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Ontology describing a nuclear decommissioning project

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Abbreviations and acronyms

Acronym	Description
BIM	Building Information Modelling/Management
D&D	Decommissioning and Dismantling
DILIGENT	Distributed, Loosely-controlled and evolving Engineering of oNTologies
DIN	Deutsche Industrienorm (German Industrial Standard)
DOE	Department of Energy of the United States Government
DOGMA	DOGMA means Ontology-Grounded Methods and Applications
ERP	Expert Review Panel
EU	European Union (in most cases referring to the European Commission and its entities)
HC NPP	José Cabrera Nuclear Power Station
HCOME	Human-Centred Collaborative Ontology Engineering Methodology
IAEA	International Atomic Energy Agency
IFC	Industry Foundation Classes, a data model intended to describe architectural, building and construction industry data
ISDC	International Structure for Decommissioning Costing of Nuclear Installations
KM	Knowledge Management
KPI	Key Performance Indicator
NeOn	New Ontology Paradigm
OECD-NEA	Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD)
OWL	Web Ontology Language
RDF	Resource Description Framework
SAMOD	Simplified Agile Methodology for Ontology Development
SKOS	Simple Knowledge Organization System
SPARQL	SPARQL Protocol and RDF Query Language
SSC	Structures, systems and components
UPON	Unified Process for Ontology building
URI	Universal Resource Identifier
VIM	International Vocabulary of Metrology – Basic and General Concepts and Associated Terms
WM	Waste Management

Acronym	Description
WP	Work Package
XML	Extensible Markup Language

Executive Summary

The main objective of this task was development of a nuclear decommissioning specific ontology. This ontology forms the philosophical backbone of the PLEIADES project by providing a common understanding of the decommissioning process that is described in various nuclear decommissioning support software packages. The provision of a Decom Core Ontology is a key element of the overall PLEIADES project as it ensures a common vocabulary for the further exchange between the software packages and the processes they support. Beyond that, the ontology also provides the technical basis for the development of a database serving as an interim solution for data management.

For the development of the ontology, several methods for ontology engineering have been identified, consulted and examined. In the end, we have derived a very basic but suitable method to develop the ontology.

In parallel with the ontology development process, we have consulted several interested parties, partially within the consortium (measurement and waste management specialists) as well as outside (IAEA, EU, OECD-NEA). This allowed us to develop an ontology that will also be compatible with the major knowledge sources for decommissioning, providing such compatibility to the foreseen users of the PLEIADES ecosystem.

Definitions of the top-level ontology concepts have been documented within the ontology. The sources have been mainly international and national standards (ISO, DIN, IAEA Safety Glossary) but also common-sense sources, such as Merriam-Webster. In some cases, there was no source for a definition and, hence, a definition had to be developed within PLEIADES.

Finally, the ontology was formalized using Vocbench into an RDF/XML file including the definitions and some translations.

Keywords

Nuclear, Decommissioning, Software Platform, Digital Tools, Knowledge Management, Ontology, Semantic technology, RDF

1. Introduction

The PLEIADES project aims at providing a platform connecting digital tools for nuclear decommissioning provided by several organisations via a standardised interface (PLEIADES Consortium 2020). The complexity of this task originates not only from the notoriously complex activity of decommissioning in the nuclear field, but also from the differences regarding policies of countries and, overall, from the perception and notion of terms and definitions within the various cultural backgrounds of individuals and organisations working in this field.

The complexity has led to standardization efforts (independent from this project) initiated by international organisations like the IAEA (IAEA 2021), OECD/NEA or the DOE, that aim for providing unambiguous terms and definitions in dedicated database systems.

Having unified terms and definitions, a network of classes (or categories), which are involved in nuclear decommissioning, can be rigorously defined and their relationship and properties be set, leading to a core decommissioning ontology (called Decom Core Ontology in the following). Classes are understood as a group of similar items (such as “cities”), where each class has a definition applicable to each and every instance in the class. Properties (such as “is in country”) are descriptive data sets that make it possible to distinguish the instances of the classes. The set of properties is usually set for the whole class, the combination of property values allows to query, filter, and aggregate within the class. Also, properties can provide conjunctions between classes. In the example, the property “is in country” links the classes “cities” and “countries”. Additional restrictions may apply: Each instance of the property “is in country” would need to point to exactly one instance in the class of “countries”. No city can be in two countries at the same time.

The establishment of a common ontology is one of the key points of international standardisation efforts. Without an agreement on the main concepts, it is not possible to exchange data between different software programs and modules. As the project will primarily utilize existing software tools, it was essential to agree on the conceptual level as the terms may be used differently in different tools. The ontology defines concepts and their linkage allowing connection to the conceptual frameworks of each software tool ensuring that data is retrieved and manged correctly.

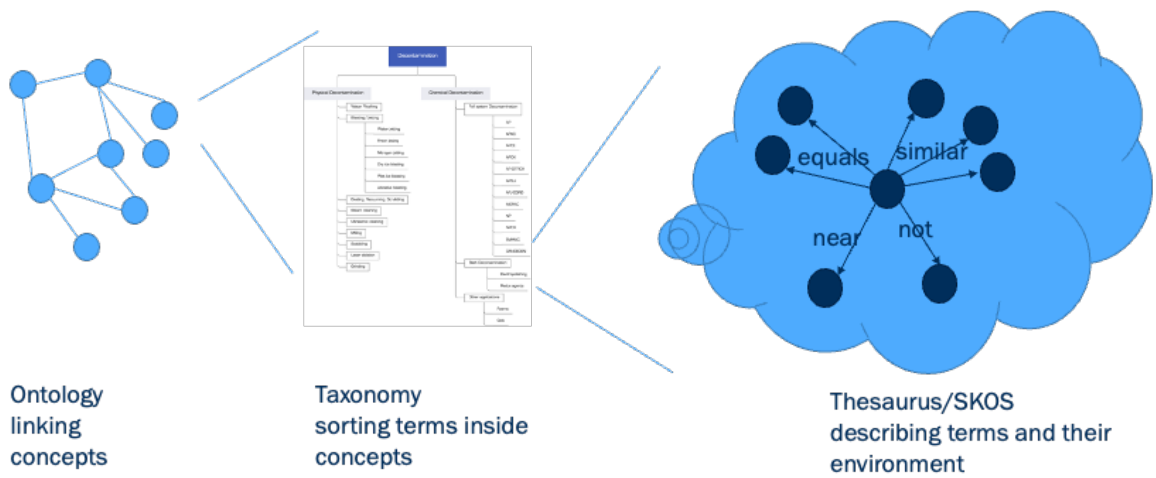

Figure 1: Ontologies, Taxonomies and Thesauri

2. Fundamentals of an ontology

2.1. Definition

Ontologies are formal, schematic representations of a knowledge domain and form a model of the reality (Li, Raskin, Ramani 2007; Weller 2013). They consist of a vocabulary and rules for its composition and are used as content-describing metadata in various (internet-) services and are establishing themselves as an additional method of knowledge organization, which is increasingly being used alongside classical methods (such as Thesauri). Ontologies are written in machine-readable ontology languages so that computer systems can automatically read and, if possible, interpret the information (Weller 2013).

The components of an ontology are composed of (Weller 2013):

- *concepts*, mostly hierarchically ordered and implemented and defined in the form of *classes*
- *instances,* as concrete elements of these classes
- *properties,* as descriptions of the characteristics of and relationships between concepts
- *restriction*s, that can model the structure of an ontology

2.2. Structure and Development

The building of an ontology is an iterative process. Main steps are the definition of classes (representing concepts), the design of a hierarchy (taxonomy) within each individual class (super-/subclasses) and the definition of concept properties. First of all, the domain and the application in which the ontology is used must be clearly identified. The next step should consider if existing ontologies can be reused. Furthermore, important concepts in the modelled domain shall be identified. Following this, class hierarchies need to be identified (Vertan 2003). For this step, two possibilities exist: In the top-down approach, foundational ontologies and their formalizations are used. The bottom up approach can reuse legacy material to generate candidate classes and relations to speed up the building of an ontology (Keet 2020). The next step is the drafting of a structured ontology in which characteristics are identified and specified for each class. Finally, the initiation is performed by specifying the instances and attribute values for each class (Vertan 2003).

Ontology programs can support the construction of ontologies (Weller 2013). As a language for the development of ontologies, the Web Ontology Language (OWL) was established (Uschold 2018). OWL is available in several versions with different expressive strengths. Beside OWL, less complex languages exist e.g., RDF (Resource Description Framework) and SKOS (Simple Knowledge Organization System). By an URI (Universal Resource Identifier), classes, instances and properties become clearly referenceable. In the data storage process, the ontology is considered as a collection of several triples (three-digit information units) consisting of subject, predicate and object (Uschold 2018). To reuse the above example: Berlin (as instance of the class “cities”) is in country Germany (as instance of the class “countries”).

People involved during the ontology life cycle are (Kotis, Vouros, Spiliotopoulos 2020):

- Domain experts: persons with knowledge/expertise about the domain and/or data sources; usually practitioners who are not familiar with ontology languages, specifications, etc.
- Ontology engineers: persons with knowledge/expertise to create specifications and coordinate ontology engineering tasks
- Knowledge workers: persons who use the ontology under "operational" conditions to solve problems or perform data-driven analysis tasks (such as domain experts – this time from a user perspective)

2.3. Methodologies

While there are only limited recent articles on ontology engineering, most of the scientific work has been done during the 2010s. More recent literature mainly concentrates on the collaboration and collaboration tools, while the early articles try to describe the basic approaches.

2.3.1. Gruber

The approach of Gruber is the first effort to consolidate the experience gained in the development of ontologies. It could be characterized by the following design criteria: clarity, coherence, extensibility, minimal ontological commitment and minimal encoding bias. (Li, Raskin, Ramani 2007; Gruber 1995)

2.3.2. Uschold and King

Uschold and King describe a skeletal methodology for the construction of an ontology on the experience gained in the development of the Enterprise Ontology. (Jones, Bench-Capon, Visser 1998) (Iqbal, Murad, Mustapha, Sharef 2013)

The phases of this methodology consist of (Jones, Bench-Capon, Visser 1998):

1. Identify purpose: Determining the level of formality for the description of the ontology
2. Identify scope: Creating a “Specification” to fully capture the range of information to characterize the ontology
3. Formalisation: Generating the “Code”, definitions and axioms of terms in the Specification
4. Formal evaluation of the resulting ontology: Evaluation criteria can be specific to a certain ontology or general; Phase 2 and 3 could be revised based on the evaluation results.

The approach of Uschold and King distinguishes between informal and formal phases. In the informal phase, key concepts are identified and followed by providing text definitions for concepts and relationships. (Jones, Bench-Capon, Visser 1998)

Uschold and King suggested three strategies (top-down, bottom-up, and middle-out) for the identification of the ontology. (Li, Raskin, Ramani 2007)

This was the first proposed methodology for building ontologies. However, it does not accurately describe the techniques and activities (Iqbal, Murad, Mustapha, Sharef 2013) required for ontology development.

2.3.3. Grüninger and Fox

In 1995, Grüninger and Fox proposed a methodology (Grüninger, Fox 1995) for designing and evaluating ontologies for the business domain based on the experience in creating the ontology for the TOVE (Toronto Virtual Enterprise) project. For the determination of the scope and the extraction of the main concepts, the methodology uses competency questions (a set of natural language questions). The main focus is on the construction of the first-order logical model representation. (Li, Raskin, Ramani 2007) (Iqbal, Murad, Mustapha, Sharef 2013).

