ONTO COMMONS
ONTOLOGY-DRIVEN DATA DOCUMENTATION FOR INDUSTRY COMMONS

Report D3.10 “Report on the Second focused workshop on domain ontologies“

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Report D3.10 “Report on the Second focused workshop on domain ontologies“

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Glossary of terms and acronyms

Item	Description
IAOA	International Association for Ontology and its Applications.
ESWC	European Semantic Web Conference.
IOF	Industrial Ontology Foundry
FOMI	Formal Ontology Meets Industry

Keywords

Ontology; Data; Standardisation; Ontology; Industry; Wokshop; FOMI

Disclaimer

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Executive Summary

The focused workshop 3.2 was entitled *"Formal Ontologies Meet Industry"* which took place along with the eponymous workshop FOMI, 2022. was organised by École Nationale d'Ingénieurs de Tarbes at the institute's premises at Tarbes, France. By engaging with not only to FOMI workshop but also with Industrial Ontology Foundry, this workshop had opportunity to gain attendance of almost 100 participants from academia, industry, and research, majority of whom were also physically present at the venue and fostered a great deal of interactions. These activities helped the project to gather inputs from the community in the field of materials and manufacturing and disseminated the mission and vision of OntoCommons to them. In this document, many aspects of this event are described mainly focussing on the OntoCommons focus workshop on Day 2.

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1. Introduction

This deliverable reports on the second OntoCommons Focused Workshop (FW) on Industrial domain ontologies (Work Package 3), FW 3.1, belonging to Task 3.1, Networking and Consultation. The aim of this activity was to support the Semantic Landscape Analysis in the materials and manufacturing (MM) domain, and it targeted all interested parties, including MM domain experts and developers of ontologies and semantic tools. The workshop was entitled "Formal Ontologies Meet Industry" (FOMI) that comprised of 4 days of events in Tarbes, France with physical and online participation.

Having two events of different nature allowed us to have a varied audience, to connect to the wider European semantic web community and to attract contributions at different levels (e.g., survey answers and research papers). The 15th March event also permitted to gather the community and was the basis for further domain-specific expert meetings organized by WP3 in May 2021. The material there gathered informed the preparation of the 7th June event and provided input for the semantic landscape analysis (see Deliverable 3.2).

The present document is structured as follows. In Section 2 we outline the main organizational aspects and point out relevant references, such as the event website, where presentations can be found. In Section 3 we detail the event agenda, summarize all the presentations and report on the attendance. In Section 4 we present and analyze the participants' input, and the modalities in which it was gathered. In Section 5 we summarize the workshop conclusions, and in Section 6 present our acknowledgements. The Appendixes contain further details: Appendix A the list of participants, and Appendix B, C and D give the topics addressed and extracts from the results obtained *via* a short survey embedded within registration, the interactive (Mentimeter) presentations and domain-specific discussions (on a visual collaborative board, MIRO), respectively. As the FW3.1 was split into two events, the sections of this document often mirror this splitting.

2.Organization and references

2.1 Organizers

The OntoCommons second focused workshop 3.1 held an event from 12 to 15th September, 2022, has been organized mainly by Hedi Karray and Arkopaul Sarkar (ENIT, France) from the host organisation ENIT, along with Emilio Sanfilippo (CNR, Italy), Dimitris Kiritsis (EPFL), Joana Morgado (IWM, Germany), and members of Trust-IT, namely Rita Guifforda, Cristina Mancarella, and Luigi. Beside the core group, close interactions have been kept with the members of other workpackages. For the FOMI conference, a *Programme Committee* (PC) has also been formed, with both OntoCommons and external members. While its main role was in connection to the management of paper submission, review and preparation for FOMI conference, the PC has also been consulted for OntoCommons, IOF and other sessions in the event.

