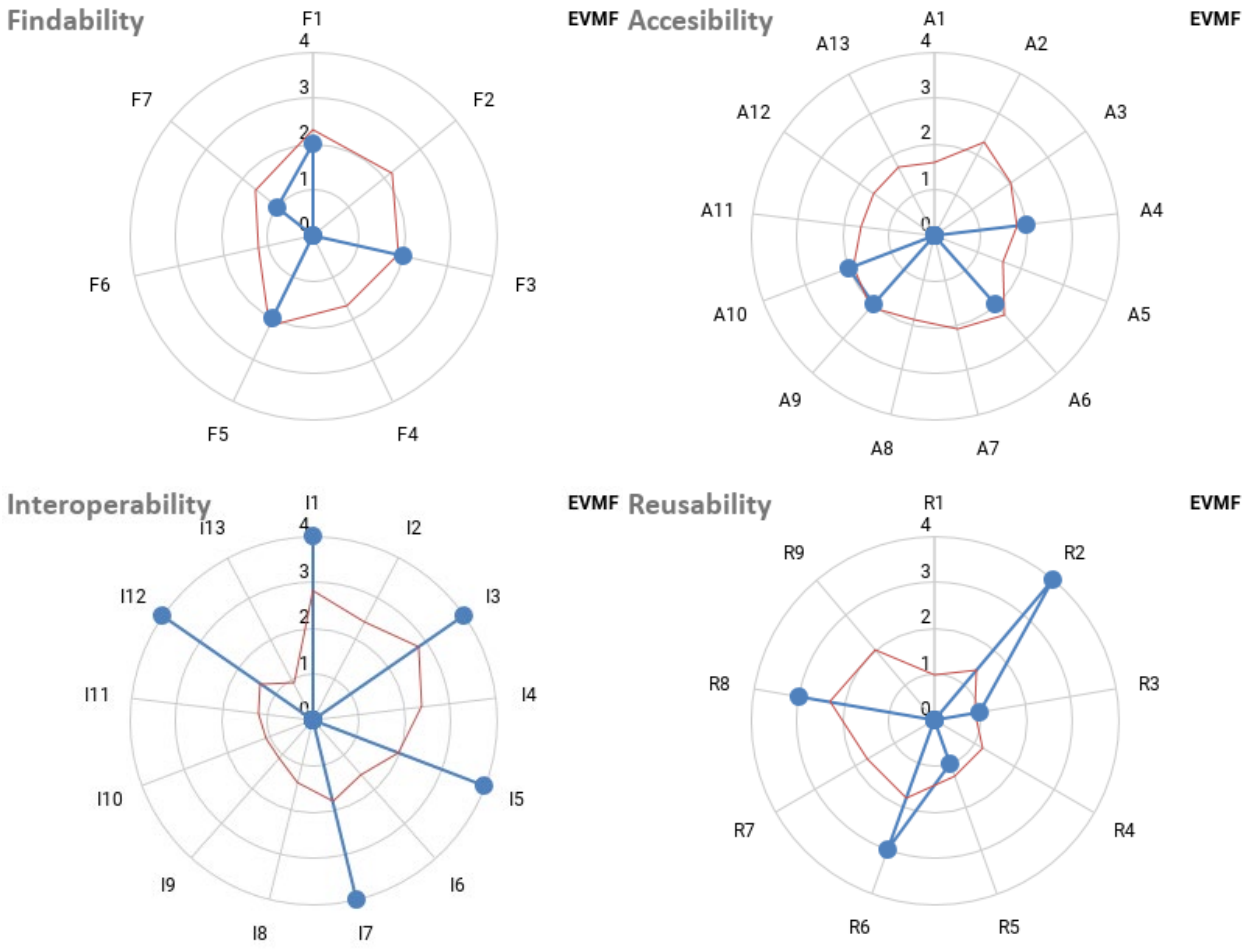


Figure 2.5.1: FAIR Charts of UC5

2.6 UC6: OAS

OAS AG is a privately owned SME based in Bremen, Germany. It has 250 employees in 5 subsidiaries over Germany. The company specialises in turn-key solutions for process control in food, concrete, chemical and other process industries; process control and visualisation systems for highly-automated processes; yard management solutions and weighing data processing systems.

Table 2.6: Overview of UC6

Use case owner:	OAS AG
Involved partner:	ATB Bremen, OAS AG
Technology Readiness Level:	TRL4-TRL5
Data sources used:	Internal data sources regarding yard management and logistics

	Internal data sources containing data about process control system for yard logistic objects and devices
Ontologies considered:	Product Service System (PSS) Ontology IOF Core Ontology Material Ontology (reuse existing) Logistic Ontology (reuse existing) Supply Chain Ontology (reuse existing)
Main challenges:	• Easy definitions of rules to support decisions within configuration • Challenge is to allow for flexibility in the definition of rules and take dependencies of rules into account (e.g., flexibility in definition of rules of sequence/prioritisation of lorries entrance to yard based on diverse aspects: materials, lorry types, parking availability). Allowing (on mid-term) that services may self-learn and adapt to site-specific dynamically-changing conditions. • Collaborative aspects – ontology to allow for effective work together with the customers and their clients to find the best definition of workflow and rules (common terminology and rules) • Ontologies should support standardisation of yard management services; yard sites do differ from each other leading to very individual solution for each site • Ontologies from different domains need to be used and work together harmonised • Different hardware/software systems need to be able to process the ontologies used • Hardware components used possibly with low processing capabilities • Actors with different skills (e.g., software engineers, hardware maintenance experts, project managers, etc.) or domain expertise (e.g., logistics, machine or material manufacturing, business management/administration etc.) need to be able to use the ontology

The main goal of the use case is to improve the automation of yard management. Yard management, plant logistics, and dispatch automation covers the planning, organisation, control, processing, and supervision of the entire flow of materials and goods. The use case will make use of semantic technologies to assist the decision-making process regarding the yard management, for example

inferring the next action of a lorry in the yard given various logistics data and ontologies describing that data. The main expected benefits are:

- standardisation of yard management services via formal description of their building blocks,
- effective collaborative work between customers and the service providers by providing a common terminology and rules, and
- time and cost-effectiveness for yard management.

The figure shows the workflow for the semantically-enhanced yard management configuration.

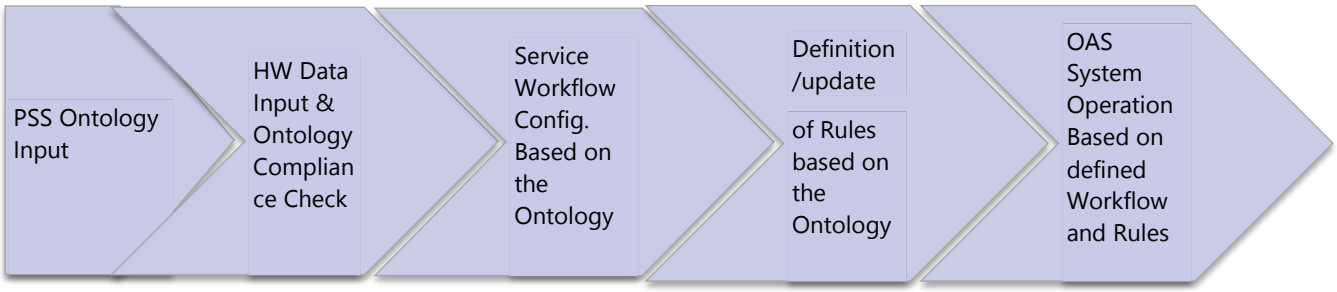


Figure 2.6.1: Overview of UC6

For summarized further details, see Table 2.6, Figure 2.6.1 and Figure 2.6.2.

FAIRness of the Demonstrator

The OAS use case is already at a quite mature state in terms of FAIRness, especially for the Accessibility dimension, with all applicable principles already in a fully implemented stage. Findability principles are also followed in a similar fashion. There is certainly a room for improvement regarding Interoperability and especially Reusability dimensions. The use case can benefit from the *OntoCommons* best practices and *OntoCommons* project can analyse the mature dimensions while building best-practices for ontologies and tools.