This methodology involves the following stages (Jones, Bench-Capon, Visser 1998):

1. Motivating scenarios: initial point is a set of problems occurring in a particular company
2. Informal competency questions: requirements for the ontology, described as informal questions to be answered by the ontology; serves as an evaluation of the ontological commitments (classes and their linking properties) made previously
3. Terminology specification: objects, attributes and relations are formally specified
4. Formal competency questions: requirements are formalized in terms of formally defined terminology
5. Axiom specification: axioms to specify the definition of terms and constraints on their interpretations are provided in first-order logic; axioms must be sufficient to express the competency questions and solutions
6. Completeness theorems: evaluating the completeness of the ontology by defining conditions under which the solutions of the competency questions are complete

Similar to the methodology of Uschold and King, Grüninger and Fox only describes the activities and techniques on an abstract level. (Iqbal et al., 2013)

2.3.4. HCOME

The Human-Centred Collaborative Ontology Engineering Methodology (HCOME) supports a human-centred approach involving knowledge workers in the ontology life cycle. This approach to engineering of an ontology underlines the close collaboration between knowledge workers and domain experts. The management of the ontologies depends on the capabilities of the workers. The ontologies can be developed both individually and collaboratively, are based on worker experience and placed in the working activities of the workers as an integrated element of a "knowing" process.

This active participation in the ontology lifecycle requires tools providing more opportunities for the management and interaction to solve diverse problems. The three phases, specification, conceptualization and exploitation/evaluation, are supported in the execution of tasks by an iterative approach. Considering the role of the knowledge workers, the approach emphasizes the use of data in operational context. In conjunction to that, the updated version of the HCOME methodology also proposes a data-driven (bottom-up) conceptualization approach. (Kotis, Vouros, Spiliotopoulos 2020)

2.3.5. DILIGENT

For the creation and evolvement of ontologies, DILIGENT (Distributed, Loosely-controlled and evolving Engineering of oNTologies) intends to support domain experts in a distributed setting and focuses on a collaborative and distributed ontology development. The development process comprises the following activities: building, local adoption, analysis, revision and local update. Collaboration is the essential aspect of this approach. This methodology proposes the creation of various ontology versions with respect to the dynamic dimension of an ontology. Nevertheless, no guidelines are proposed for the management or creation of these versions or for management of the impact of changes to the ontology. Furthermore, this method does not include guidelines for the reuse and re-engineering of existing knowledge resources. (Gómez-Pérez, Suárez-Figueroa 2009)

2.3.6. DOGMA/DOGMA-MESS

DOGMA means Ontology-Grounded Methods and Applications and is a collaborative methodology following a data-driven (bottom-up) approach. The extension is named DOGMA-MESS. Modelling of shared ontologies based on stakeholders' own terminology and context is supported by DOGMA through the introduction of the following four modes of knowledge conversion: socialization, externalization, combination and internalization. The centre of this methodology is an Ontology Server embedded in a central system supporting ontology development. Core domain experts, other domain experts, and ontology engineers comprise the three types of participants in the ontology development. The iterative ontology evolution process is guided by social knowledge transformation modes until an optimal trade-off between differences and commonalities of organizational and shared perspectives is achieved. Ontology management in this approach, is partially supported by import and identification of conflicts of ontology definitions. (Kotis, Vouros, Spiliotopoulos 2020)

2.3.7. METHONTOLOGY

The METHONTOLOGY methodology allows the building of ontologies at the knowledge level and builds domain ontologies from scratch. (Iqbal, Murad, Mustapha, Sharef 2013) (Gómez-Pérez, Suárez-Figueroa 2009)

In contrast to TOVE and Enterprise, this methodology covers in detail the activities and techniques used. (Iqbal, Murad, Mustapha, Sharef 2013)

The methodology starts with the identification of the activities below for an ontology development:

1. Specification: determination of the purpose and the scope of the ontology; the result is a natural language ontology specification document.
2. Knowledge acquisition: done mainly in parallel with stage 1; any type of knowledge source and data election method can be used
3. Conceptualisation: identification and informal representation of concepts, instances, verbs, relations or properties of domain terms
4. Integration: adoption of definitions from other ontologies to achieve some uniformity
5. Implementation: representation of the ontology by using a structured language
6. Evaluation: a lot of attention is paid on this phase; searching for incompleteness, inconsistencies and redundancies
7. Documentation: compilation of documents resulting from other activities; life cycle of an ontology within these activities is based on the refinement of a prototype ontology

The ontology includes the following states, some of which are the same as the activities mentioned above: specification, conceptualization, formalization, integration and implementation. This is followed by the maintenance state, which covers knowledge acquisition, evaluation and documentation throughout the lifecycle. As with TOVE, the central aspect of the methodology is maintenance. (Jones, Bench-Capon, Visser 1998)

METHONTOLOGY lists activities that are performed during the ontology reuse and re-engineering process, but it does not offer detailed guidelines, nor does it take into account different levels of granularities. (Gómez-Pérez, Suárez-Figueroa 2009)

2.3.8. NeOn

The NeOn Methodology for building ontology networks is scenario-based. NeOn remediates the disadvantages of several methodologies (e.g. METHONDOLOGY and DILLIGENT) and profits of their advantages. (Gómez-Pérez, Suárez-Figueroa 2009)

The methodology focuses on the development of ontology networks and the use of existing resources for the ontology development. Developers and ontology practitioners are involved at the same time. This is a collaborative methodology taking into account the existence of diverse ontologies in ontology networks and the reuse and reengineering of knowledge. The definition of NeOn is based on the analysis of a set of nine scenarios for building an ontology. (Kotis, Vouros, Spiliotopoulos 2020)

The nine flexible scenarios are aimed at building of ontology networks (Gómez-Pérez [kein Datum])

1. from scratch without reusing existing resources
2. by reusing and reengineering non ontological resources
3. by reusing ontologies or ontology modules
4. by reusing and reengineering ontologies
5. by reusing and *merging* ontologies or ontology modules
6. by reusing, merging and *reengineering* ontologies or ontology modules
7. by reusing ontology design patterns
8. by restructuring ontologies or ontology modules
9. by localizing ontologies or ontology modules

A data-driven conceptualization approach in not reported, nor is a discussion/argumentation to support consensus/agreement building explicitly reported. (Kotis, Vouros, Spiliotopoulos 2020)

2.3.9. UPON

The UPON methodology derives from the Unified Software Development Process and takes advantage of the Unified Process (UP) and also uses the Unified Modelling Language (UMS). This makes the development of an ontology for the domain experts and knowledge engineers handier. The methodology is composed of cycles, phases, iterations and workflows and adheres to the paradigm of UP. The nature of the use-case driven, iterative and incremental methodology distinguishes UPON from other processes, both in terms of software and ontology engineering. On the other hand, this method does not give comprehensive details and the collaboration aspect is also neglected. (Iqbal, Murad, Mustapha, Sharef 2013)

2.3.10. SAMOD

The Simplified Agile Methodology for Ontology Development (SAMOD) is a simple agile methodology for the development of ontologies. The steps of an iterative process that focuses on the development of documented ontologies, beginning from typical examples of domain description, are specified in this approach. Domain experts and ontology workers are included in the loop. However, knowledge workers are involved on the process. The collaboration between domain experts and ontology engineers takes place in specific initial steps of the development. This approach is not data driven and is led by motivating scenarios and informal competency questions. The validation of the ontology is tested iteratively using example data. No detailed tracking of definitions of the ontology is supported explicitly, but a versioning support is available at the level of the models. Typical tasks of the management are not addressed. Ontology tools partially support this methodology, for example transformation of diagrams into OWL and automatic generation of documentation. (Kotis, Vouros, Spiliotopoulos 2020)(Peroni 2016)

Table 1: Collaborative methodologies and supported features (Kotis, Vouros, Spiliotopoulos 2020)

	HCOME	DILLI-GENT	DOGMA-MESS	NeOn	SAMOD

Domain Experts/Knowledge Workers involvement	√	√	√	√	partially
Collaborative engineering processing	√	√	√	√	√
Iterative processing	√	√	√	√	√
Data-driven/bottom-up processing	√	√	√	no	no
Evaluation/Validation/Exploitation	√	√	no	√	partially
Arguments/Discussions	√	√	√	√	no
Detailed versioning	√	√	√	√	partially
Ontology management (import/reuse, compare, merge)	√	partially	partially	√	no
Tool support	√	√	√	√	partially

Table 2: Comparison of non-collaborative methodologies (Iqbal, Murad, Mustapha, Sharef 2013)

	TOVE	Enterprise model approach	METHONTOLOGY	UPON
Type of development	Stage based	Stage based	Evolving prototype	Evolving prototype
Reusability support	√	√	√	√
Degree of application dependency	Application semi-independent	Application independent	Application independent	Application independent
Life-cycle recommendation	No	No	√	No
Strategies for identifying concepts	Middle out strategy	Middle out strategy	Middle out strategy	Middle out strategy
Methodology details	Some details	Some details	Sufficient details	Some details
Interoperability support	No	No	No	No

2.3.11. Summary

All methods described in this chapter have at least the following common steps necessary to elaborate an ontology:

1. Setting the system boundary. What area of knowledge will be described, to which detail and which areas will be regarded as out of scope?
2. Collecting concepts from domain experts
3. Connecting the concepts with the aid of domain experts
4. Checking the consistency by testing the process and organizational aspects using examples by domain experts
5. Formalization of the ontology in a suitable language and by adding definitions, translations and synonyms.

3. Generation of the Decom Core Ontology

3.1. Procedure

Taking into account the various methodologies described in chapter 2.3, it was essential not to use a method that would require a specific software, as it was not yet decided, in what format the ontology will be captured.

Following roughly the concepts of Uschold and King, as well as Grüninger and Fox (which are, despite different wording, rather similar), the first step was to define the boundaries and the core concepts. This step included several iterations to define the core concepts. The sub-class level was used to generate examples for each concept in order to align the general understanding of the concepts. This sometimes led to changes in the understanding and the definition of the first level concepts.

The discussions and the capturing were done on two levels: The first level was a generic model of a decommissioning project using a simple mindmap tool. The second part resulted in a spreadsheet capturing the definitions behind the concepts.

As a second step, the concepts were connected via properties. It was decided, to mainly use one property to connect each pair of concepts (if there was connection) and to use intermediate concepts for a connection were appropriate. This led to a few concepts that are highly connected and became central concepts in the ontology. One example for such a central concept is “Task”, where schedule, asset, method, role and risk all come together. Some other properties are connected indirectly (e.g., plant data via asset, persons or teams via role). This ensures that no unnecessary connections are established that would undermine the “single point of truth” approach and lead to inconsistent data.

The third step was the evaluation of the applicability by thinking through concrete decommissioning projects or tasks. It was, each time, evaluated by the workshop participants whether the structure allowed to describe all necessary facts and connections. In a second part of the evaluation step, the participants investigated, whether the structure was in contradiction with their own organization’s structure.

A fourth step involved discussions outside the participants of this work package. This included presentations to and discussions with external domain experts with knowledge within measurements, waste management, and decommissioning knowledge management, for example from the OECD-NEA, IAEA and a working group of the IAEA, EU and OECD-NEA. The latter was deemed very important as this working group has the complementary task to develop a common understanding on decommissioning. This approach was limited by the differing aims of the ontologies (knowledge management for decommissioning vs. management of decommissioning projects/activities/programmes).

3.1.1. Re-Using common ontologies

It was clear at a very early stage, that existing ontologies shall be reused to the maximum extend, not only in order to save time and effort, but also in order to ensure compatibility. Any part of the ontology that will address concepts that already exist, will reuse the existing related standard ontologies and taxonomies.