2.2 Workshop chairs

The entire workshop was chaired by Hedi Karray (ENIT), Arkopaul Sarkar (ENIT), Emilio Sanfilippo (CNR) and Dimitris Kiritsis (EPFL). Hedi Karray took the role of primary host of the workshop along with managing industrial demonstrations on 15th September, while Emilio Sanfilippo led the FOMI conference held on 12th September, Arkopaul Sarkar led the OntoCommons session on 13th September, and Dimitris Kiritsis led the IOF sessions on 14th September.

2.3 Programme Committee

- Bahar Aameri, University of Toronto, Canada.
- Emna Amdouni, ENIT, France.
- Farhad Ameri, Texas State University, USA.
- Stefano Borgo, ISTC-CNR, Italy.
- Ana Correia, ATB, Germany.
- Linda Elmhadhbi, INSA Lyon, France.
- Jesper Friis, Sintef, Sweden.
- Emanuele Ghedini, University of Bologna, Italy.
- Cheong Hyunmin, Autodesk Research, Canada.
- Dimitris Kiritsis, École Polytechnique Fédérale de Lausanne, Switzerland.
- Boonserm Kulvatunyou, National Institute of Standards and Technology, USA.
- Jinzhi Lu, EPFL, Switzerland.
- Riichiro Mizoguchi, Japan Advanced Institute of Science and Technology, Japan.
- Dimitris Mourtzis, University of Patras, Greece.
- Elisa Negri, Politecnico di Milano, Italy.
- Hervé Panetto, University of Lorraine, France.
- Pieter Pauwels, Eindhoven University of Technology, Netherlands.
- Arkopaul Sarkar, ENIT, France.
- Stefan Schulz, Medical University of Graz, Austria.
- Lorenzo Solano, Polytechnic University of Valencia, Spain.
- Dušan Šormaz, Ohio University, USA.
- Walter Terkaj, STIIMA-CNR, Italy.
- Marcela Vegetti, CONICET, Argentina.
- Alessandro Umbrico, ISTC-CNR, Italy.

2.4 Timeline highlights

- Proposal submitted to IAOA:
- Notification of acceptance from ESWC:
- Paper submission open:
- Paper submission deadline:
- Notification to paper authors: 15th July, 2022
- Camera-ready version of papers: 5th August, 2022
- Event commencement: 11th September 2022

2.5 Website, proceedings, and relevant references

The event website has been set up by Trust-IT and regularly updated when needed at https://ontocommons.eu/news-events/events/12th-international-workshop-formal-ontologies-meet-industry-fomi22.

Paper submission has been handled *via* EasyChair, at https://easychair.org/conferences/?conf=fomi22.

The accepted papers are collated in IAOA proceedings volume 3240 (urn:nbn:de:0074-3240-6) and published at https://ceur-ws.org/Vol-3240/. There were 15 papers submitted for peer-review to FOMI. Out of these, 14 papers were accepted for this volume, among which 7 full-papers, 3 short-papers, and 4 poster-papers.

All sessions are recorded and distributed publicly via YouTube. They can be found under the channel https://www.youtube.com/@ontocommonsproject1052. Please refer to section 3 for link to individual session recording.

3.Report on sessions

3.1 FOMI conference (September 12)

FOMI is an international forum where academic researchers and industrial practitioners meet to analyze and discuss application issues related to methods, theories, tools and applications based on formal ontologies.3 There is wide agreement that knowledge modelling and the semantic dimension of information play an increasingly central role in a networked economy: semantic-based applications aim to provide a framework for reliable data and knowledge sharing, exchange, and integration, as well as for automated reasoning over knowledge and data, meaning negotiation and coordination between distinct organizations or among members of the same organization. Theoretical ideas are often promising but their actual implementation may bring up unexpected problems and issues. Every ontology development is also required to follow a robust technical principle regarding metadata documentation, licensing, version, and release management to be sustainable for long-term use. Hence, the main purpose of the FOMI workshop series is to collect and share useful experiences and lessons learned by the presentations from both academia and industry of:

1. New research results.

2. New insights on known problematic issues.

3. Experience with problems in ontology application.

4. Successes and observations in ontology implementation.

5. Lessons learned on the best way to apply ontological methodologies and tools to real-world situations.

6. Demo of ontology-based applications in industry.

Similar problems arise in disparate application contexts and an open discussion helps to highlight commonalities and to spread ideas for possible solutions. FOMI welcomes researchers and practitioners that embrace this perspective without restrictions on the domains they deal with business, medicine, engineering, finance, law, biology, geography, electronics, etc. To achieve FOMI's mission, the 2022 edition takes place in tandem with other international events related to the use of ontologies and ontology-based information systems in industry. These events are organized within the scope of both the European project OntoCommons (EU H2020 project)[1] and the Industrial Ontology Foundry (IOF)[2]. In this way, the workshop participants will have the chance of engaging with a broad community of international researchers, stakeholders, and practitioners in industry to share experiences, insights, and discuss common research and application challenges.

The proceedings present 14 papers with 7 regular papers, 3 short papers, and 4 poster papers; they all originate from academic research at the intersection with industry, and stakeholders' experience with the use of ontologies in real-world application settings.

The regular and short papers were presented on September 11, designated for FOMI'22 conference. Due to the lack of time, poster papers were moved to September 15 as paper presentation.

3.1.1 Functional modelling in engineering: A first comparison of approaches on two problems

Speaker: Francesco Compagno

Abstract: Functional modelling is a well-studied topic in engineering and applies more broadly to areas like biology, management and organization studies. While it is clearly an essential part of building and describing engineering systems, functional modelling is seldom and irregularly used in industry, as it is difficult to apply consistently in practice. This obstacle becomes especially painful as digitalisation becomes an increasingly important aspect in modern engineering enterprises. To study the causes of such a difficulty, we analyze two typical problems that are encountered when modelling engineering systems and that are intertwined with functional aspects: identity of systems' components across time, and granularity management of the system models. The problems are introduced and used to compare a few ontological and engineering approaches that can deal with them. We illustrate our findings with a brief example.

3.1.2 Taxonomy of Manufacturing Joining Operations based on Process Characterization

Speaker: Arkopaul Sarkar

Abstract: Depending on the complexity of the assembly design and required production constraints, factories employ various types of joining operations as part of product fabrication. Manufacturers, who are in the business of assembling, gain their competence based on what types of processes and resources they use as well as how they are used in these joining operations. For data interoperability and exchange among the partners of distributed manufacturing, these joining operations need to be described formally to build a common set of vocabulary. Current ontologies in the related topics lack the details of the process characterization in their analysis and do not adopt foundational concepts to build such definitions. This paper presents an ontology-driven characterization of the joining operations to formalize a set of definitions on ontologically grounding concepts towards the

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1 https://www.ontocommons.eu/

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construction of a taxonomy of the joining operations. Furthermore, the ontology also includes many additional concepts, such as joining defects, associated costs, equipment, operators and their capabilities and skills. Following the rigorous definitions provided of these joining operations, resources, and performance indicators, an OWL-based version is also proposed which is shown to be effective in modelling joining operation data in a practice.

3.1.3 Ontology for Industrial Engineering: A DOLCE compliant approach

Speakers: Emilio Sanfilippo, Walter Terkaj

Abstract: Recent academic and industrial initiatives show an increasing interest for the use of foundational ontologies (FO) to support the development of domain-specific ontologies. Foundational ontologies guarantee indeed formal and conceptual robustness, while at the same time supporting the integration of multiple domain-ontologies aligned to the same FO. We report in this paper the work in progress about the use of the DOLCE ontology for the manufacturing domain, taking advantage of the recent formal representation of DOLCE in Semantic Web languages. On the basis of previous works, we show how different modeling strategies can be used depending on the engineering requirements at hand and discuss the advantages and disadvantages of these strategies. We exemplify the discussion by means of an industrial case study.