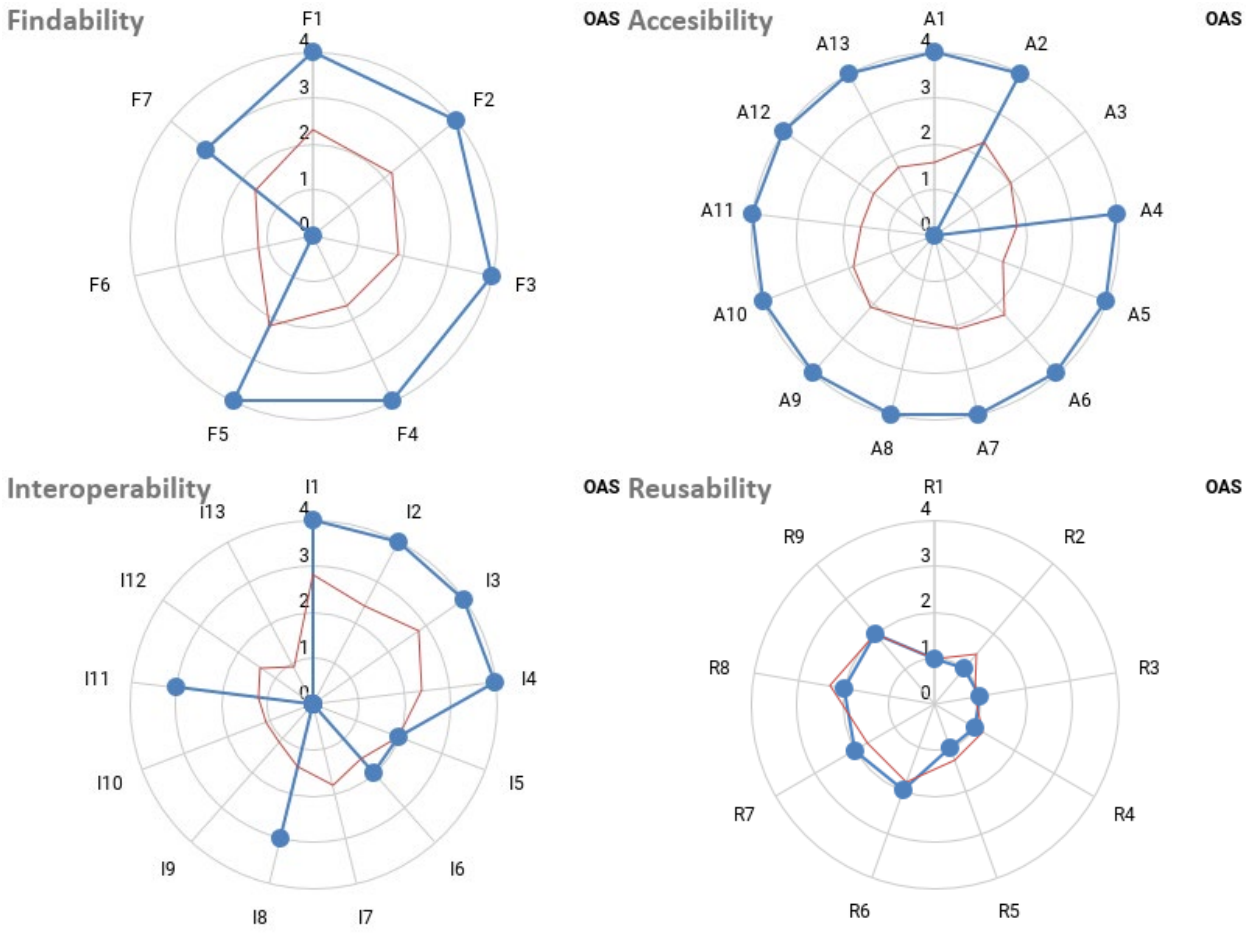


Figure 2.6.2: FAIR Charts of UC6

2.7 UC7: Feedstock Quality Assurance

The Fraunhofer Institute for Manufacturing Technology and Advanced Materials is one of 72 institutes of the non-profit research organisation Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V.. The Powder Technology department of Fraunhofer IFAM has experience in processing techniques and material development. New materials and processes are being developed in the areas of additive manufacturing, functional printing, powder technology, production technology, and lightweight construction. The materials range includes metals, alloys, ceramics, composites and biopolymers.

Table 2.7: Overview of UC7

Use case owner:	Fraunhofer IFAM
Involved partner:	Fraunhofer IFAM
Technology Readiness Level:	TRL3
Data sources used:	Source material data

	Machine Data (torque, time, temperature)
Ontologies considered:	EMMO

Main challenges:	• data integration of different devices/machines for the mixing process
	  ○ machines from different companies without standardised interfaces for data transfer from one to another
	  ○ data formats and structure (e.g. it is not always known in detail when the data will be recorded or requested)
	• data correlation for decision making is not yet done in the mixing process
	• vendor information on material (e.g. metal powder and binder material) mainly on paper or as pdf
	• some machines only provide log-files that are accessible after the process (no data stream, no interaction during operation)
	• limited possibilities for machine settings to adjust the process (lack of device-setting-customisation options)

The main focus of this use case is improving feedstock quality assurance. The mixing of metal powders and polymeric binder components (feedstock) is a crucial part of the Metal Injection Molding process, as well as for the production of parts via extrusion. The process depends on the source materials (chemical composition, quantity of the components, shape and size of the metal powder particles). The quality (homogeneity, reproducibility...) of the feedstock not only influences the following production steps, but also have a strong influence on the produced parts (e.g. dimensions, homogeneity, mechanical properties). So far, the quality of feedstock is not objectively quantifiable. A shared formal specification like an ontology could help to identify the main process and material parameters that allow describing the quality in an objective way.

The use case will be demonstrated on a decision support system, where a feedstock developer feeds the relevant data and the ontology (describing material characteristics and the mixing process) to the system and an upon triggering by an operator, the system will decide on the proper mixing process configuration and measure the conditions of the mixing process. The main expected benefits are:

- digital representation of the entire mixing process,
- recognition of previously unknown correlations,
- deciding on adjustable process parameters,
- consistent quality of feedstock.

The use case has the workflow as depicted in Figure 2.7.1.

For summarized further details, see Table 2.7, Figure 2.7.1 and Figure 2.7.2.

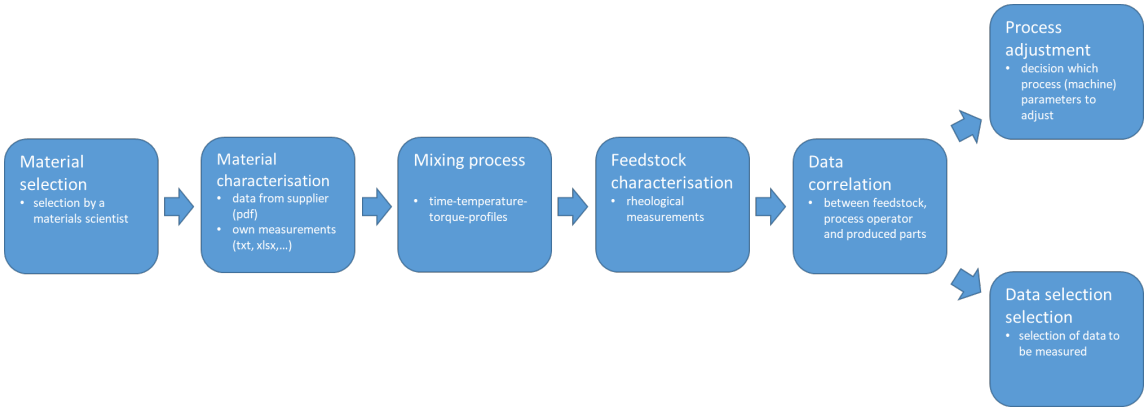


Figure 2.7.1:Overview of UC7

FAIRness of the Demonstrator

The use case currently has a very limited adoption of FAIR principles with only a few principles are in planning phase in Accessibility and Reusability dimensions. *OntoCommons* results may initiate an effort towards implementing some of the principles that are not being considered at the moment.