The most prominent part thereof will be the usage of Industry Foundation Classes (IFC) in the form of the OpenBIM standard. It is essential not to redefine any of its core parts in order to ensure later compatibility with standard BIM tools. However, it also became clear that for example the existing provisions to integrate radiological data, such as contamination, are not commensurate with the level of detail necessary within the PLEIADES approach. Thus, this standard will have to be complemented by elements that are specific for nuclear decommissioning projects, such as the operational purpose of the structures, systems and components (SSCs) and other nuclear plant specific data from different phases of the plant's lifecycle.

Any metadata in documents resulting from this task (including the ontology itself) will use the Dublin Core schema. This ensures the possibility to import and export and re-use bibliographical information.

Elements of the PLEIADES ontology related to persons and organisations will be based on the friend of a friend (foaf) schema to ensure compatibility to information on persons and organizations e.g., in social networks and company wide information portals.

In addition, parallel to the development of this ontology, a broad effort was undertaken to align the PLEIADES ontology approach with that of a common working group of IAEA, EU and OECD-NEA which has the aim to elaborate a common ontology and terminology for decommissioning. Such compatibility make it possible to retrieve suitable regulatory, case study and technology information from the knowledge repositories and communities of practice of these organizations.

3.1.2. Development of ontology

Originally it was intended to mainly re-use the concepts and ontologies that have been defined inside the existing software tools (by the consortium member organisations). However, it turned out that these ontologies were in most cases unavailable in an abstract level and were rather directly encoded in the tools. As most of the software packages have different evolutionary development processes and a histories, the ontologies have not been defined in a similar way. Nevertheless, it was concluded that the ontological approach is needed to define the interfaces between the software packages and to ensure a common understanding of the overall decommissioning process and its terminologies.

The ontology development was supported by a series of approximately biweekly workshops lasting from October 2020 to March 2021. During this time, the domain experts discussed the concepts, the relations between the concepts and the terminology. Subclasses and sub-concepts were used to foster common understanding. Two larger workshops, involving relevant personnel from the partner organisations were held for discussing the topics of measurements and waste management.

For the measurement ontology, besides (Barcellos, Fablo, Frauches 2014), a major resource was the VIM (*International vocabulary of metrology – Basic and general concepts and associated terms* 2012) which served as a resource for both terms and their relationships.

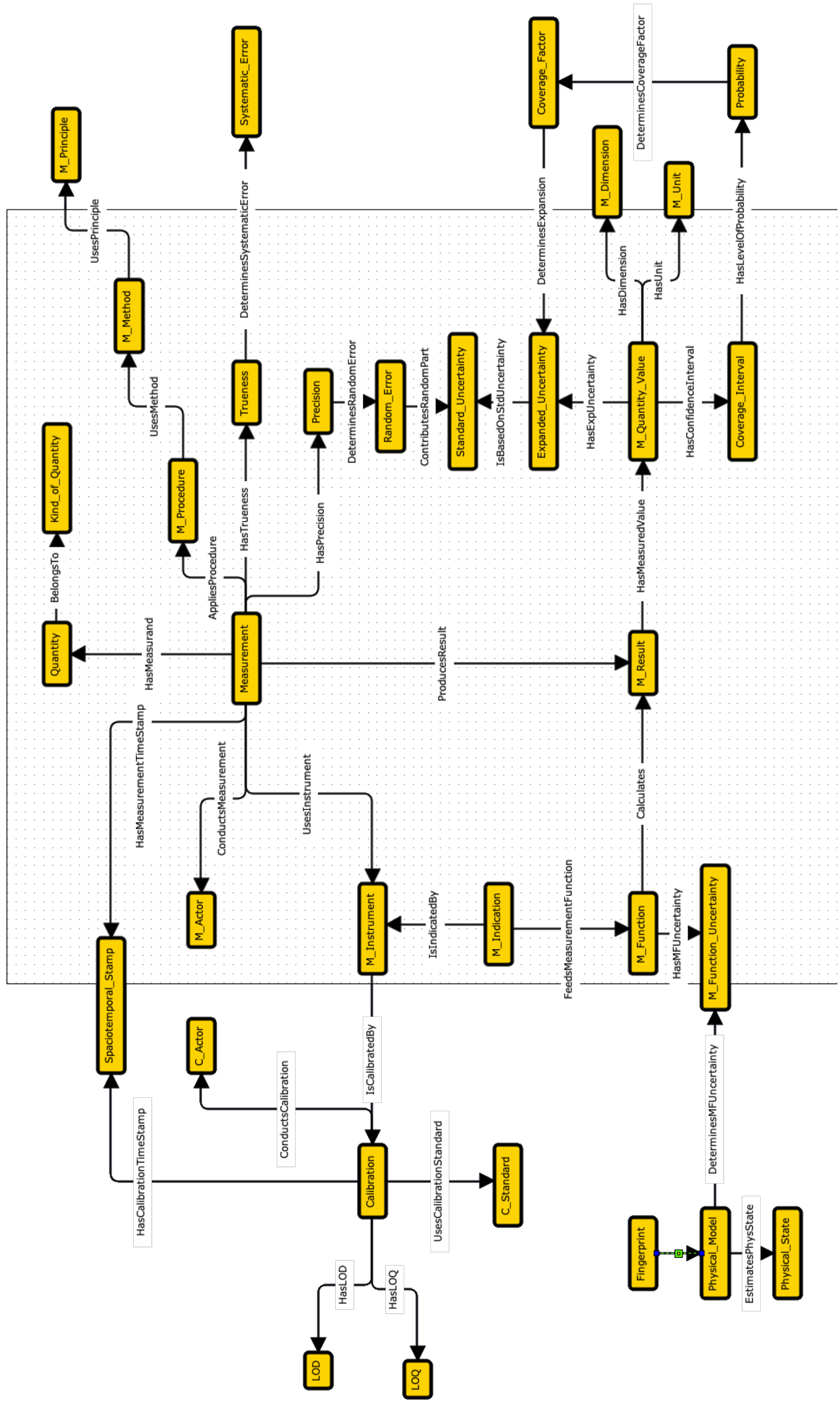

Figure 2: Draft measurement ontology

It was concluded, in general project discussions, that, for measurements, level of detail in Figure 2 may be necessary to properly address all features of measurements and that these are important, especially, when the measurements are used a basis for decisions during the decommissioning process. However, the level of detail needs to be reduced in the Decom Core

Ontology. A reduced version of the measurement ontology was then introduced into the Decom Core Ontology draft shown in Figure 4.

In the same manner, an ontology for the description of waste management was discussed, established, vetted and adapted throughout an internal PLEIADES workshop.

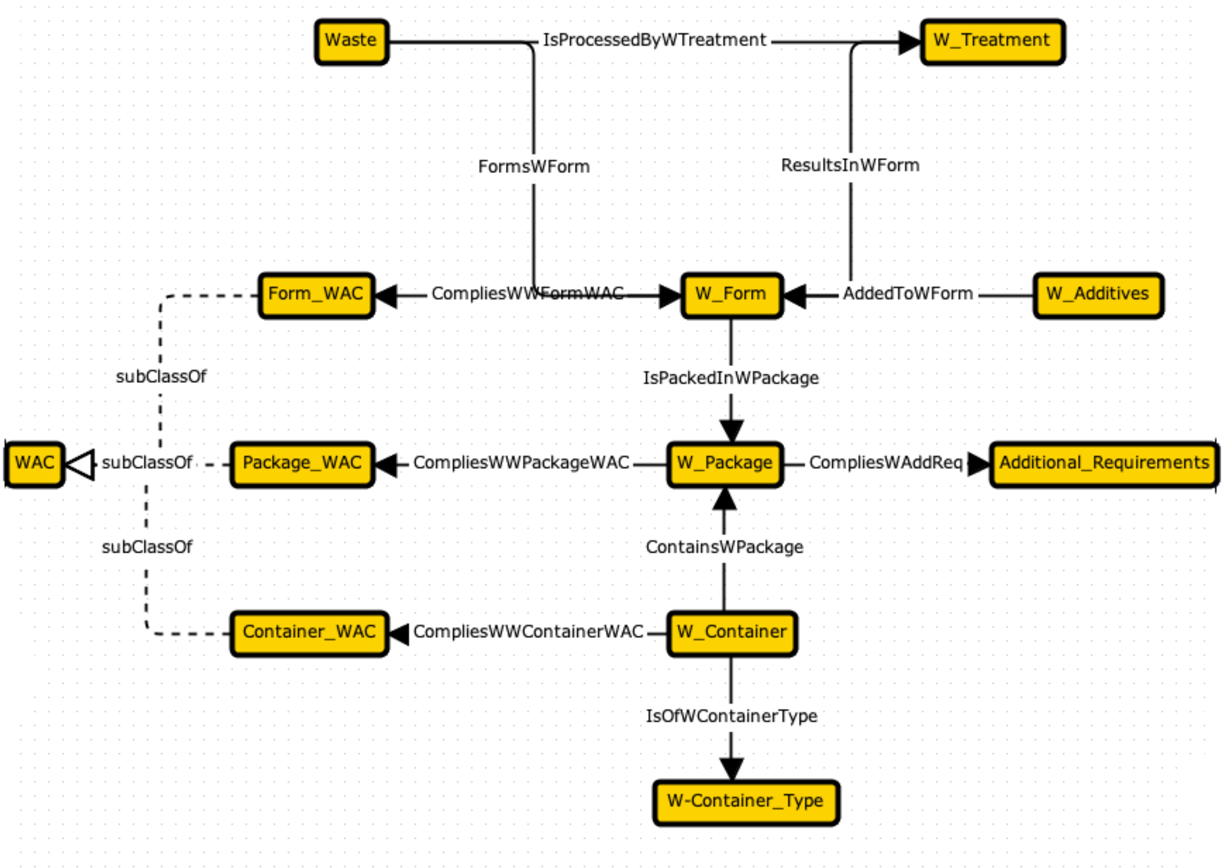

Figure 3: Waste management ontology

In further discussions, it was concluded that waste disposal will be excluded from the scope of this project, as it is not in the realm of the considered software solutions.

The concepts in the partial ontologies on measurements and waste management can be mapped against (integrated with) the concepts in the Decom Core Ontology.

Discussions led to a further abstraction of the ontology. It was concluded that Industry Foundation Class (IFC) classification, as well as the operation-based classifications in SSCs (structures systems and components) will be properties describing the concept of assets. It was further concluded that parts (e.g., fragments) of SSCs (different than subcomponents of larger SSCs represented as daughter SSCs) will be called “part”-s (e.g. fragments of a reactor vessel resulting from cutting into smaller pieces). This “part” concept inherits the properties from the parent concepts (e.g., the IFC localisation and structure and the SSC origin). This way, the properties important for defining waste pathways for the part are preserved. Such inherited properties can for example include information on activation determined by its operational origin as part of an SSC (for example the core internals of a reactor), but also contamination determined by its location in a certain place of the building (in this example the reactor cavity) with known contamination levels. As the part inherits these properties, it also passes them into its further phases towards final disposal e.g., as part of a waste package. Furthermore, any part can be part of any other part, so that also the content of a waste container can be described consistently as a part, comprising several other parts with their inherited properties. This way, each item can, in parts, be followed throughout the whole decommissioning project, from disassembly or dismantling from its origin SSC until the emplacement in a waste disposal container. The outcome of this process was a draft ontology, shown in Figure 4.