3.1.4 The industrial Ontology Foundry (IOF)

Speaker: Milos Drobnjakovic

Abstract: The Industrial Ontologies Foundry (IOF) has been formed to create a suite of interoperable ontologies that would serve as a foundation for data and information interoperability in all areas of manufacturing. To ensure that the ontologies are developed in a structured and mutually coherent manner, the IOF has committed to the tiered architecture of ontology building based on the Basic Formal Ontology (BFO) as top level. One of the critical elements of a successful tiered architecture build is the domain mid-level ontologies. However, there has far been no mid-level manufacturing ontology that is based on BFO. The IOF has recently released the IOF Core version 1 beta to fill this gap. This paper documents the development process and gives an overview of the current content of the IOF Core. Finally, the paper describes how the IOF Core can be used as a basis for a more domain-specific Supply Chain Ontology.

3.1.5 The CHAMEO ontology: Exploiting EMMO's multiperspective versatility for capturing materials character

Speaker: Pierluigi Del Nostro

Abstract: The characterization of materials includes a plethora of different methods and terminologies, and as such has historically been a challenging field for promoting effective mechanisms of interaction and interoperability among its communities. This work introduces the CHAMEO ontology, whose purpose is to provide a common modeling framework for materials characterization, in terms of a domain-level ontology under which method-specific, application ontologies in the field may be developed. CHAMEO, based on the CHADA documentation scheme, is part of a larger effort in standardizing materials modeling and scientific activities that has EMMO, the Elementary Multiperspective Material Ontology, as its core. In this regard, this work shows how CHAMEO, via its alignment with EMMO and the exploitation of the latter's constructs and perspectives, can effectively help scientists model processes and activities for materials characterization.

3.1.6 Towards an ontology of offshore petroleum production equipment

Speaker: Nicolau Santos
Abstract: This document shows the current research progress and methodology applied to build a domain ontology for describing facilities in offshore petroleum production well, based on an extensive requirement collection developed in industry and formalized through a set of competency questions. The final goal is to create a uniform and formally defined reference vocabulary to help engineers and information technology people label and relate measures and facilities in the production plant monitoring and simulation. The ontology uses BFO as a top-level ontology and employs GeoCore and an ongoing version of the core ontology produced by the Industry Ontology Foundry (IOF) as middle-level ontologies. This research is part of the Petwin project that studies the best practices for developing a digital twin for monitoring and simulating petroleum production in the industry.

3.1.7 Requirements for an Ontology of Asset Management

Speaker: Megan Katsumi
Abstract: Asset management is comprised of data-intensive activities such as condition and performance monitoring, scheduling of repairs and preventive maintenance, capital project monitoring, and life-cycle costing. Like so many areas of industry, asset management is hindered by an evolution of legacy systems that has resulted in a complex web of disparate data systems making it difficult to track and report on assets.

We aim to address this challenge for Toronto Water with the implementation of an ontology-supported data hub. Toronto Water is a major organization responsible for the treatment and supply of safe drinking water, the collection and treatment of wastewater, and stormwater management for the City of Toronto, serving a population of over 6 million people.

In this paper, we focus on the identification of requirements for an ontology of asset management. This will be a key deliverable of the project that will serve to guide the survey of existing ontologies, as well as the development of the data hub itself.

It is our hope that these requirements will serve to inform both the ontology and industry communities. The requirements not only identify the required scope for the ontology, but also illustrate the way in which ontologies can be used to support various asset management activities.

3.1.8 Multi-perspective approach to integrate domain-specific semantics into the system model

Speaker: Elaheh Maleki
Abstract: Space System Engineering is an iterative process in which various domain-specific viewpoints are integrated to present the final mission. This multi-disciplinary character of digital space systems creates interoperability issues. To deal with these issues, creating various modular domain ontologies and integrating them into the ESA top-level space system ontology (OSS) seems to be a promising solution. This paper aims at proposing a framework to create domain-specific ontologies for space systems. Each engineering domain that is the focus of the ontology is considered as the Universe of Discourse (UoD) in which the core concepts are presented as the

System Of Interest (SOI) and all other related systems are named External Systems. During each SOI modelling, its external systems, related attributes, and data exchanges will be modelled. This approach let us to identify all important information for each discipline as well as identifying interfaces between sub-systems. The proposed approach is presented by means of an example from a simulated earth observation mission (EagleEye) and the ontology is made using NORMA ORM tool.