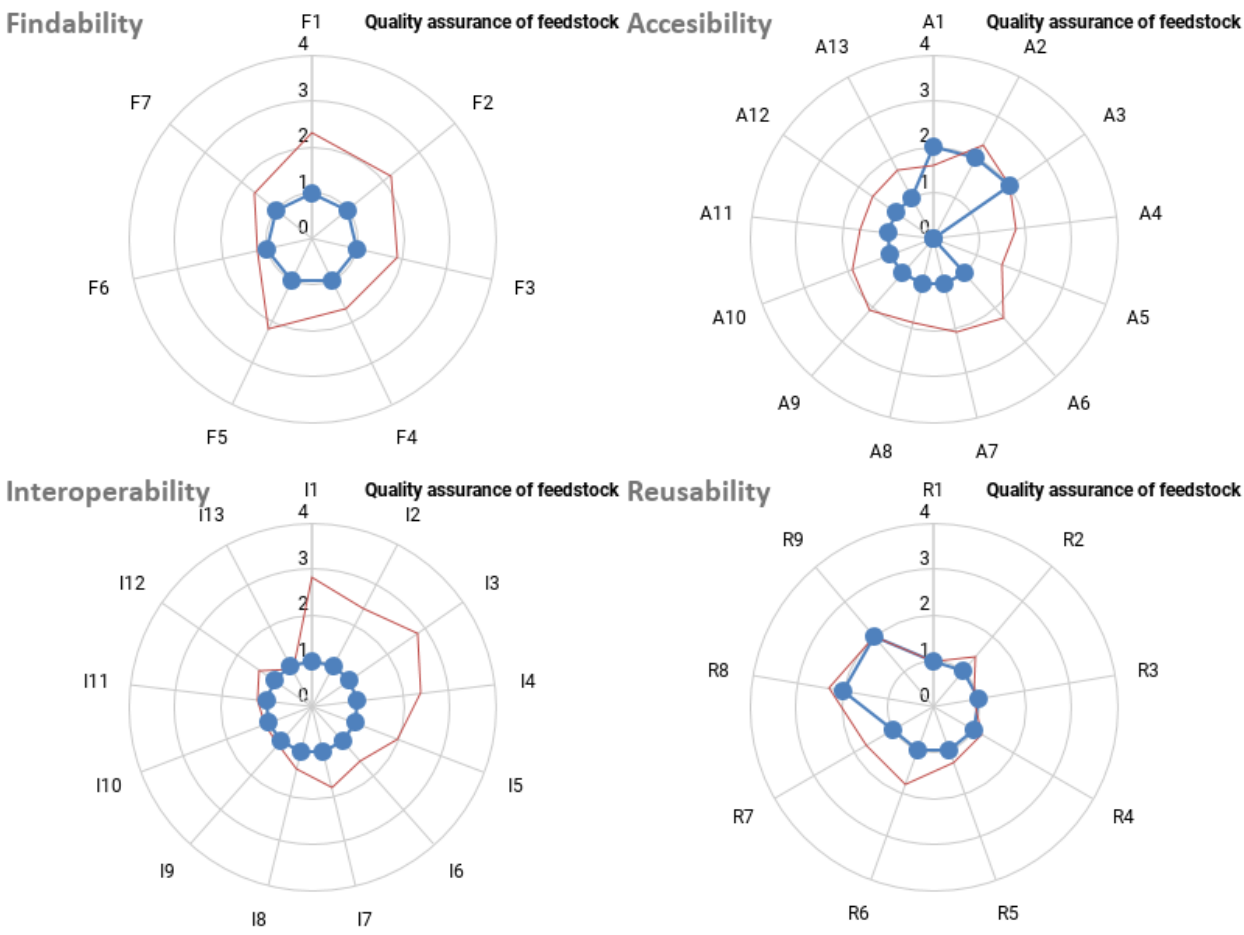


Figure 2.7.2: FAIR Charts of UC7

2.8 UC8: Nanomaterials Characterisation

Innovation in Research & Engineering Solutions (IRES) was established in 2015, bridging the gap between academia and industry with TRL transition. The key company activities include data science and digitisation in material science applications, health, risk and safety management and activities in environment, sustainability and circular economy.

Table 2.8: Overview of UC8

Use case owner:	IRES
Involved partner:	IRES
Technology Readiness Level:	TRL4
Data sources used:	Emission / Exposure Measurement Instruments Data extraction from Nanoindentation Instrument 3D Printer Slicer
Ontologies considered:	EMMO
Main Challenges:	• Scarcity of available data • Knowledge gaps towards detailed correlation between the nanomechanical properties and Nanosafety domain. • Domain ontologies of interest are based on different Top Level Ontologies • Ontologies used for the use case may need further development

The main goal of the use case is to bridge the gaps between material characterisation and nanosafety domains. In the use case, the data collected from exposure and emission measurement devices collected by a risk analyst and the experimental data collected by a nanoindentation engineer will be integrated via domain ontologies and top-level ontologies like EMMO in a tripe store with reasoning capabilities. Afterwards, the potential causal relationships between the nanomaterial characterisation process and safety risks will be analysed via inference and querying. The main expected benefits are:

- automation of the experimental data collection process,
- semantic integration of data from different experimental measurements,
- studying the correlation between Material Characterisation and Safety Domain through reasoning.

For summarized further details, see Table 2.8, Figure 2.8.1 and Figure 2.8.2.

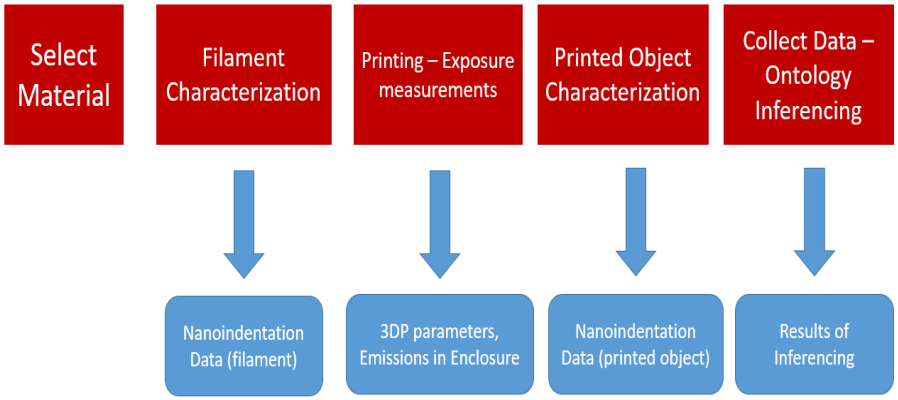


Figure 2.8.1: Overview of UC8

FAIRness of the Demonstrator

The use case has already implemented the principles regarding machine-accessible metadata and data. Several other principles in Interoperability and Reusability dimensions are in the planning phase. The *OntoCommons* best practices can influence the further development of these principles in the use case.

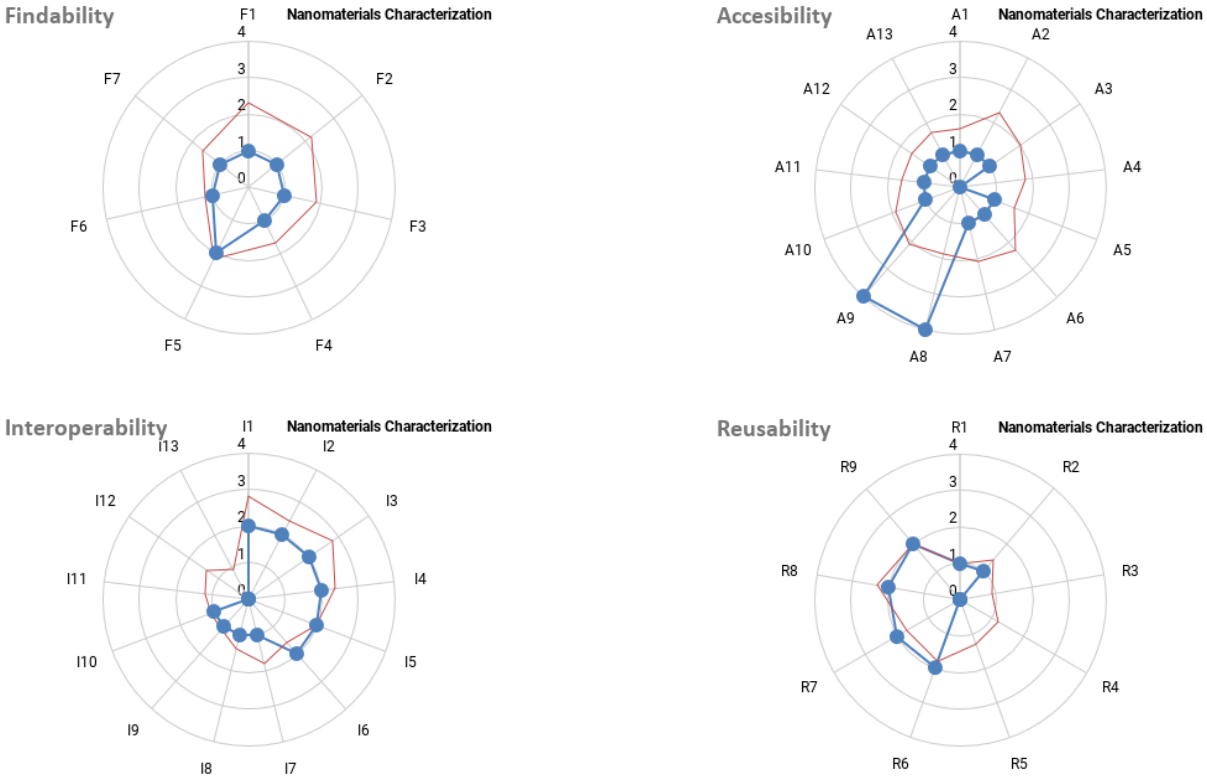


Figure 2.8.2: FAIR Charts of UC8

2.9 UC9: Ontology-based Maintenance

Adige S.p.A. is an Italian company and part of the BLM Group, an industrial group specialised in designing, producing, selling and maintaining industrial equipment for working on metal tubes and profiles. BLM Group is a global partner for the whole tube processing lifecycle, from laser cutting to cold saw, bending, end-forming, and measurement, with a worldwide presence. This wide range of solutions is manufactured in dedicated production sites, with highest expertise and skill levels, established in more than 50 years work and experience in the tube processing technology, with thousands of applications all over the world. Within the BLM Group, Adige produces laser cutting systems and machines for disc-cutting tubes, solid pieces and sections. Adige develops internally also the software suite deployed with its machines.

Table 2.9: Overview of UC9

Use case owner:	Adige SpA
Involved partner:	CNR/ISTC
Technology Readiness Level:	TRL3
Data sources used:	Technical design data from CAD Machine documentation Instructional media (e.g., videos)
Ontologies considered:	DOLCE
Main challenges:	• Data are collected in different formats and channels (natural language text, forms with open/closed entries, phone calls, data sensors, machine logs) • Data may refer to different views: machinery structure, machinery function, machinery behaviour. • Experts' knowledge is often implicit in data generation

The main goal of the use case is to create a common formal terminology for diagnosis and repair of the machines manufactured by Adige SpA. To that end, an ontology that contains technical information, possible malfunctions reasons and diagnosis, as well as maintenance processes and their relationships will be developed in the scope of the use case. This ontology will be then used to annotate malfunction reports from clients and possible reasons and machine parts relevant to the malfunction will be listed to a technician. Such a formal report can be also used for purposes like semi-automated analysis of malfunctions and their comparison. The main expected benefits can be listed as following:

- Comprehensive records of maintenance cases, frequency and solutions,
- Elicitation of comparable cases/histories of maintenance,

- Assessment of new anomaly cases and associated solutions,
- Allocation of maintenance skills and spare parts,
- Alignment of terminology across internal (and possibly external) personnel,
- Optimisation of company/client maintenance service interaction.