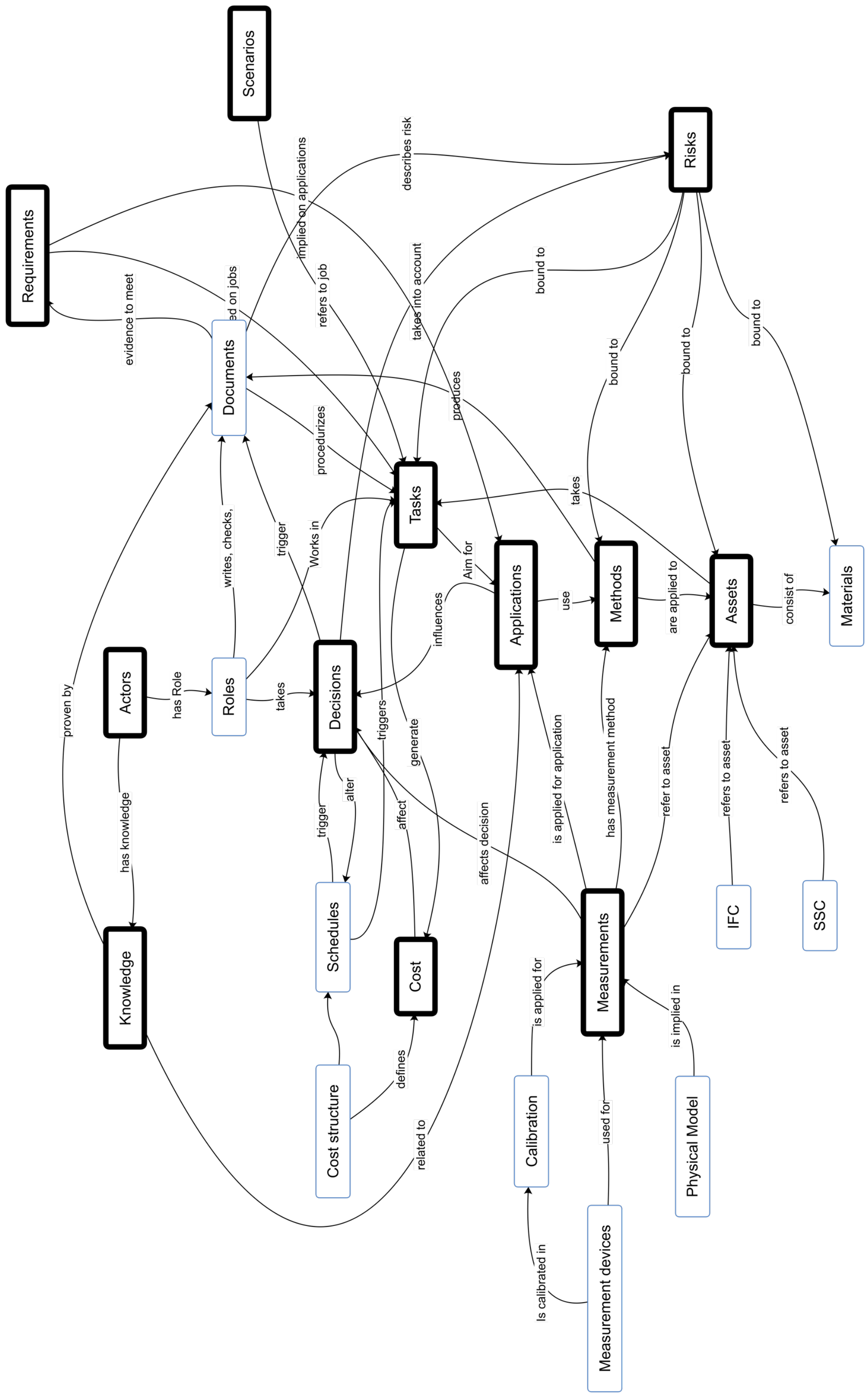

Figure 4: Draft Decom Core Ontology

The draft ontology was vetted with a wider audience at two additional workshops, one being part of the DigiDecom 2021 workshop and one specific open workshop for the development of the Decom Core Ontology.

In the Digidecom workshop, a MURAL (tool providing a digital workspace for on-line interactived collaboration) session was conducted in 3 steps:

- Brainstorming of thoughts about an international Decom Core Ontology
- Sorting the thoughts into Capabilities, Requirements, KPIs, Enablers and Blockers
- Voting about the importance of the remarks

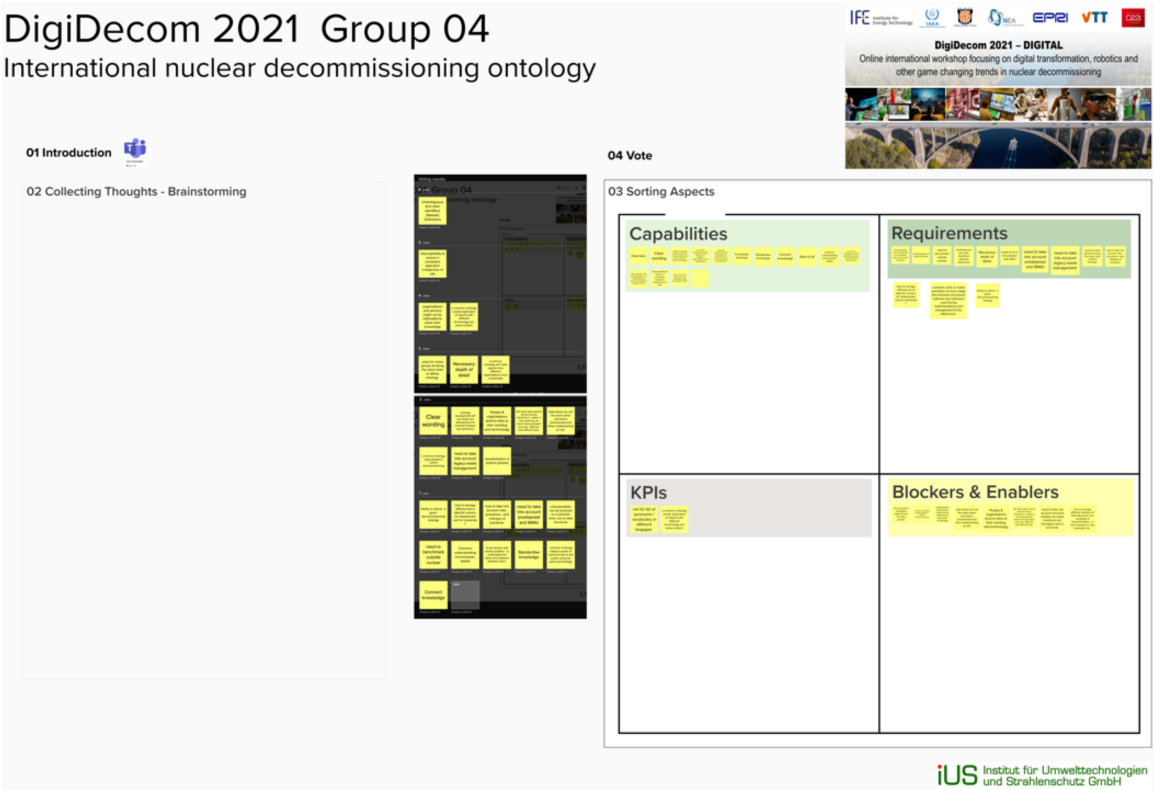

Figure 5: Snapshot from the result of the Mural session from DigiDecom 2021

The following remarks were made (in the order of the number of votes for each remark, for those with at least two votes):

<u>Capabilities:</u>

- Capability to ensure a consistent approach, irrespective of the site
- A common ontology will make the reports of different organizations more comparable
- Clear wording
- Common ontology development will also foster the development of common thesauri and definitions

<u>Requirements:</u>

- Unambiguous and clear definitions of terms and concepts
- Standardization of systems globally
- Interoperability on semantic, not on term level
- Necessary depth of detail to be defined
- Diversity of domain experts to represent the complete value chain
- Need to consider legacy waste management

KPIs:

- Avoidance of duplicate reports due to different terms used, but with similar content

Blockers & Enablers

- Organizations and persons might not be prepared to share knowledge
- Organizations and persons tend to stick to their own wording
- A common ontology urges people to rethink decommissioning
- Besides wording, also the data definitions and data usage might be different within the industry
- Data might change between inventorying and implementation

Some of the remarks are pointing more in the direction of the implementation of the ontology than on its elaboration. Others are more focussed on the international collaboration between the organizations than in the direction of the PLEIADES project.

The most important aspects to be considered for the development inside PLEIADES were:

1. Necessity to define terms and concepts (and agree on these beyond PLEIADES)
2. Interoperability on semantic level, not on term level will be key
3. Ensure the diversity of experts involved in order to ensure also compatibility with other areas, e.g. waste management, even if they are not actively included at this stage
4. Don't underestimate resistance (of experts and organisations with regard to change)

As a second step, the draft ontology was discussed in a dedicated workshop where various experts from IAEA, OECD-NEA and EU, complemented participants from the consortium representing operators, TSOs, research organisations, and contractors. A total of 24 participants took part in this workshop.

Once again, a Mural session has been used to collect input from the audience.

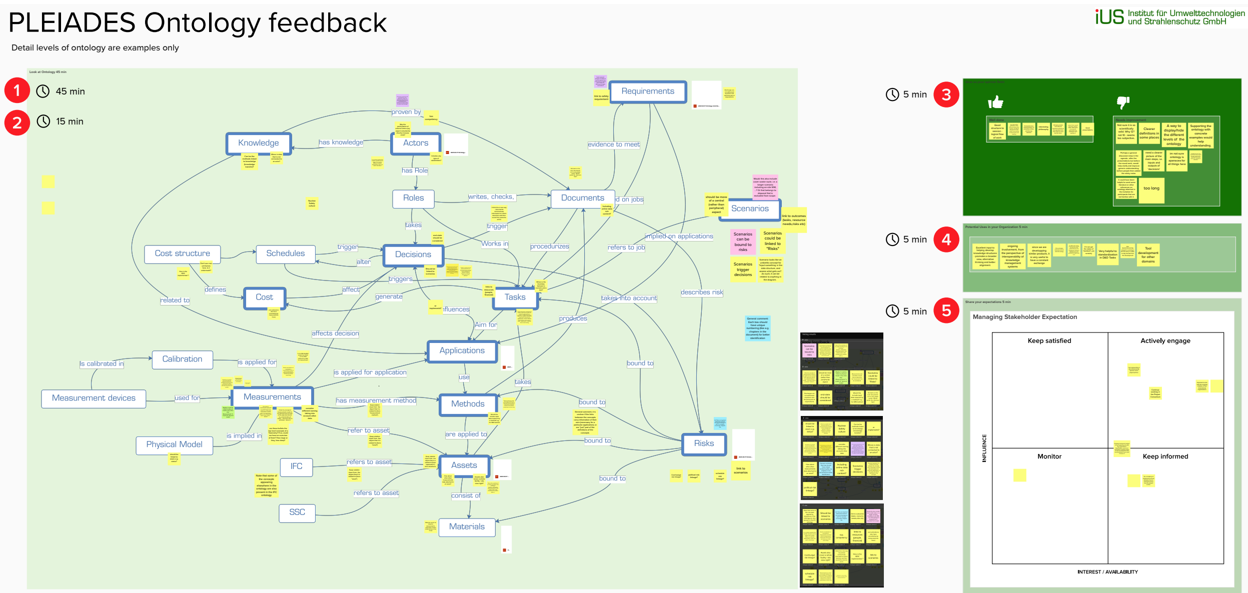

Figure 6: Snapshot from the Mural session results

The MURAL session consisted of 5 steps

1. Review of the ontology by inserting remarks as labels close to the related concepts (see Figure 6)
2. Voting on the remarks (using the voting functionality provided by the software) in order to prioritize feedback
3. General feedback on the methodology
4. Potential uses at the participants' organizations
5. Gathering stakeholder expectations

Some of the feedback made clear that more explanation would have been necessary in advance, as some concepts were not clearly understood by the participants. The following feedback has been distilled from the answers:

- The partial ontology on measurements is too detailed on top level, and other aspects may be important with regards to plant data.
- Some terms caused misunderstandings, "documents" had been understood in the sense of the ISO 900x series, but was interpreted as paper-centric by some participants
- Identification of concepts that allow different terms for the same concept is important
- Some remarks were rather addressing the formal presentation (keep relations free from the object they are pointing to – with regards to the naming of properties).
- Additional remarks pointed out that further simplification would be necessary.