3.1.9 KIDE4Assistant: an Ontology-Driven Dialogue System Adaptation for Assistance in Maintenance Procedure

Speaker: Patricia Casla

Abstract: Developing systems that facilitate natural interaction between humans and industrial systems by using current state-of-the art technologies, such as Deep Learning techniques, requires large amounts of training data, usually scarce in industrial scenarios, and the resulting systems are difficult to adapt to other settings. This paper illustrates an ontology-driven adaptation of KIDE4I, a generic semantic-based task-oriented dialogue system, to set up with a limited amount of effort KIDE4Assistant, a dialogue system for assistance in maintenance procedures through natural interactions. This adaptation approach bridges the gaps related to data availability and system reuse by exploiting expert knowledge together with existing ontologies and resources to obtain a fully-functional task-oriented dialogue system. Furthermore, the evaluation of KIDE4Assistant, performed through a user experimentation, shows the promising results of this approach.

3.1.10 Towards An Open Translation Environment for Supporting Translators in The Material Domain

Speaker: Florina Piroi

Abstract: In this paper, we report on the current state of the development of the Open Translation Environment(OTE), which is based on the Elementary Multiperspective Material Ontology (EMMO) – a top-level ontology for applied science, to support Translators in the Materials domain. We describe the conceptual architecture of the OTE, as well as some of its main components. Moreover, the contribution includes an industrial application for the use of an ontology-based digital platform and its components to support Translators following an exemplary scenario in a preparing use case.

3.1.11 Bring together model and business ontologies for protective coatings

Speaker: Salim Belouettar

Abstract: This work discusses how to connect business decision support systems, implemented in terms of the BPMN and DMN standards, with materials modelling workflows. The suggested approach facilitates interoperability of materials modelling software tools covering the main phenomena involved in advanced corrosion protection and active protective coatings' behaviour. The proposed system integrates materials modelling methodologies with decision support in business processes using a knowledge-based architecture. Thus, this contribution showcases the missing link between business processes, materials science, and computational engineering workflows for industrially relevant use cases; here, specifically, corrosion and protective-coating modelling. At the implementation level, we report on novel features of the process modelling suite ProMo for ontology and process-topology based materials modelling workflow construction and documentation. ProMo is extended to address challenges specific to the H2020 project VIPCOAT which works toward establishing an open innovation platform for active protective coatings and accelerated corrosion tests, including assessments of their in-service durability. Connections between

quantitatively reliable materials modelling tools, their integration into simulation workflows, and ontology-based knowledge representation are considered, addressing the use case from VIPCOAT.

3.1.12 Use of ontologies to structure and manage digital technical data of industrial assets: First steps towards an ecology of knowledge in multi-energies industry

Speaker: Jean-Charles Leclerc

Abstract: The use of semantic web technologies and of ontologies is raising growing interest in industry. On the other hand, in industry, there is an implicit Ontology, related to an Ontology of the factual sciences, an Ontology of systems, to design, manufacture, operate and maintain complex industrial assets with success. This mindset has supported during years the realization of industrial assets and the production of knowledge with concepts proven by lessons learnt from a long experience.

Recent European H2020 projects and clusters, Joint Industrial Projects in industry and advanced standards of Standardization Development Organizations converge towards new ways of modelling, structuring, and managing digital technical data across applications using ontologies thanks to advanced conceptual, methodological, and technological frameworks.