For summarized further details, see Table 2.9 and Figure 2.9.1

FAIRness of the Demonstrator

The use case is around the average of all use cases in terms of FAIR adherence. Most of the principles are in the planning phase, which can benefit from the *OntoCommons* best practices.

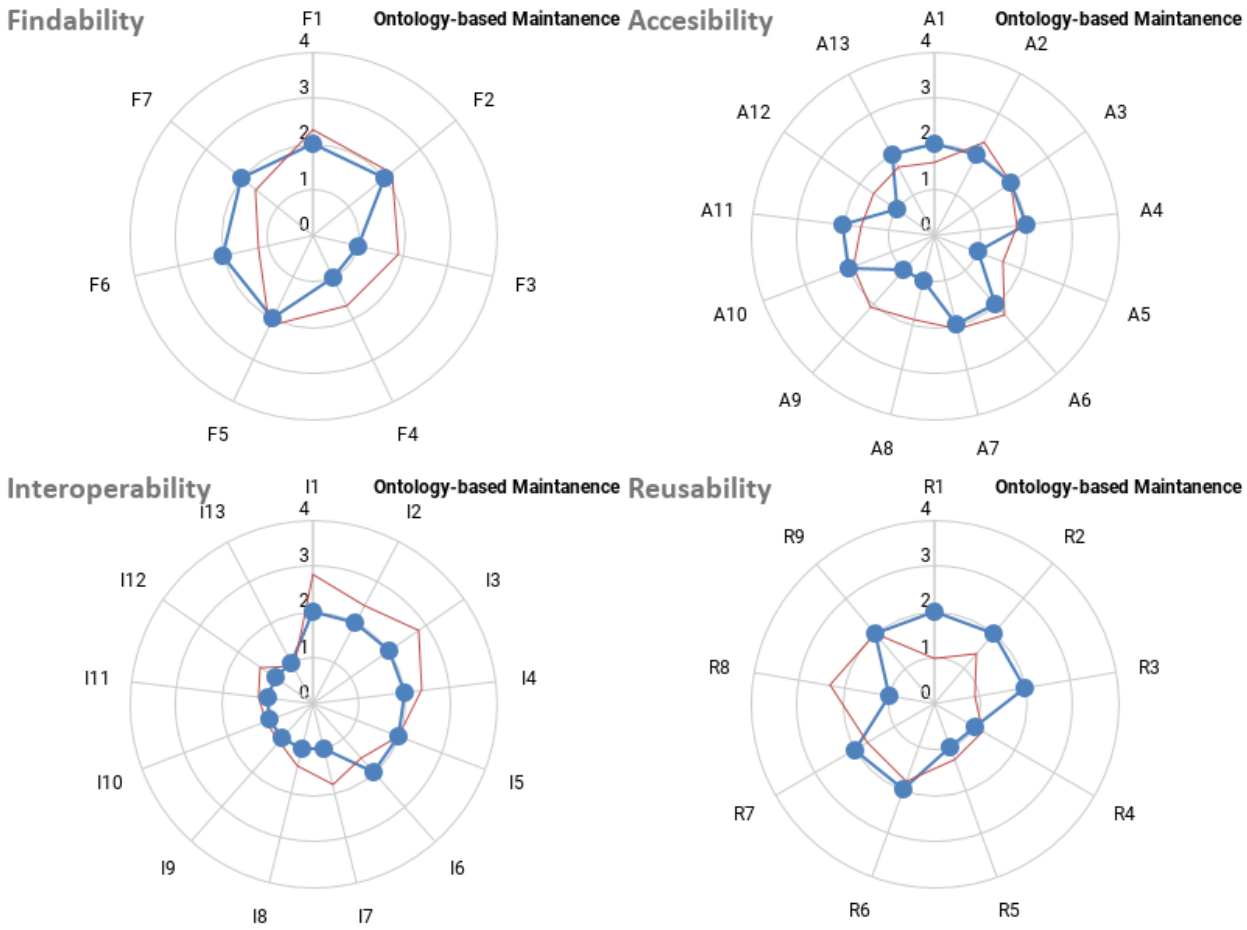


Figure 2.9.1: FAIR Charts of UC9

2.10 UC10: Data Integration and Interoperability in Manufacturing

Halcor is the copper tubes division of ElvalHalcor S.A. and has a dynamic commercial presence across European and global markets with a tube production capacity of approximately 80,000 tons. Halcor

has been offering solutions in fields, such as plumbing, HVAC&R, renewable energy, architecture, engineering and industrial production.

Table 2.10: Overview of UC10

Use case owner:	ElvalHalcor S.A.
Involved partner:	University of Oslo
Technology Readiness Level:	TRL3
Data sources used:	ERP MES SCADA Energy Management Waste Management Traceability systems and hardware.
Ontologies considered:	None
Main Challenges:	• Data format too diverse • Disconnected or poorly connected Information Systems • Semantic data relations missing

The use case focuses on development of ontologies to empower a decision support system for design and procurement of raw materials (billets) for tube production plants. The ontologies that will be developed for the use case aims to unify the data from different departments involved in the design and procurement process and help the data integration and interoperability. The ontologies will describe data about energy monitoring, manufacturing execution, traceability systems and waste management. The main expected benefit is the development of an ontology-based procurement system for billets interconnected with the process ontologies is expected to contribute in developing a Smart Decision System in order to optimise product quality, reduce manufacturing costs and environmental footprint.

For summarized further details, see Table 2.10 and Figure 2.10.1

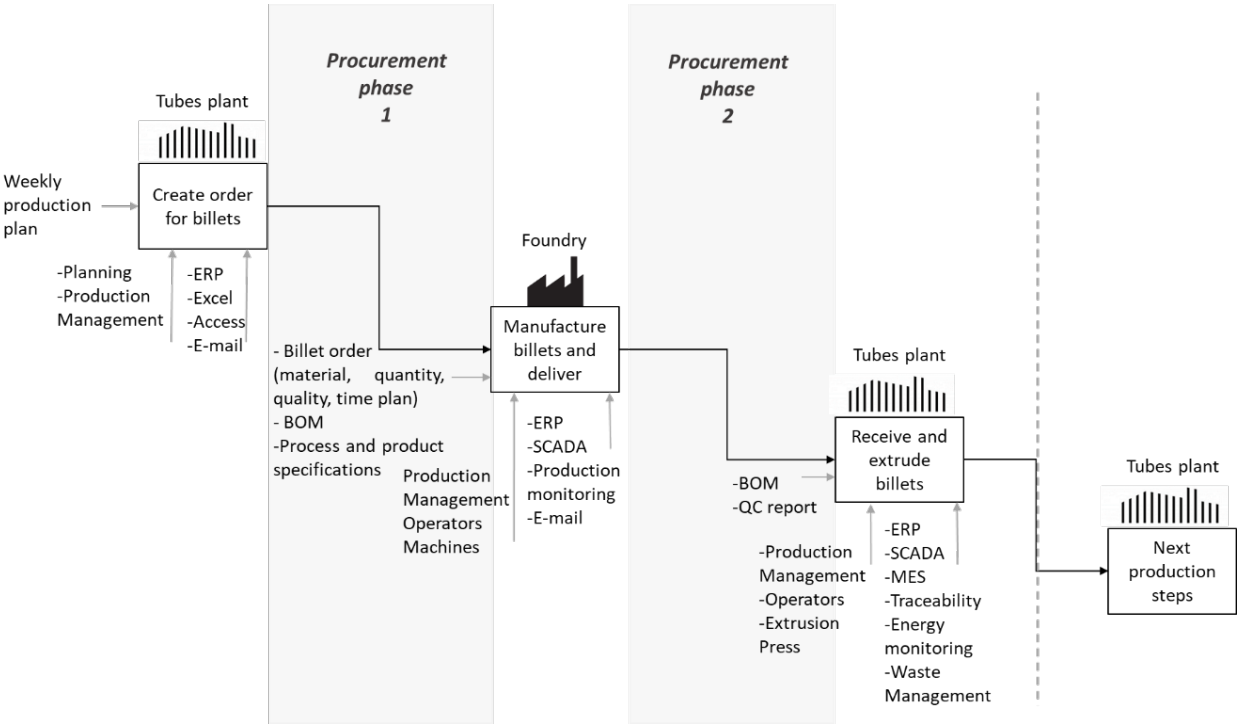


Figure 2.10.1: Overview of UC10

FAIRness of the Demonstrator

ElvalHalcor's use case is at the very beginning of implementing FAIR principles in their data and metadata therefore all principles can be considered as "not being considered yet", but they aim to gain traction towards adopting FAIR principles throughout the project.

2.11 UC11: Digital Manufacturing / Complex Equipment

Siemens provides products and services in various industrial domains such as healthcare, digital infrastructure and mobility, and energy.