Remarks from the participants of the workshop were addressed in an internal follow-up session and led to a modified ontology model (shown in Figure 7), slightly simplified compared to the starting point (shown in Figure 4).

3.2. Definition of Terms

In order to ensure a common understanding of the main concepts the terms need to be properly defined. Wherever possible we used existing definitions either by the IAEA Safety Glossary 2018 or other international or national standards. This ensures that we do not implement definitions that cause difficulties at a later stage and ensures a broad consensus on terms used.

3.2.1. Requirement

Requirement (safety): established or required by the Fundamental Safety Principles (IAEA Safety Fundamentals) or IAEA Safety Requirements publications or by (national or international) laws or regulations [IAEA Safety Glossary 2018]

Requirement: A need or expectation that is stated, generally implied or obligatory [ISO 9000]

> Note 1 to entry: "Generally implied" means that it is custom or common practice for the organization (3.2.1) and interested parties (3.2.3) that the need or expectation under consideration is implied.
>
> Note 2 to entry: A specified requirement is one that is stated, for example in documented information (3.8.6).
>
> Note 3 to entry: A qualifier can be used to denote a specific type of requirement, e.g. product (3.7.6) requirement, quality management (3.3.4) requirement, customer (3.2.4) requirement, quality requirement (3.6.5).

Note 4 to entry: Requirements can be generated by different interested parties or by the organization itself.

Note 5 to entry: It can be necessary for achieving high customer satisfaction (3.9.2) to fulfil an expectation of a customer even if it is neither stated nor generally implied or obligatory.

Note 6 to entry: This constitutes one of the common terms and core definitions for ISO management system standards given in Annex SL of the Consolidated ISO Supplement to the ISO/IEC Directives, Part 1. The original definition has been modified by adding Notes 3 to 5 to entry.

3.2.2. Decision

A decision is the informed choice between at least two options (one of them may be keeping the status quo) by a management entity. An informed decision includes an analysis of the required inputs/resources and the desired output and side effects. This analysis may comprise, but is not limited to risk assessment, cost-benefit analysis, probabilistic or statistical assessments and considerations about the influence on the schedule. Frameworks, such as the IRIDIM process may be used especially for safety related design decisions. Decision making should also include taking into account possible biases that are caused by the organization or the decision-making entity. [PLEIADES consortium]

3.2.3. Application

A use to which something is put [Merriam-Websters]

The general purpose or aim of a task in the process of achieving the decommissioning end state [PLEIADES consortium]

3.2.4. Method

Method: a procedure or process for attaining an objective: such as a systematic procedure, technique, or mode of inquiry employed by or proper to a particular discipline or art [Merriam-Websters]

Method: a procedure or process for attaining an object or objective, such as a systematic process, procedure, technique, application of a technology or methodology or tool. [PLEIADES consortium]

3.2.5. Asset

Asset: Item, thing or entity that has a potential or actual value to an organization [ISO 55000]

Note 1 to entry: Value can be tangible or intangible, financial or non-financial, and includes consideration of risks

Note 2 to entry: Physical assets usually refer to equipment, inventory and properties owned by the organization. Physical assets are the opposite of intangible assets, which are non-physical assets such as leases, brands, digital assets, use rights, licences, intellectual property rights, reputation or agreements.

Note 3 to entry: A grouping of assets referred to as an asset system (3.2.5) could also be considered as an asset.

Synonyms: Object, entity, item: anything perceivable or conceivable. [ISO 1087-1]

Note 1 to entry: Objects can be material (e.g. an engine, a sheet of paper, a diamond), non-material (e.g. conversion ratio, a project plan) or imagined (e.g. the future state of the organization).

3.2.6. Material

(1): The elements, constituents, or substances of which something is composed or can be made

(2): Matter that has qualities which give it individuality and by which it may be categorized

[Merriam-Websters]

3.2.7. Task

Element (of project management) describing a process with defined beginning and end [DIN 69900]

Synonym: activity: smallest identified object of work in a project [ISO 10006]

3.2.8. Scenario

A scenario is a postulated or assumed set of conditions. A scenario may represent the conditions at a single point in time or a single event or a time history of conditions and/or events.

[IAEA Safety Glossary 2018]

The latter is the meaning that is mostly used in the PLEIADES context: A possible sequence of tasks in order to achieve a certain goal. By comparison of several scenarios (e.g. different sequences of tasks or different tasks to achieve the same goal), optimization can be achieved.

3.2.9. Actor

Actively acting person, team or organization, comprising but not limited to operators, service providers, regulators, interested parties.

An organization or team is a person or group of people that has its own functions with responsibilities, authorities and relationships to achieve its objectives. [ISO 55000]

3.2.10. Role

Role: a function or part performed especially in a particular operation or process [Merriam-Websters]

3.2.11. Document

Information and the medium on which it is contained [ISO 9000]

EXAMPLE:

Record, specification, procedure document, drawing, report, standard.

Note 1 to entry: The medium can be paper, magnetic, electronic or optical computer disc, photograph or master sample, or combination of these.

Note 2 to entry: A set of documents, for example specifications and records, is frequently called “documentation”.

Note 3 to entry: Some requirements (e.g. the requirement to be readable) relate to all types of documents. However, there can be different requirements for specifications (e.g. the requirement to be revision controlled) and for records (e.g. the requirement to be retrievable).

3.2.12. Risk

Effect of uncertainty on objectives [ISO 31000]

Note 1 to entry: An effect is a deviation from the expected — positive and/or negative.

Note 2 to entry: Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process).

Note 3 to entry: Risk is often characterized by reference to potential events (2.17) and consequences (2.18), or a combination of these.

Note 4 to entry: Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood (2.19) of occurrence / effect of uncertainty on objectives

3.2.13. Plant Data

Plant data: A set of values describing the physical, chemical or radiological state of a plant or its parts. Plant data comprises measurements, understood as a process to determine a value. Thus, measurements comprise not only chemical, physical and radiological measurements, but also calculations, estimations and observations. [PLEIADES consortium]

3.3. Structure of the ontology

As a result of the external review and the following internal review of the ontology, an updated version has been derived from the preliminary ontology.

3.3.1. Top level

The following graph shows the Decom Core Ontology, as agreed upon by the participants of task 1.4.

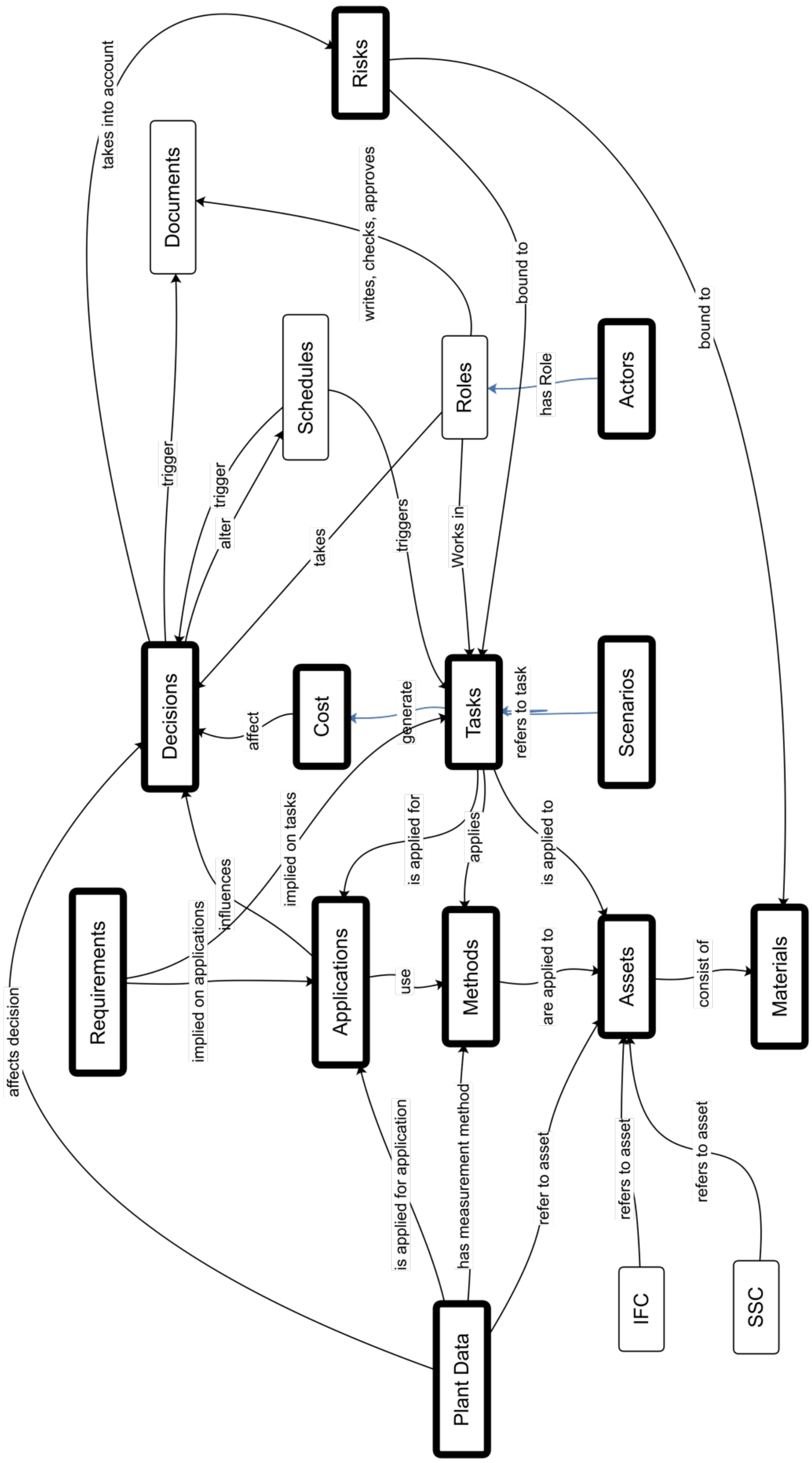

Figure 7: Final Decom Core Ontology

3.3.2. Subclasses

The subclasses have not been fully developed within the Decom Core Ontology as this goes beyond the scope of task 1.4. The subclasses shown in the following have been derived as examples to help understanding the concepts of the top-level classes. It was not the goal to develop complete and concise subclasses at this stage of the project, but rather finding a common understanding of the foreseen content of the subclasses.

3.3.2.1. Requirements

As the definition of 'Requirements' (3.2.1) shows, these are mainly boundary conditions or expectations from the outside. In a highly regulated environment like the nuclear power industry, these consist mainly of direct regulations, but also of industry standards and waste management requirements (which are a complex set on their own). The examples shown mainly refer to EU and German regulations.