In this paper, we will provide preliminary results for structuring transverse information knowledge and data in a proper manner using industry standards. Promoting use of semantic web technologies and tools to enable implementation of a unified information modeling, contextualizing TotalEnergies data individual elements linking rules to standards classes as a preliminary structuring step of future extended data exchanges capabilities. We will question the use of ontologies in industry for an improved integration of digital technical data and structuring models by presenting, in the context of the domains of fossil energies and more generally across multi-energy-industries:

- the way we foresee structuring and managing transverse digital technical data domains to align and share reference business standards objects as parts of our industrial systems, based on formal auto-regulating axioms exclusively derived from high level ontologies such as ISO15926-14. Those high-level governing constraints, completed by additional references taxonomies (Domain Specific Languages DSL) following ISO 15926-14 axioms such as ISO/IEC 81346, ISO 14224, ISO-15926-13 or ISO 19008 standards.
- Promoting a unique company methodology of formal semantization of knowledges driven by common layering principles: any single object (individual or class) shall be kept integrated within a taxonomy sourced by a class type inherited from the formal ontology. Any edge (relation) linking those nodes shall exclusively derive as sub-properties of upper-level properties authorized by the formal ontology axioms.
- this semantic information modeling framework required for the alignment of internal data, models, and technical repositories supported by external ontologies-based on standards, such as ISO 15926, especially Part 14 for simple access, and other future SMARTs (Standards Machine Applicable Readable and Transferable), digitalized sources repositories according to common principles and rules for the provision of consistent digital specifications and configurations.

This implies the use of a set of tools enabling industry standards visualization, manipulation, and mapping/linking capabilities to enterprise data. All these operations, based on capabilities offered by the W3C semantic web and the linked-data standards, pave the way to distribute activities between automated ones by the machine and those, which need the various competencies of the

diverse disciplines to face contextualized operational needs in the context of TotalEnergies digital transition to enable multi-energies business challenges.

3.1.13 An implementation of OWL-S to Support Semantic Discovery for SWIM

Speaker: Jose M Parente de Oliveira

Abstract: The lack of an effective way for applying semantics on Web Services Discovery leads communities to face a fat, growing and disorganized infrastructure for Web Services. Developers implement hardcode connections among requesters and providers and manually create non-standardized service compositions, which need complex algorithms for trying to discover the desired Web Service. Current practices tend to focus on lightweight specifications of OWL-S which are obtained using different tools to build mixed descriptions between SOAP artifacts and OWL, managing the use of both technologies. This paper describes an implementation of OWL-S that describes a multicriteria way to publish, advertise and make semantic discovery attending the requirements of the System Wide Information Management (SWIM) Program sponsored by the International Civil Aviation Organization (ICAO), within the Air Traffic Management context. Furthermore, a set of Competency Questions is described with their respective answers and translated to SPARQL protocol, to make it possible to show a relationship between the results and requirements.

3.2 OntoCommons (September 13)

3.2.1 Upper Ontology and Standards for Industry (Manufacturing)

3.2.1.1 **Upper Ontology and Standards for Industry**

Speaker: Stefano Borgo

Summary:

- Standards are collection of normative statements, but many assumptions and commitments are not given. Also, the intention of the community complying to the standard is not given.
- Terminology has always been the central issue of standard.
- Glossary have been added to standards for many years.
- Four different ways ontologies are changing standards:
    - Linguistic rewriting: ontologies are used to systematise the terminology and to make the standardised material to be exploitable by reasoners and knowledge management tools.
    - Ontological re-organisation: Identify what concepts require more rigorous modelling.
    - Ontological re-conceptualisation: Letting interpretation of one standard influence the understanding of another. Also helps in reusing existing standards for new standard.
    - Ontological interoperability: Standards to have common understanding and meaning. It is necessary to build standards that are applicable even when there are some ontological disagreements.
- There are standards for ontology and ontological framework, e.g., ISO 21838
- Speaker provided an example of data harmonisation in industry and how ontology can help in understanding different meaning of natural language statements.