Table 2.11: Overview of UC11

Use case owner:	Siemens
Involved partner:	University of Oslo
Technology Readiness Level:	TRL5
Data sources used:	Physical engineering system Functional engineering system Electrical Engineering System Sensors

	Actuators Control Systems Asset Management System Operations Monitoring System Weather Forecast Service
Ontologies considered:	ISO 15936 QuED SSN UMATI eClass OPC-UA (in-house transformation from the standard) CFIHOS
Main Challenges	• Different data format (pdf, txt, emf...), storage structure and locations (unit systems) • No material data request possible (knowledge hidden in individual experts' minds) • Waste of productive hours duplicate tests, delays and uncertainties • Legal liabilities (e.g., access to IP protected data and metadata)

The main goal of the use case is to provide a data layer as part of the IOT platforms of Siemens that reduces application/customer-specific data provisioning and integration costs. To that end, Siemens will develop an ontology library that covers various relevant domain ontologies as well an ontology transformations of various industrial standards. The worldwide-distributed, heterogeneous data sources of Siemens will be mapped to the ontologies in this library and stored in the data layer. Applications from various departments of Siemens will have access to the integrated and curated data via this data layer. The main expected benefits are

- Overview of existing industry ontologies with relevance for Siemens, potential for becoming part of library:
  - Material data models
  - Equipment / O&G data models (e.g. CFIHOS)
  - Building data models (e.g. BIM)
  - Energy data models (e.g. CIM)
  - Automation data models (e.g. AutomationML, OPC-UA Companion Standards, etc.)
- Best practice for data model governance as well as modelling tools (also for domain experts)
- Guidelines and best practices for modelling, modularization and maintenance
- Training material for developers and other stakeholders.

For summarized further details, see Table 2.11, Figure 2.11.1 and Figure 2.11.2.

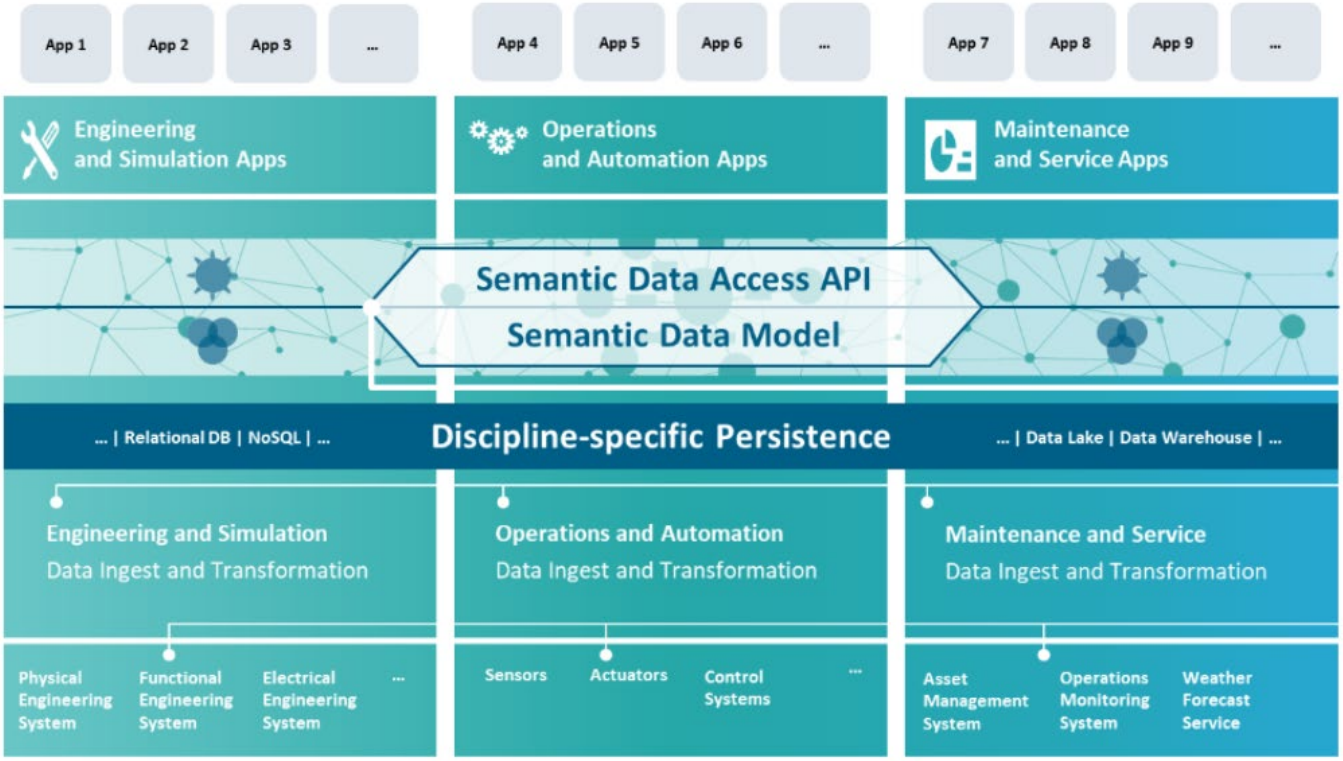
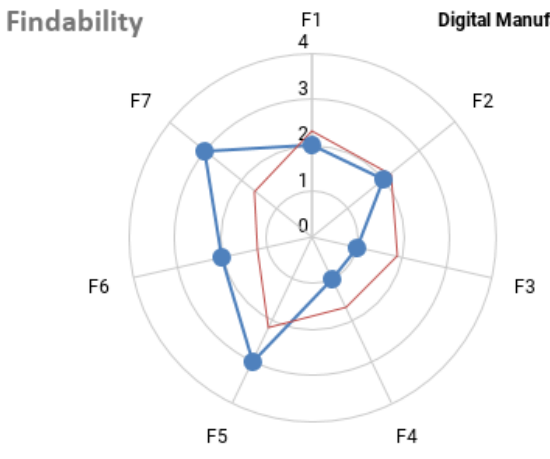
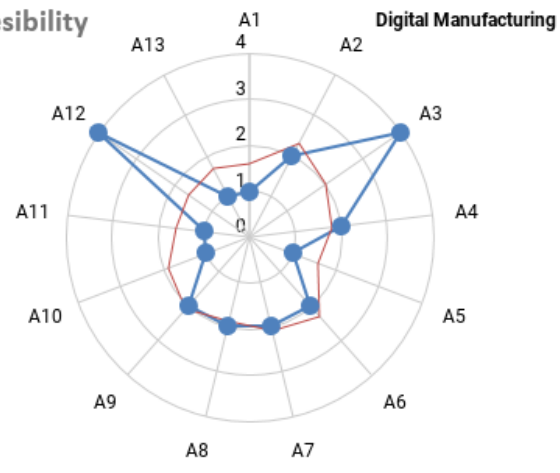


Figure 2.11.1: Overview of UC11

FAIRness of the Demonstrator

The use case is around or better than the overall demonstrator average in terms FAIR principles adoption. The use case already uses machine-understandable and linked metadata. Several Accessibility and Interoperability principles are currently being implemented or in the design phase.





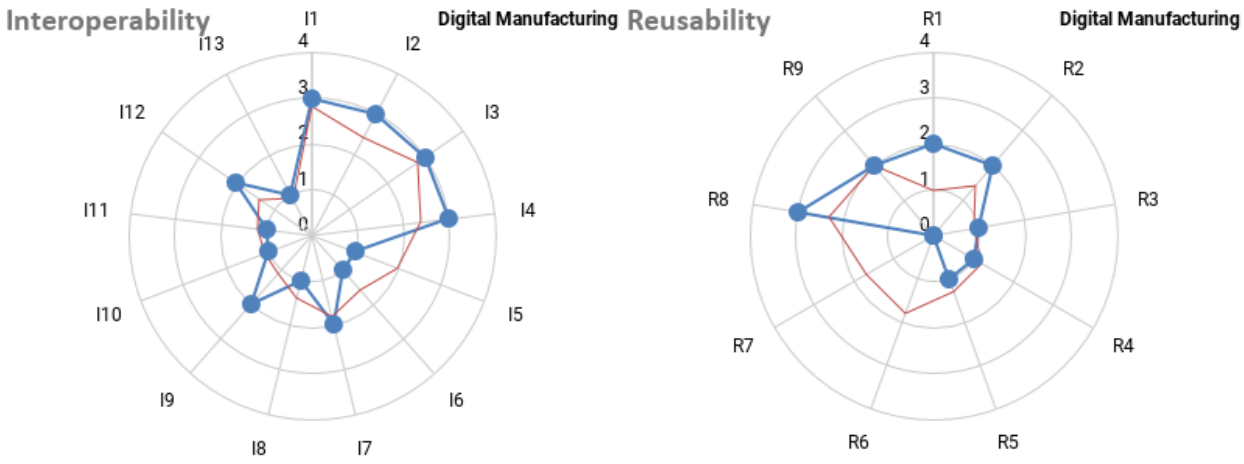


Figure 2.11.2: FAIR Charts of UC11

3. First Focused Demonstrator Workshop for Requirement Collection and Refinement

On 09/03/2021 and 10/03/2021 a workshop for the harmonisation of requirements between the initial use cases, ontologies and ontology tools was held. Due to the current pandemic situation, the workshop was designed as a digital event over the course of two days. The main objectives were:

- to collect and analyse requirements from the 11 initial use cases concerning data interoperability and ontology use
- to provide a platform for internal discussions between the use cases and the linked *'Industrial domain ontologies'* and '*OC EcoSystem Toolkit'*
- to provide an overview on ontologies and development tools
- to inform the public about our current use cases and their role in the project
- to provide a platform for discussions about the use cases
- to offer the public the opportunity to ask questions to experts
- to support networking of industrial use cases and wider stakeholders

To reach those objectives, the workshop was divided into a public and a non-public part. The public part included presentations of all 11 initial use cases as well as presentations on ontologies and development tools. An open session on day 2 was established to get in direct contact with experts on ontologies to discuss questions from the industry as well as from academia. The objective was to generate a pool of potential new use cases for the project. The non-public part was designed as a discussion of the initial use cases with experts from the project. The use cases were divided into 4 groups based on a previously conducted survey regarding the objectives.