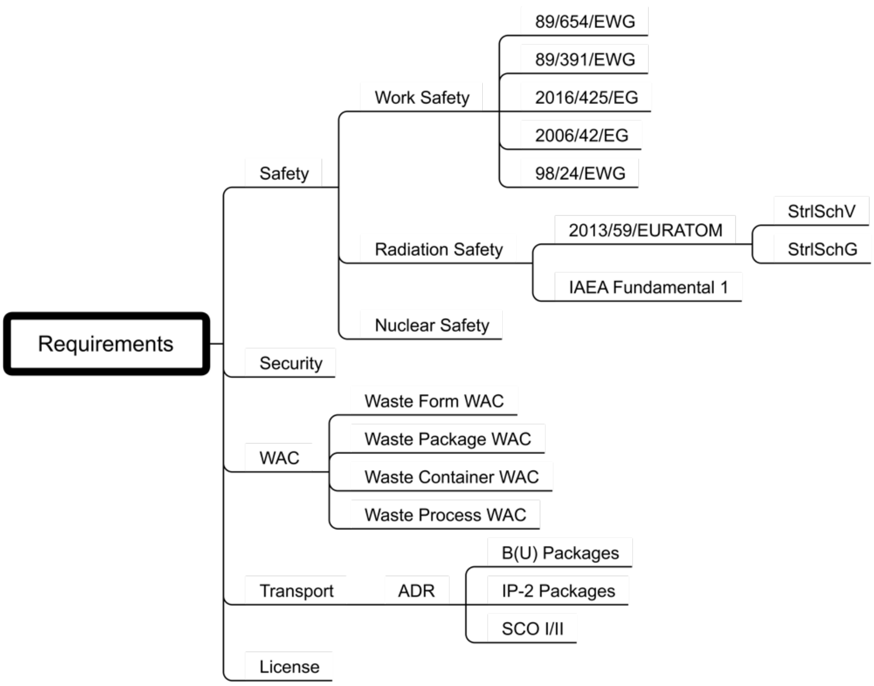

Figure 8: Subclasses of Requirements

3.3.2.2. Applications

Applications (see definition in chapter 3.2.3) are sorting criteria to order tasks to broader aims and subgoals of decommissioning. The main feature of this class is to find applicable methods, examples and experiences for a certain task without prejudicing the method to be used. We have concluded that there is a very limited number of general tasks (Management, Decommissioning, Remediation, Waste Management) that are used to drive the decommissioning project from start to end state. Besides these specific tasks there are a number of general (not decommissioning specific) tasks that are used for various purposes, such as cutting, characterization or decontamination. Applications is a descriptive concept linked to methods and tasks as an aggregation and filtering property.

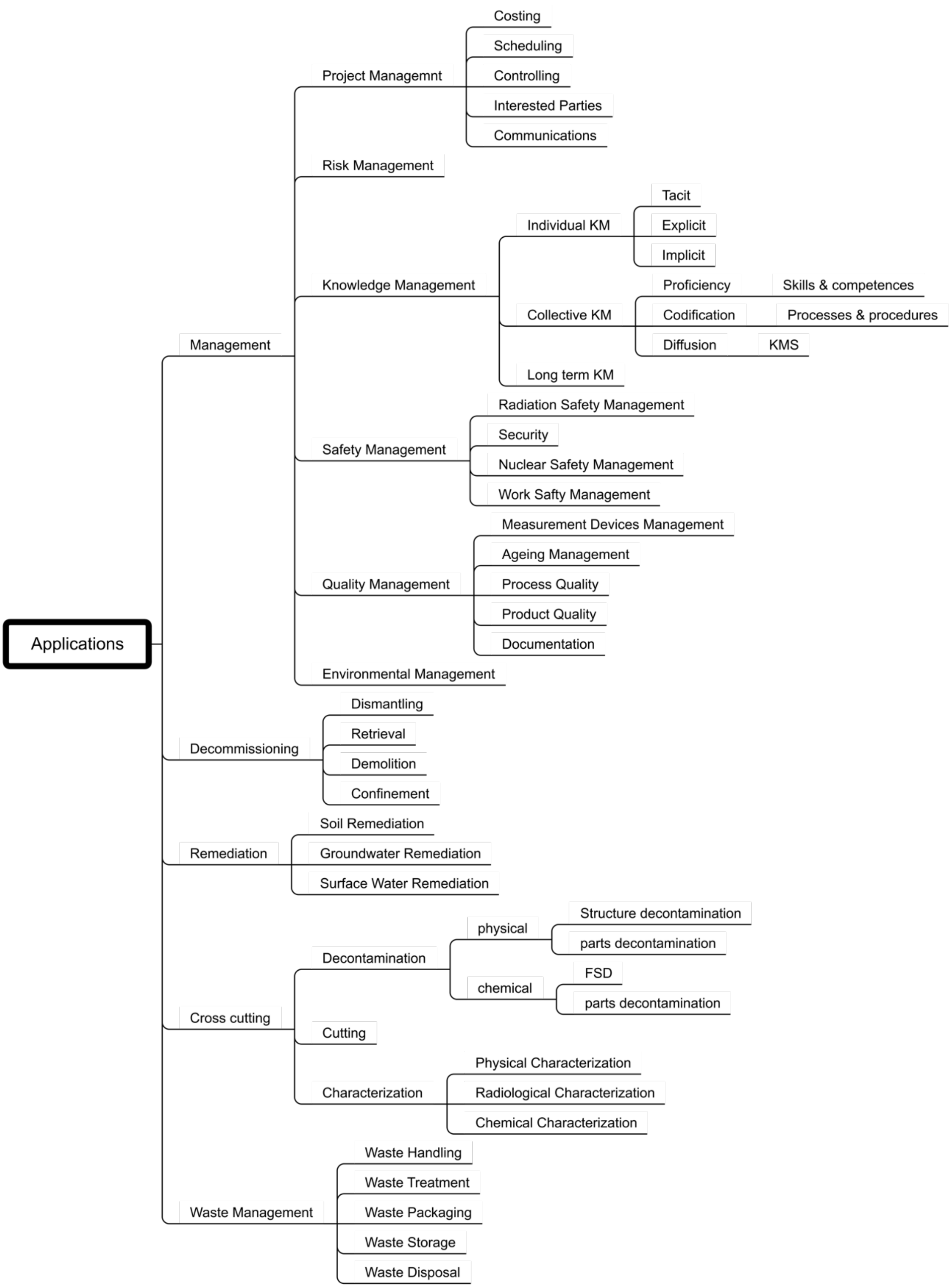

Figure 9: Subclasses of Applications

3.3.2.3. Methods

Methods (see definition in chapter 3.2.4) follow the same subclass-structure than Applications, but, while these remain on a general level, the Methods can be very specific. Usually, there will be a number of methods for each application (1 to n relation). The purpose of methods is to have a class describing the processes applied to implement the tasks.

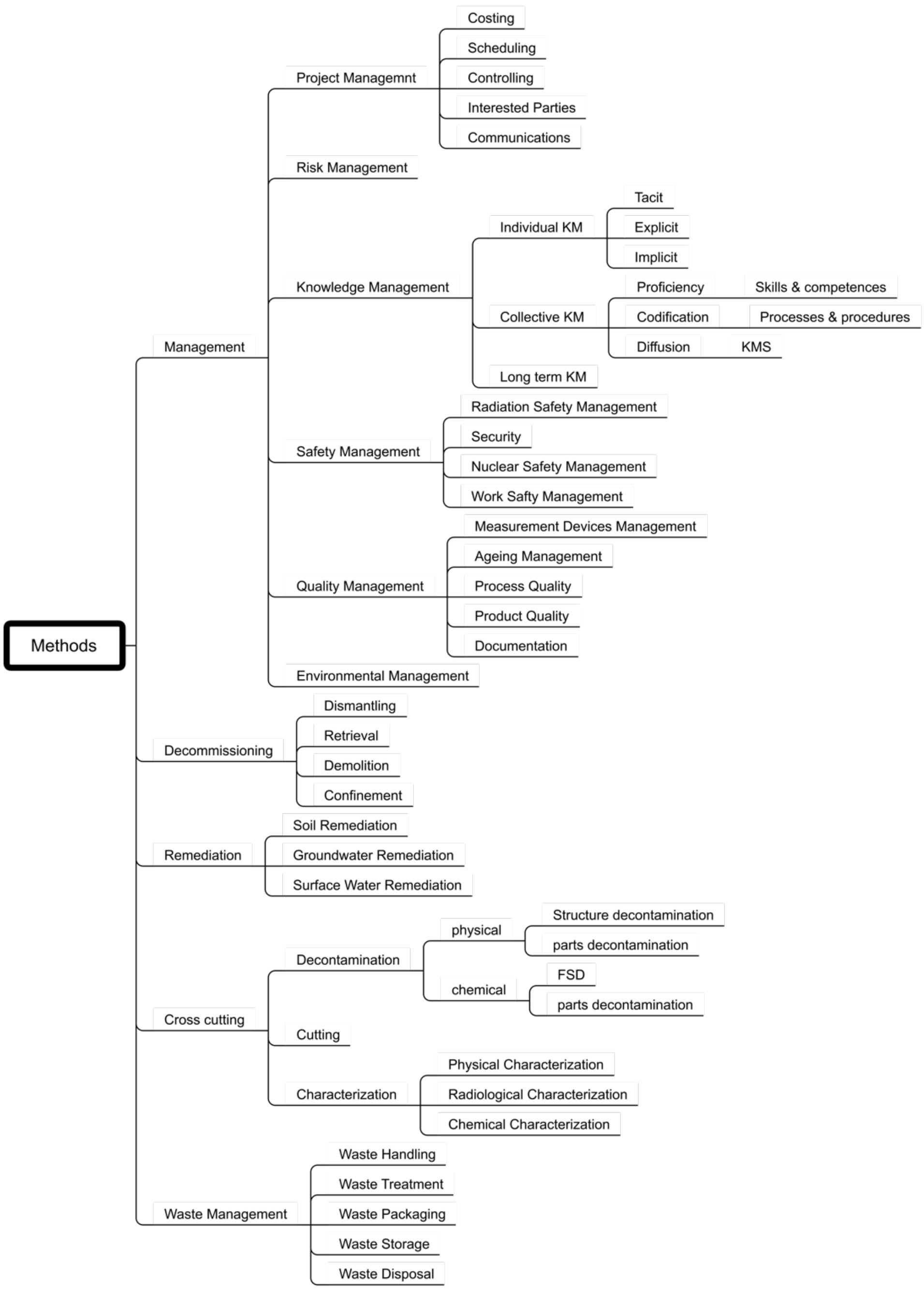

Figure 10: Subclasses of Methods

3.3.2.4. Assets

Assets (see definition in chapter 3.2.5) are one of the central concepts, describing everything being of (positive or negative) value for the organization. This comprises tangible and intangible goods. For the tangibles, the Part concept is important as it comprises all parts being dismantled from the plant (see explanation in chapter 3.1.2).

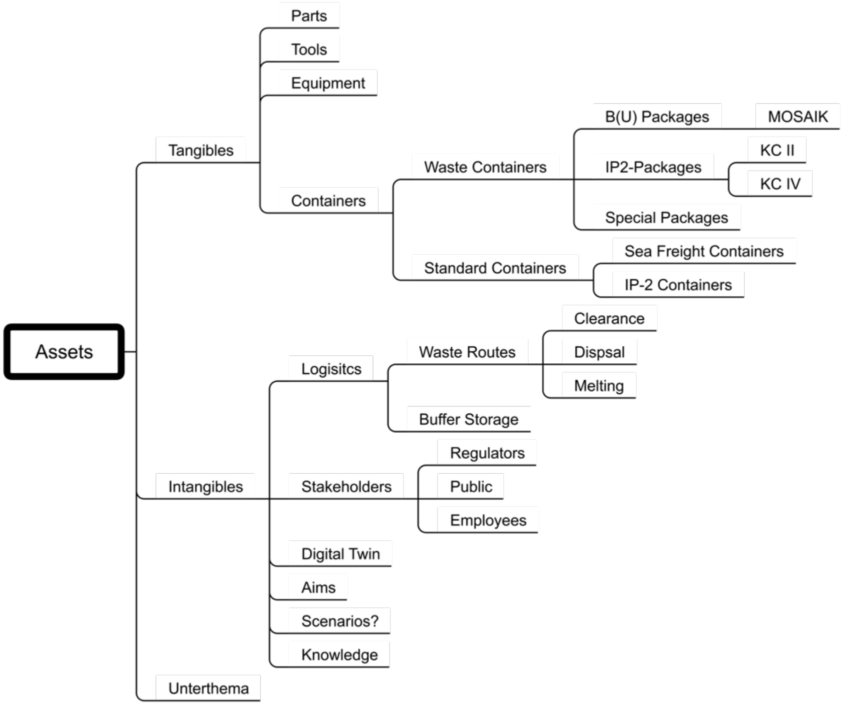

Figure 11: Subclasses of Assets

3.3.2.5. Materials

Materials (see definition in chapter 3.2.6) are a concept describing what things, especially parts are made of. This includes ingredients that determine the nature and the pathway of the parts, such as the nuclide vector or the polychlorinated biphenyl (PCB) content. The Material concept is a descriptive concept, that is linked to assets as a property.