The workshop was advertised by the project partner Trust-IT through the following activities:

- Publication of workshops on the *OntoCommons* website: Trust-IT has created a dedicated page with the general information about the workshop, agenda and registration form on the *OntoCommons* website. The page is accessible here: https://ontocommons.eu/workshop-demonstrators-and-use-cases
- Workshop Banner: a graphic banner has been developed to promote the workshop in a compelling way. All the main info (date, time, title, logo, and call to actions) were included. The banner was posted on the website and on the *OntoCommons* social media channels
- Promotion of the event through social media channels: the workshop was promoted on both social media channels (Twitter and LinkedIn).
  The posts on the social media were promoted from 25 February until the days of the workshop.
- Promotion of the event through the newsletter: the workshop was promoted on the newsletter, which was sent on the 5th of March. The newsletter was sent to 127 people.

Furthermore, all partners directly informed their contacts, such as partners from other relevant projects, about the workshop and stakeholders from other European projects (e.g. ORIENTING, DOME 4.0) were contacted and invited.

3.1 Schedule & Participation

Day 1: March 9th, 2021

Date	Content & presenter/moderator	Type of session
09:00 – 09:15	**Opening Day 1** *Umutcan Simsek and Anna Fensel (Semantic Technology Institute, University of Innsbruck)*	Public
09:15 – 11:15	**Presentation of 11 initial use cases** *Moderation: Umutcan Simsek* Rebeca Arista (Airbus SE): **IRIS - IndustRIal co-design Support** Evgeny Kharlamov (Robert Bosch GmbH): **SeDIM: Semantic Data Integration for ManufacturingSemantic AI-Solutions for Industry 4.0** Anders Gjerver (Aibel): **Engineering for Procurement** Steffen Lamparter (Siemens AG): **Siemens Digital Manufacturing/Complex Equipment** Iker Esnaola (Fundación Tekniker): **Materials' Tribological Characterisation**	Public

	Silvia Chiacchiera (STFC Daresbury Laboratory): **EVMF: European Virtual Marketplace Framework** Karl Krone (OAS Ag): **Use Case OAS** Janne Haack (Fraunhofer IFAM): **Feedstock Quality Assurance** Theodoros Efthymiadis (IRES): **Nanomaterials Characterisation** Stefano Borgo (Laboratory for Applied Ontology ISTC-CNR): **Ontology-based Maintenance** Maria Kostopoulou (ElvalHalcor S.A.): **Data integration and interoperability in Manufacturing**	
11:20 – 12:20	**Working session** *Moderation: Christian Weck*	Non-public

Day 2: March 10th, 2021

Date	Content & presenter/moderator	Type of session
09:00 – 09:10	**Opening Day 2** *Christian Weck (Fraunhofer IFAM)*	Public
09:10 – 09:35	**Presentation on ontologies** *Moderation: Christian Weck* María Poveda-Villalón (Universidad Politécnica de Madrid): **Ontologies: a brief introduction**	Public
09:35 – 10:05	**Presentation on development tools** *Moderation: Christian Weck* Mathieu d'Aquin (NUI Galway): **Tools for Ontology Engineering**	Public
10:15 – 11:15 & 11:15 – 12:10	**Public Session "Call the Expert"** *Moderation: Umutcan Simsek* *Expert: Hedi Karray (The National School of Engineering in Tarbes)*	Public
10:15 – 11:15 &	**Parallel working session for the use cases regarding ontologies and development tools**	Non-public

11:15 – 12:15	*Moderation: Ana Teresa Correia (ATB), Rebecca Siafaka (ATB), Dragan Stokic (ATB)* *Experts: Arkopaul Sarkar (The National School of Engineering in Tarbes), Mathieu d'Aquin (NUI Galway), María Poveda-Villalón (Universidad Politécnica de Madrid)*	

The slides from the presentations can be found under https://ontocommons.eu/workshop-demonstrators-and-use-cases.

The workshop had 99 registrations from 21 different countries and over 70 different institutions and companies. Two thirds of the participants already had experience in projects or initiatives involving ontologies, standardisation and/or FAIR initiatives. As can be seen in the chart, the participants had very different background, but approximately half of the participants described themselves as scientists and researchers. See Figure 3 for the details.

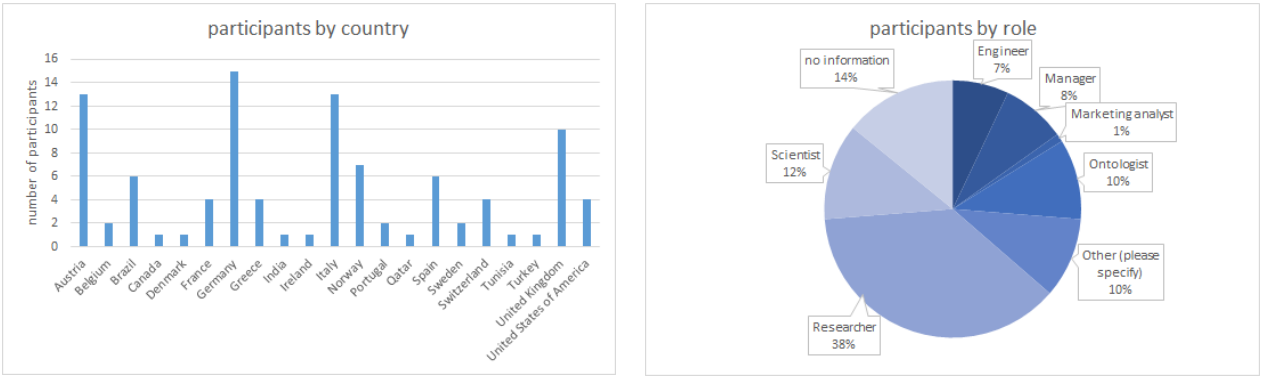


Figure 3.1.1: Workshop Participants Summary

From the 99 registered participants over 70 participated in the public sessions. The presentation of the use cases has occasionally led to specific questions from the public to the speakers, which were then also answered directly. The same applies to the presentations on ontologies and development tools on day 2.

In the open session "call the expert", there were live discussions with the public about the objectives of the project. OntoCommons Technical Manager presented the *OntoCommons* project and focused on its main objectives OBJ1 "Community Development", OBJ2 "Ontology Commons EcoSystem" and OBJ3 "Demonstrators". It was also clarified to the stakeholders that the objective of the project *OntoCommons* is to bring all experts together to generate a joint ontology-thinking and strive for a common mind-set. One of the main points was about the development and use of tools. The discussion revealed that many of the tools available are not user-friendly enough. In addition, the need for established best-practices approaches was highlighted. Three potential new use cases for the project also emerged from the discussions.

4. Requirements

4.1 General Requirements

In this section we provide the initial set of requirements on ontologies (existing and new ones) and ontologies-tools, needed in the 11 selected demonstration cases (Use Cases - UC, UC1 to UC11). The approach for the collection of the requirements from the demonstration cases included two main procedures:

- Using the template for the description of the use cases and the structured definition of requirements (see Section 2), the 3rd party industrial partners and the corresponding project partners involved in the eleven use cases, defined the requirements relevant for their demonstrators.
- In the scope of the 1st Focused Demonstrator Workshop for Requirement Collection and Refinement (see Section 3), the involved partners discussed and further extended the requirements.

The collected requirements have been analysed and harmonised. For example, a number of requirements in diverse use cases and those defined with the workshop were aggregated and put together. The following list includes harmonised requirements.

The requirements are structured in several groups and subgroups:

- General requirements including
  - Requirements concerning the use/application of ontologies
  - Requirements concerning standardisation
- Requirements on
  - Development of Ontologies
  - Maintenance/extension of ontologies
- Requirements on tools

The requirements are prioritised in three main groups: shall, should and may.

For each requirement, the table includes references to the requirements defined by the specific use cases or within the different sessions carried out during the workshop.

The "UIDs" and the "Requirement Origin" IDs in the following tables are defined in the following way:

- **CRQ_[CATEGORY]_[SERIAL NUMBER]** for all the harmonised demonstrator requirements

  where:

  CRQ = Common Requirement,

  CATEGORY= **U** for use of ontologies, **D** for development, **S** for standardisation or **M** for maintenance

  SERIAL NUMBER = incremental identification number

  e.g. CRQ_U_01

- **UCx_RQ_[CATEGORY]_[SERIAL NUMBER]** for use-case-specific requirements,
  where:
  UC = Use Case
  x = 1 to 11 for the identification number of the related use case.
  RQ = Requirement

  CATEGORY= **U** for use of ontologies, **D** for development, **S** for standardisation or **M** for maintenance

  SERIAL NUMBER= incremental identification number
  e.g. UC6_RQ_02

- **WSx_RQ_[SERIAL NUMBER]** for requirements acquired in the different sessions of the 1st Focused Demonstrator Workshop,
  where:
  WS = Workshop
  x = **O** for workshop-session on ontologies, **T** for workshop-session on tools
  RQ = Requirement
  SERIAL NUMBER= incremental identification number
  e.g. WSO_RQ_12 or WST_RQ_04

Please note that within the further work on the specification and implementation of the 11 demonstrators these requirements will be further elaborated and refined. This will be documented in the *report on Specification of initial cases*. The following requirements will be covered by different components of the *OntoCommons* solutions, (e.g. the methodology, the toolset) and by the ontologies to be (further) developed.

Table 4.1: General requirements

UID	Title	Description	Priority [1]	Requirement Origin
Use/application of ontologies				
CRQ_U_01	Support domain description	Ontologies to be used shall include the key aspects of domain terms and processes addressed in the use cases.	**Shall**	UC1_RQ_U_01 UC2_RQ_U_01 UC5_RQ_U_02 UC7_RQ_U_01 UC7_RQ_U_02
CRQ_U_02	Requirement traceability	Ontology should support requirement traceability from design choices to assembly design.	**Should**	UC1_RQ_U_02
CRQ_U_03	Support co-simulation	Co-simulation between models in different modelling languages.	**May**	UC1_RQ_U_03
CRQ_U_04	Rules supporting reasoning and	The ontologies shall allow for easy adding/updating of application specific rules among the entities and application of	**Shall**	UC1_RQ_U_04 UC3_RQ_U_05 UC6_RQ_U_02 UC7_RQ_U_05 WSO_RQ_15

	decision making	such rules in the ontologies for reasoning and decision making.		
CRQ_U_05	Rule flexibility	The ontologies should allow for flexibility (diverse types and forms of rules) in adding/updating of application specific rules among the entities.	**Should**	UC3_RQ_U_05 UC6_RQ_U_03
CRQ_U_06	Good alignment with corresponding domains	The ontology-based glossary shall be developed according to, and aligned with, top level ontologies to allow for interoperability.	**Shall**	UC2_RQ_U_03 UC2_RQ_U_07 UC9_RQ_U_02
CRQ_U_07	Allow for quality metrics	Ontology shall allow for consistency, connectivity and other quality metrics.	**Should**	UC2_RQ_U_08 UC3_RQ_U_06
CRQ_U_08	Ontology-based data access and correlation	Should allow ontology-based selection, correlation, and identification of information within the stored data (e.g. in a database) via SPARQL queries.	**Should**	UC3_RQ_T_02 UC4_RQ_U_01 UC7_RQ_U_04 UC8_RQ_U_02
CRQ_U_09	Documentation of domain	Ontology should allow for effective documentation of domain data including related terms.	**Shall**	UC6_RQ_U_08 UC9_RQ_U_01 UC7_RQ_U_03 WSO_RQ_11
CRQ_U_10	Documentation of domain software	The tool documentation shall capture the key aspects of software used in a domain (e.g. capabilities, requirements, libraries, operating systems, licensing, etc.).	**Shall**	UC5_RQ_U_01
CRQ_U_11	Computational efficiency	The ontologies shall be processable by hardware systems with low processing capabilities.	**Shall**	UC2_RQ_U_02 UC6_RQ_U_01
CRQ_U_12	Lightweight ontology language	The ontologies should use lightweight ontology languages for the reasoning.	**Should**	WSO_RQ_07
CRQ_U_13	Application of ontology for self-learning	The ontologies may allow to apply (on mid-term) self-learning of application specific rules (automatic updating of rules based on self-learning).	**May**	UC6_RQ_U_04 UC11_RQ_U_01
CRQ_U_14	Ontologies re-use and modularisation	The ontologies should be possible to apply, as a whole or partly, in combination with other ontologies.	**Should**	UC2_RQ_U_04 UC6_RQ_U_05 UC8_RQ_U_01
CRQ_U_15	Non-ontology expert user	The ontologies shall be usable by non-ontology experts. The	**Shall**	UC3_RQ_U_01 UC6_RQ_U_06

		natural language definitions of entities and relations shall be understandable by domain experts without knowledge on ontology science.		WSO_RQ_08
CRQ_U_16	Compliance with the respective domain of application	The natural language definition of entities may be related to the taxonomy used in the domain.	May	UC6_RQ_U_07
CRQ_U_17	Standardisation of processes and communication	The ontologies should allow for efficient standardisation of processes and communication among systems (HW/SW).	Should	UC6_RQ_U_10 WSO_RQ_16
Standardisation				
CRQ_S_01	Conformance to standards	There shall be compliance to relevant domain and W3C standards (e.g. ISO).	Shall	UC2_RQ_U_05 UC2_RQ_U_06 UC2_RQ_S_01 UC2_RQ_S_02 UC3_RQ_S_01 UC3_RQ_S_02 UC3_RQ_S_06 WSO_RQ_06 UC11_RQ_D_04
CRQ_S_02	Good practices of modelling	Good practices of modelling that will be defined in the scope of the project should be applied.	Should	UC2_RQ_S_03 WSO_RQ_10
CRQ_S_03	Wider agreement with experts and community	Consultations shall be made with the community and related H2020 projects (e.g. focus-areas on digitalisation and interoperability.	Shall	UC05_RQ_S_01 WSO_RQ_11
CRQ_S_04	Standard Definitions of Entities	The ontologies should use definitions of entities which are standard in the domain.	Should	UC3_RQ_S_01 UC3_RQ_S_02 UC4_RQ_S_01 UC6_RQ_S_02 UC7_RQ_S_01
CRQ_S_05	Interoperability between TLOs	There shall be harmonisation of ontologies allowing for interoperability among ontologies that are based on different top-level ontologies.	Shall	UC6_RQ_S_01 UC8_RQ_S_01 WSO_RQ_01 UC11_RQ_S_06 UC11_RQ_D_04 UC11_RQ_S_06
CRQ_S_06	Licensing and sharing	The method shall define ontology harmonisation steps for licensing between different stakeholders, systems (HW/SW) and data owners/users, to enhance data sharing.	Shall	UC3_RQ_U_07 UC11_RQ_U_02 WSO_RQ_16

CRQ_S_07	Ontology repositories	A document with available ontology-repositories in diverse domains should be created to enhance ontology reusability.	Should	WSO_RQ_17

[1] Priority 1: Shall, Priority 2: Should, Priority 3: May

4.2 Requirements for Development and Maintenance in Ontologies

Table 4.2: Requirements for Development and Maintenance in Ontologies

UID	Title	Description	Priority	Requirement Origin
Development of ontologies				
CRQ_D_01	Compliance to higher-level ontologies	Should allow to follow higher level ontology models (top or middle-level ontologies	Should	UC1_RQ_D_01 UC1_RQ_D_02 WSO_RQ_01 UC11_RQ_D_04
CRQ_D_02	Controllability	Ontology development needs to charter good practices and guarantee high quality of development.	Shall	UC2_RQ_D_01 UC11_RQ_D_04 UC11_RQ_S_06
CRQ_D_03	Compatibility* *related to CRQ_U_14	The ontologies should allow to be used together with other onto-logies without the need to adjust them.	Should	UC6_RQ_D_02 WSO_RQ_04
CRQ_D_04	Documentation for interoperability	The ontology documentation should define how the reuse and harmonisation of different ontolo-gies could be achieved.	Should	UC6_RQ_D_03 WSO_RQ_04
CRQ_D_05	Usability and understandability	The ontology should have the minimum (but sufficient) number of levels in term hierarchy and with understandable natural language definitions of terms to allow for easy processing and for under-standing by non-ontology experts.	Should	UC3_RQ_U_01 UC6_RQ_D_04 UC7_RQ_D_01 WST_RQ_02 WSO_RQ_08
CRQ_D_06	Ontology Scope	Ontology shall contain definitions to a range of entities that are relevant to and provide agree-able coverage of the selected domain	Shall	UC6_RQ_D_01 UC9_RQ_D_01 UC9_RQ_D_02 UC9_RQ_D_03
CRQ_D_07	Methodology user audit	Methodology should be provided to support user expert audits assuring that the relations and	Should	WSO _RQ_13

		concepts have human under-standing.		
CRQ_D_08	Ontology re-use	Methodology should be provided to support reusing of existing ontology following the best practice to first define model of concepts and relations needed for our domain and applications and then analyse how to combine/re-use other ontologies.	Should	WSO_RQ_14
CRQ_D_09	Development of methodology for ontologies	The ontologies shall follow a methodology for development. (Related to CRQ_D_02)	Shall	UC2_RQ_M_01 WSO_RQ_03
CRQ_D_10	Methodology for ontology engineering	Methods/guidelines/tools should be provided for integration of different steps in the ontology engineering processes.	Should	WST_RQ_02
CRQ_D_11	Methodology - conceptual phase	Methodology should be provided for initial brainstorming to define concepts of the domain and collaboration keeping the point of view of the user. Methodology should support conceptual phase.	Should	WSO_RQ_12
Maintaining/extension of ontologies				
CRQ_M_01	Extension for new processes	The ontology should allow for extension from partial and case-by-case behaviour models to parametric behaviour models.	Should	UC1_RQ_M_01
CRQ_M_02	Provenance	The ontology methodology should include provenance metadata	Should	UC2_RQ_M_02
CRQ_M_03	Easy maintenance of ontology	The ontology shall be easy to maintain (e.g. adding lower level terms, additional relations, etc.) from non-ontology experts (e.g. SW engineers).	Shall	UC4_RQ_M_01 UC3_RQ_M_01 UC5_RQ_M_01 UC6_RQ_M_02 UC6_RQ_M_01 UC7_RQ_M_01 WSO_RQ_02
CRQ_M_04	RDF Triple Store	Expert consulting on how to create an appropriate triple store for our application.	Should	UC8_RQ_M_01 UC8_RQ_T_01