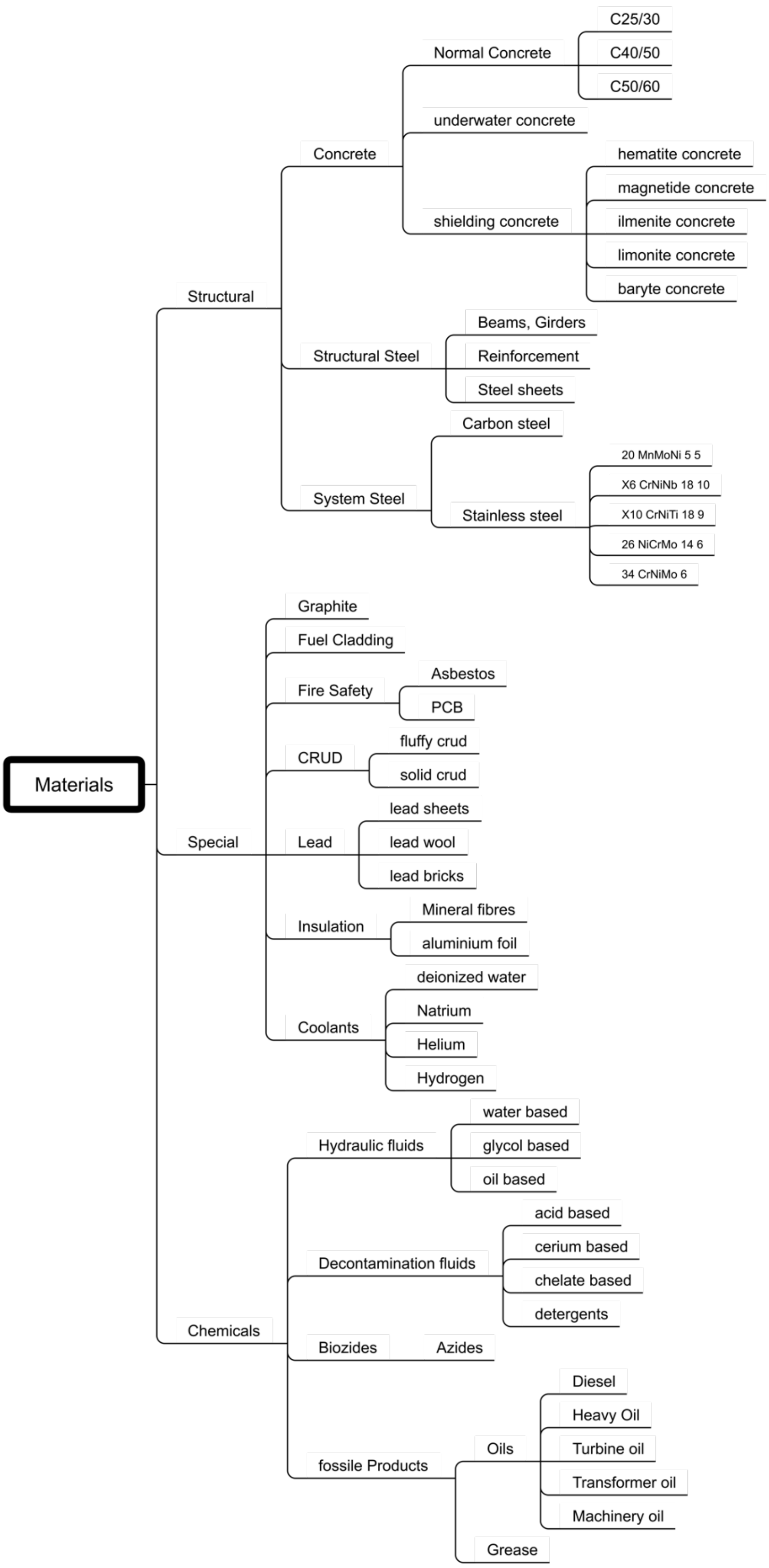

Figure 12: Subclasses of Materials

3.3.2.6. Risks

Risks (see definition in chapter 3.2.12) comprises a concept linked to tasks, materials, decisions. The subclass structure follows (IAEA 2019).

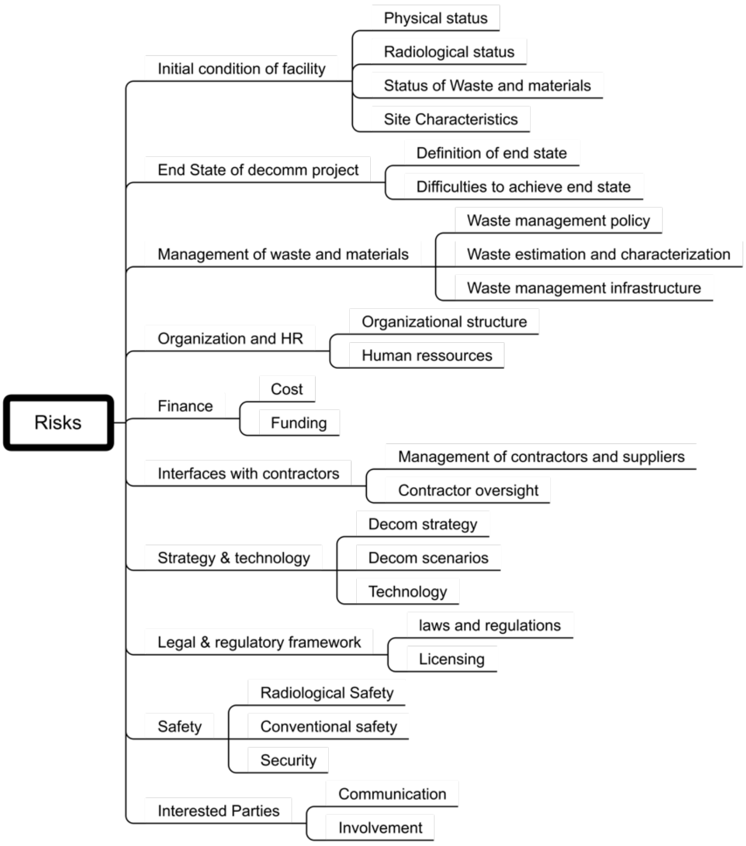

Figure 13: Subclasses of Risks

3.3.2.7. Actors

The concept actor (see definition in chapter 3.2.9) is implemented via a role model. This allows the different actors to act independently in various roles.

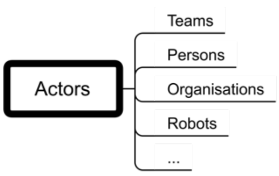

Figure 14: Subclasses of Actors

3.4. Used tools

3.4.1. Protégé

In the first approach to formalization, the ontology design was addressed suing the freeware tool Protégé from the medical labs at Stanford. The tool allows the design of ontologies and their formalization. Although Protégé is usually considered to be the standard application for ontology engineering, we encountered some drawbacks: The server version and the standalone version of the tool deliver slightly different formats and boundary condition, making it difficult to exchange versions between the participants. Also, some restrictions were encountered when defining properties, as these need to have unique names. In other ontology tools, this is solved by applying a label to a property with a unique ID. In these cases, several IDs can have the same label, but still are distinguished by their ID.

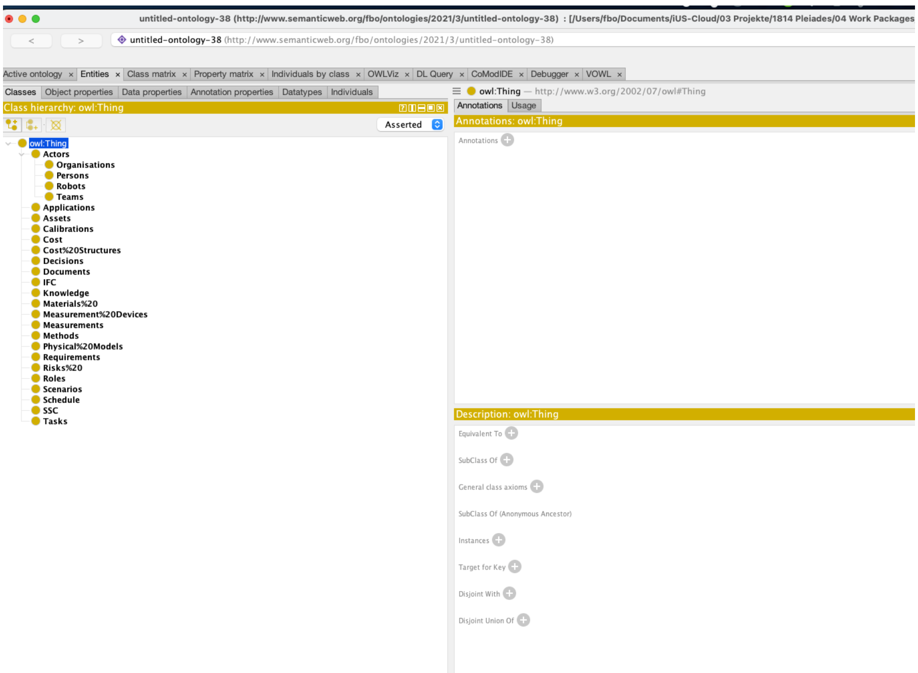

Figure 15: Protégé view of the class definitions

Figure 16: Screenshot of the VOWL viewer in Protégé

3.4.2. Vocbench

In the next step, we tested the Vocbench software developed by the University of Rome in an EU project. This server-based software allowed us to use an SKOS approach in a sound implementation, allowing, for instance, translations and definitions to be integrated into the ontology framework. This makes exchange with other partners easier. In addition, the software allows to assign separate prefabricated roles to any user and enables a process for the development of the ontology that takes into account that not all users have the same capabilities and responsibilities. Further, this software tool has proven to be fully compatible with the format and software (poolparty) used by the joint working group mentioned. This will, on the longer perspective, allow us to reuse parts of the definitions and thesauri developed by the IAEA.

Vocbench has currently been installed on a test server for the project. After the finalization of the tests, the server will be shared with the participants of PLEIADES to ensure access to the ontology at any time. This access can then be used to contribute to the further development of the ontology, but also to have the possibility to look up translations, synonyms and definitions.