4.3 Requirements on Tools

Table 4.3: Requirements on Tools

UID	Title	Description	Priority	Requirement Origin
CRQ_T_01	Collaboration of multiple stakeholders	The ontology development tool should allow different stakeholders to work simultaneously.	Should	UC1_RQ_T_01 UC3_RQ_U_04 UC3_RQ_D_01 UC6_RQ_U_09 WSO_RQ_09 UC11_RQ_M_05
CRQ_T_02	Visualisation	The tools shall support visualisation of ontologies.	Shall	UC2_RQ_T_01 WSO_RQ_04 WST_RQ_07
CRQ_T_03	Debugging	The tools shall support debugging.	Shall	UC2_RQ_T_02
CRQ_T_04	Validation	The tools shall support Validation.	Shall	UC2_RQ_T_03 WST_RQ_06
CRQ_T_05	Quality assurance and analytics	Support quality assurance in domain operations and ontology development.	Shall	UC2_RQ_T_03 UC3_RQ_U_06 UC3_RQ_D_02
CRQ_T_06	Allow/support different mechanisms to access data	The tools should support easy interaction with ontologies, for example, via REST APIs alongside SPARQL queries for retrieving data.	Should	UC4_RQ_T_01 UC3_RQ_U_02 UC3_RQ_U_03
CRQ_T_07	Support for OWL	The tool for edition and maintenance of the ontologies shall be able to edit OWL files.	Shall	UC6_RQ_T_01
CRQ_T_08	Ontologies import	The tool for edition and maintenance of the ontologies shall be able to import and reuse existing ontologies.	Shall	UC6_RQ_T_02
CRQ_T_09	User friendly	The tool for edition and maintenance of the ontologies should be easy to use for non-ontology experts.	Should	UC3_RQ_T_01 UC6_RQ_T_03 WSO_RQ_01 UC11_RQ_U_01 UC11_RQ_M_05
CRQ_T_10	Connected ontologies	The tools for ontology should enable/ support compatibility of different domains (e.g. processes and materials), since different ontologies might be needed.	Should	UC7_RQ_T_01 WST_RQ_07
CRQ_T_11	Tool integration	Integrated tool shall be provided to support initial brain-storming on models of concepts relevant for the domain and applications, to enhance transition from initial ideas to standard tools (e.g. Protégé).	Shall	UC3_RQ_T_04 WSO_RQ_01 WST_RQ_07
CRQ_T_12	Modularisation	The tools should facilitate modularization of ontology models.	Should	WSO_RQ_07

CRQ_T_13	Tools for searching ontologies	The tools should allow for ontology search (find ontologies, entities, definitions, etc., e.g. finding existing ontologies to fit an application, based on the initial model of needed concepts).	**Should**	**WST_RQ_06** **WST_RQ_03**
CRQ_T_14	Tools for re-usability of ontologies	Quality of the ontology models to be reused should be guaranteed.	**Should**	**WST_RQ_04**
CRQ_T_15	Tools for correlation among ontologies	Tools shall be provided to support establishment of relation of concepts from diverse ontologies.	**Shall**	**WST_RQ_05**
CRQ_T_16	Tools for deployment and generation of documentation	Tools should be provided to support effective deployment of ontologies, including effective generation of documentation etc.	**Should**	**WST_RQ_06**
CRQ_T_17	Tool for guide ontology reusability	The tool should guide the user and suggest whether existed ontologies can be reused or new are required.	**Should**	**WST_RQ_08**
CRT_T_18	Tool GUI labels consistency and understandability	The GUI labels of the tool should comply with terminology used in ontologies to be used by ontologists, but also clear and understandable by non-ontologists.	**Should**	**WST_RQ_09**

5. Criteria and Strategy for Selecting Further Demonstrators

As foreseen in the project planning, the effectiveness of the *OntoCommons* approach will be proved by the delivery of a set of demonstration cases built upon the OCES, spanning through several domains providing ready to use ontologies, tools and a selection of data samples for dissemination purposes, together with documentation for the users.

According to the nature of the CSA, further **community proposed demonstrators** (Community Demonstrators) up to a maximum of **other 10 will be added** to the project during the first year of the project following stakeholder consultations.

The *OntoCommons* project will conduct the process of finding and involving of the new demonstrators in an open and transparent manner. A call for participation for the potential new demonstrators will be created, published online (such as on the project website) and distributed over the channels available in the project.

The call will be emphasizing the benefits the demonstrators get with joining the project, such as:

- getting insights into the new ontology technology and support with its adoption,
- getting high visibility though the project network, events, further communication and dissemination channels,
- having extensive communication and networking possibilities, particularly, for establishment of new collaborations with leading organisations in the relevant domains,
- getting possibility to have an impact on the ontology and ontology technology field and on the roadmap produced in *OntoCommons*.

The following criteria will be applied for the selection of the demonstrators:

Relevance to the *OntoCommons* project topics. Demonstrators cases will provide suggestions about the tools and top level, mid-level and domain ontologies to be included in the OCES, and the need for new domain ontology development if needed.

Representative coverage of various domains. The demonstrators shall representatively cover different areas requested by the work programme part "Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing" and particularly by the topics of the call DT-NMBP-39-2020 under which the *OntoCommons* CSA is funded (such as manufacturing, materials processing, materials modelling, nano-safety, characterisation and life cycle sustainable analysis ontologies).

The demonstrators that are so far cover the following topics: Manufacturing (Aerospace, Assembly Process Design, Automotive, Energy, Equipment, Maintenance), Procurement, Materials (Design, Processing, Characterisation, Nanosafety), Software Documentation (related to materials).

Diversity in the technology requirements. Referring to the collected requirements, the demonstators delivering requirements complementing these will be preferred.

Appropriate technology readiness level (TLR). The demonstrators should have TRLs that are in-line with the expectation of the *OntoCommons* project (starting at 3-5 and targeting 6-7 for the end of the activity).

Geographical distribution. The demonstrators shall be geographically distributed, to cover different EU states, to ensure the representative collection of the requirements and awareness of the various national developments.

Contribution to the goals of the project and cooperation potential. The demonstrators will be selected considering the expectations towards their potential to contribute to various aims of the project. For example, in the project we expect to perform harmonisation of at least 10 agreed existing ontologies and initiate the development of at least 3 new domain ontologies (or sub-domains) covered by the project demonstrators according to the agreement of stakeholders (as required by the call). Thus, demonstrators working with various ontologies will be relevant.

Expected availability of the work. Demonstrators ontologies and data are to be publicly available and will be used as example of use of the OCES, i.e. the new demonstrators should be ready to make available their materials to the public.

Resources. The *OntoCommons* development and demonstrator activities will rely mainly on existing resources, or on external resources already dedicated to similar topics, leaving to the CSA the activities related to harmonisation, standardization and coordination, including the development of new domain ontologies as requested by the call. Limited R&D activities will be pursued for demonstration delivery, if necessary. Already at the proposal stage, several EU projects (simDOME, OntoTrans, IoTwins and others) have indicated their availability to join the *OntoCommons* project. We are taking these and similar developments into account explicitly.

When joining the new demonstrators in the project, the above criteria will be checked, and the potential demonstrators that are to be joined prioritized.

The decision on which demonstrators should be part of the project is to be carried out by selected representatives of *OntoCommons* , as well as the project coordinator and technical manager.

We aim at the following timeline for the new demonstrators joining the project:

- Call for new demonstrators is produced, published and disseminated: June 2021
- Deadline of the call for the new demonstrators: September 2021
- Decisions on which new demonstrators to join the project are made: October 2021
- Work with the new demonstrators starts on: November 2021

6. Conclusion and Future Work

In this report, we have presented the requirements on ontology tools and ontologies based on the initial demonstrators and criteria for selection of further cases.

Our future work will comprise working with the existing demonstrators on the ontology and ontology tools adoption, and also acquiring further demonstrators and starting to work with them.

The OntoCommons project together with the demonstrators, will coordinate the work towards addressing of the requirements derived here, and improving of the state of the development of the demonstrators in general, for example on the aspects such as raising of the demonstrator's TRLs and making their data more FAIR.

7.Appendix

7.1 Demonstrator Survey Form

The survey can be found in the Zenodo repository of *OntoCommons* project[7].

7.2 FAIR Survey Form

The FAIR survey filled by the demonstrators can be found on EUSurvey[8]. The individual principles can be mapped as follows:

Coding in the Radar Charts	Coding in the Survey
F	C
A	D
I	E
R	F

The numbers next to the letter codes in the survey correspond to the numbers in the radar charts in Section 2.

[7] https://zenodo.org/record/4769980

[8] https://ec.europa.eu/eusurvey/runner/b64d2bc9-28da-3347-332b-0dc6970789d3