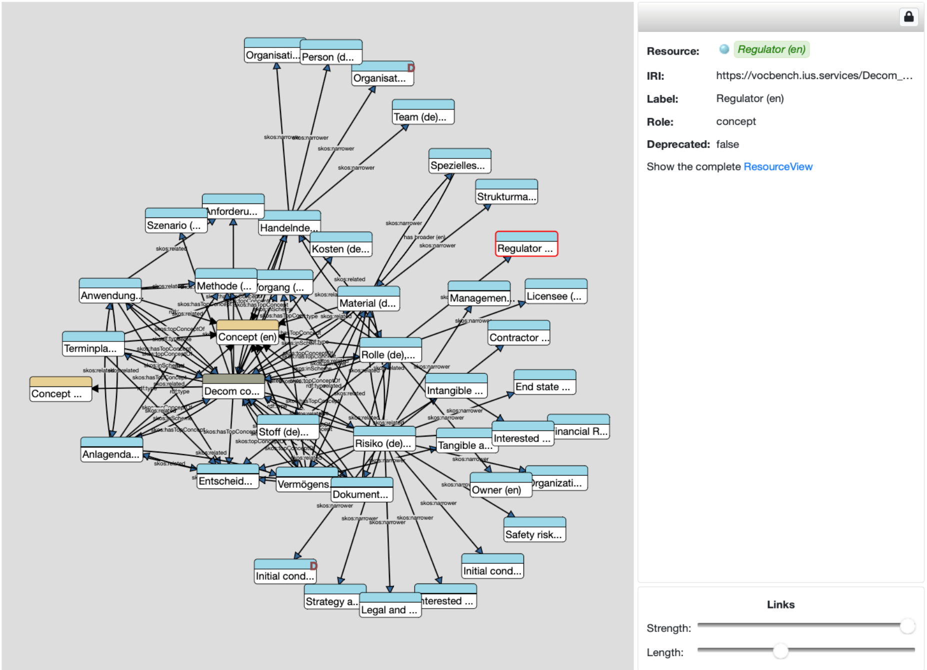

Figure 17: Ontology graph from Vocbench (German translation)

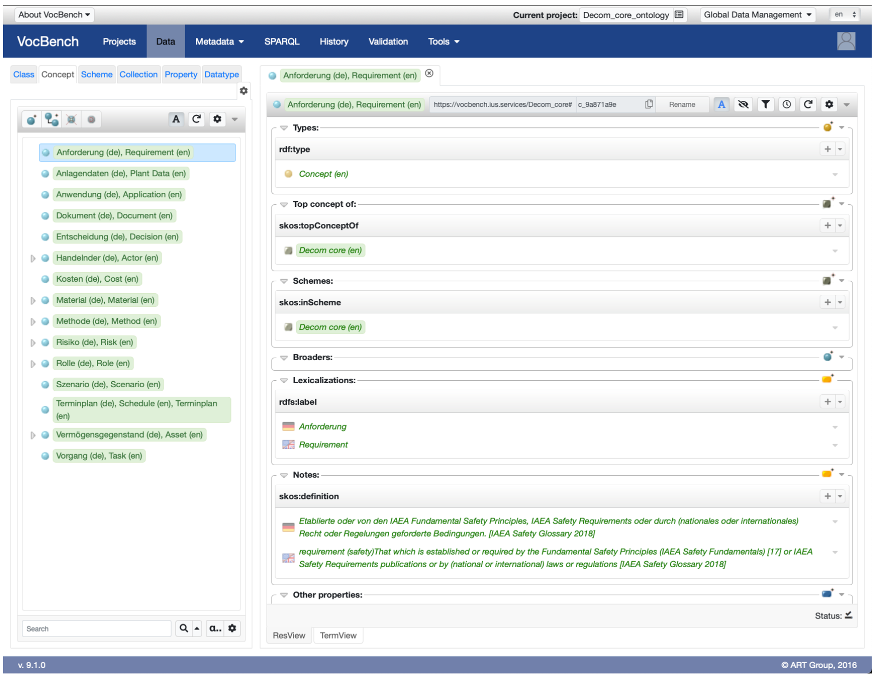

Figure 18: Vocbench screenshot for the SKOS model

3.4.3. IFE tool

To enable users to visualize the ontology and transform it into other formats (like the JSON schema used in Task 1.3) IFE developed a web-based Ontology Editor called SHISHO. This Knowledge Based System allows to read the OWL files created in Protegee and create an interactive force directed-graph.

3.5. Agreed version of the ontology

The agreed version of the ontology is depicted in chapter 3.3, Figure 7. It will be formally adopted by the general assembly.

4. Further research

4.1. System designs

Developing a system design for implementing the decommissioning ontology in the data centric BIM based system to be prototyped in this project has started as part of WP2 of the projects supported by further developments in task 1.3 in WP1. This work will have specific focus on system design that will take advantage of the ontology from this task for ultimately resulting in demonstration of a prototype software ecosystem connected via this ontology in realistic use-cases.

4.2. Implementation testing

After the development of the Core Decom Ontology the main classes, subclasses and their relationships by means of properties were defined. The structure was validated by expert ratings in workshops attended by a cross disciplinary team including representatives from international organisations.

As previously outlined, implementation of the prototype PLEIADES software platform will deliver valuable feedback to the underlying ontology. This feedback concerns the hierarchical architecture of the ontology, the flow (laterality) of data items between classes and validity of the included data types.

It is therefore planned to design a basic ontology testing system that ensures:

structural integrity of hierarchy and relations integrity to avoid lacks or ambiguous definitions in thesauri or language labels

- generic integrity of URI and other resources

All the above is integrated in the Vocbench server software (section 3.4.2), that is used to store the ontology and perform validation after modification.

The next level of implementation testing will include the conversion of the ontology structure into a data structure enabling semantic queries in a knowledge management system (KM). Similar to continuous integration in software development, this will enable automatic setup of a new semantic KM system based on the modified ontology and prefilled with specific data that allows to test the consistency by rules and constraints.

4.3. Risks and uncertainties

The most important risk identified at start, namely the risk for developing an ontology completely separated from the international community, has been addressed by the close cooperation with the related joint working group of IAEA, EU and OECD-NEA.

Nevertheless, there is a risk that some parts of the community develop something that is not fully compatible to our approach, or that our approach is not recognized or accepted in the community. In order to prevent this, we will seek to actively disseminate the ontology on various levels, inter alia by publishing it in international journals and presenting it on international conferences. In parallel, we will keep the contact with the joint working group mentioned above and seek additional contacts to other important relevant players in the field.

4.4. Adaptation of the Ontology

The Decom Core Ontology is not intended to be a static, but a living document. The version described in this report will be the basis for the development of a first prototype. Therefore, a design freeze will be implemented at first, but then a recursive process will be re-installed to ensure that the necessities arising from the concrete implementation will find their way into the ontology. A dedicated quality assurance process will ensure that concepts are generalised and are applicable beyond a single software and that we keep the utmost compatibility with the international approaches in the field.

5. Bibliography

BARCELLOS, Monalessa, Ricardo FABLO und Vinícius FRAUCHES, 2014. *Towards a Measurement Ontology Pattern Language* [online]. Brazil. [Zugriff am: 9 Juni 2021]. Verfügbar unter: https://nemo.inf.ufes.br/wp-content/papercite-data/pdf/towards_a_measurement_ontology_pattern_language_2014.pdf

GÓMEZ-PÉREZ, Asunción, [kein Datum]. Ontology Engineering Methodologies. [online]. Präsentation. Madrid, Spain. [Zugriff am: 9 Juni 2021]. Verfügbar unter: http://kmi.open.ac.uk/events/iswc07-semantic-web-intro/pdf/4.%20Ontology%20Engineering%20Methodologies.pdf

GÓMEZ-PÉREZ, Asunción und Mari Carmen SUÁREZ-FIGUEROA, 2009. *NeOn Methodology for Building Ontology Networks: a Scenario-based Methodology* [online]. Madrid, Spain. [Zugriff am: 9 Juni 2021]. Verfügbar unter: https://www.researchgate.net/publication/49911337_NeOn_Methodology_for_Building_Ontology_Networks_a_Scenario-based_Methodology

GRUBER, T. R, 1995. Toward Principles for the Design of Ontologies Used for Knowledge Sharing. *nternational Journal Human-Computer Studies*. 1995. Bd. 1, Nr. 43(5–6), S. 907–928

GRÜNINGER, Michael und Mark FOX S., 1995. Methodology for the Design and Evaluation of Ontologies. In: *IJCAI-95*. Montreal. 13 April 1995

IAEA, 2019. SRS 97: *Management of project risks in decommissioning* [online]. Vienna: International Atomic Energy Agency. [Zugriff am: 9 Juni 2021]. Safety Report Series. Verfügbar unter: https://www.iaea.org/publications/12328/management-of-project-risks-in-decommissioning

IAEA, 2021. wiki. *Connect Nuclear Wiki* [online]. 2021. [Zugriff am: 26 Mai 2021]. Verfügbar unter: https://connect-nuclear-wiki.iaea.org/wiki/Main_Page

IQBAL, Rizwan, Masrah Azrifah Azmi MURAD, Aida MUSTAPHA und Nurfadhlina Mohd SHAREF, 2013. An Analysis of Ontology Engineering Methodologies: A Literature Review. *Research Journal of Applied Sciences, Engineering and Technology*. 2013. Bd. 6, S. 2993–3000. DOI 10.19026/rjaset.6.3684

JCGM 200:2012: *International vocabulary of metrology – Basic and general concepts and associated terms*, 2012. . JCGM

JONES, Dean, Trevor BENCH-CAPON und Pepijn VISSER, 1998. *Methodologies for Ontology Development* [online]. [Zugriff am: 9 Juni 2021]. Verfügbar unter: https://cgi.csc.liv.ac.uk/~tbc/publications/itknows.pdf

KEET, Maria, 2020. *An Introduction to Ontology Engineering* [online]. South Africa. [Zugriff am: 9 Juni 2021]. Verfügbar unter: https://people.cs.uct.ac.za/~mkeet/files/OEbook.pdf

KOTIS, Konstantinos I., George A. VOUROS und Dimitris SPILIOTOPOULOS, 2020. Ontology engineering methodologies for the evolution of living and reused ontologies: status, trends, findings and recommendations. CAMBRIDGE UNIVERSITY PRESS (Hrsg.), *The Knowledge*

Engineering Review [online]. 2020. Bd. 35, Nr. e4. [Zugriff am: 9 Juni 2021]. DOI 10.1017/S0269888920000065. Verfügbar unter: https://www.researchgate.net/publication/338946601_Ontology_engineering_methodologies_for_the_evolution_of_living_and_reused_ontologies_status_trends_findings_and_recommendations

LI, Zhanjun, Victor RASKIN und Karthik RAMANI, 2007. A Methodology of Engineering Ontology Development for Information Retrieval. In: *International Conference on Engineering Design* [online]. Paris, France. 28 August 2007. [Zugriff am: 9 Juni 2021]. Verfügbar unter: https://www.researchgate.net/publication/251390219_A_methodology_of_engineering_ontology_development_for_information_retrieval

PERONI, Silvio, 2016. *SAMOD: an agile methodology for the development of ontologies* [online]. figshare. [Zugriff am: 9 Juni 2021]. Verfügbar unter: https://figshare.com/articles/journal_contribution/SAMOD_an_agile_methodology_for_the_development_of_ontologies/3189769

PLEIADES CONSORTIUM, 2020. Home. *PLEIADES – Smarter Plant Decommissioning* [online]. 2020. [Zugriff am: 26 Mai 2021]. Verfügbar unter: https://pleiades-platform.eu/

USCHOLD, Michael, 2018. *Demystifying OWL for the enterprise*. Morgan and Claypool Publishers. Synthesis Lectures on the Semantic Web: Theory and Technology. ISBN 978-1-68173-128-5

VERTAN, Christina, 2003. Darstellung von Ontologien im Semantic Web- RDFS-. [online]. Präsentation. 2003. [Zugriff am: 9 Juni 2021]. Verfügbar unter: https://nats-www.informatik.uni-hamburg.de/pub/MSW/WebHome/ontologien.pdf

WELLER, Katrin, 2013. Ontologien. In: Rainer KUHLEN, Wolfgang SEMAR und Dietmar STRAUCH (Hrsg.), *Grundlagen der praktischen Information und Dokumentation*. 6. Berlin, Germany: De Gruyter Saur