Q&A:

- Upper-level categories are hard to understand and therefore they may not be seen as a religion. What is the thought of speaker?

The speaker agrees. Formal ontologies are there for a reason but at the same time it is not for everybody. More work is needed to bridge the gap.

- Data is managed by stakeholders from different stakeholders. How can we manage data coming from different sources which are not compliant to standards?

If stakeholders are collecting the data in a coherent way, then there must be an ontology that models that data. Then some translation to formal ontology may be possible. For algorithm generated data either the algorithm needs to be changed to include ontological sense to the data or the data needs to be interpreted in post-hoc analysis. However, it is a good practice for the data providers to include an ontology along with the data they supply.

3.2.1.2 Terminologies and ontologies as a basis for industrial data standards

Speaker: David Leal

Summary:

- Industrial data standards with IGES in 1980, then STEP standards (ISO10303) in 1984. These data standards were all about data for software applications and less for physical world.
- These standards, however made textbook definitions computer-processible, they are mainly behind ISO paywall and EXPRESS language.
- The survey of industrial data models conducted in UK digital twin initiative showed that there are a huge variety of standards many of which often redo the earlier standards for capturing different perspectives.
- Different standards model data from different viewpoints.
- Data models are made for domain-specific requirements and therefore not much interoperable. Also data models have constraints coming from business activity but different business have different constraints.
- The data is not changed as per the inherent constraints of the models and therefore prone to be misinterpreted.
- To capture different viewpoints, we need multiple inheritance.
- Both in digital twins and IoT domain vast number of competing standards and conflicting definitions are prevalent.
- The core terminologies for industrial data, TC18/SC4 adopts ontology framework by adopting top level ontologies such as BFO, ISO15926 etc.
- 59 core terms are presented.
- SC4 wants to harmonise different data models using ontology.
- Data model is distinguished and related to ontology.
- What is next for standardisation:
    - The IOF vision is shared by many in ISO TC 184/SC 4 “industrial data”.
    - Extract domain knowledge from existing standard and ontologise them.
    - Use of ontologies to support combined use of data models developed independently.
- Standardisation challenges:
    - How do ontologies and traditional data models work together?
    - Can we ultimately throw the traditional data models away?

- Understanding the VIM (International vocabulary of metrology).
- Unifying geometry and topology
- Structured data – semantic wrappers for HDF5 etc.

3.2.1.3 Panel discussion on upper ontology and standards for industry

Participants: Elisa Kendall, Jim Wilson, David Leal, Michela Magas, Serm Kulvantyou

Summery:

- The speakers discussed the lack of specialization in industrial data standards committees, noting that there may be better committees elsewhere.
- They also touched on the issue of standardizing ontologies and apologize standards, acknowledging the degree of maturity of ontologies in standards.
- The speakers discussed the importance of maturity and standardization in ontology work, especially when it comes to managing reference data.
- The speakers also discussed the challenges of managing large amounts of reference data and the need for effective review processes.
- The speakers discussed the importance of establishing criteria for measuring the quality and standards of ontologies.
- They emphasize the need for testing frameworks to ensure that ontologies meet a certain level of quality and can be implemented in commercial businesses.
- The conversation cantered around the role of standards and ontologies in industry.
- While fixed systems can provide a reliable reference point, ontologies can contribute to the detection and mitigation of risks, as well as the monitoring of novel events in industrial ecosystems.
- While there is complexity to adding ontologies into enterprise integration and eco-system integration, dynamic co-creation environments of ontologies can actually lead to radical innovations that can ultimately be approved as standards.
- The importance of monitoring the broader landscape of ecosystems and value networks in the industry was discussed.
- The use of dynamic systems to pinpoint potential disruptions and the need for a modular approach in the construction industry due to the impending radical transformation is emphasized.
- The comment of an attendee about the importance of ontology being free and its role in making standards clear and unambiguous is also highlighted.
- The speakers discussed the benefits of using ontologies to clarify definitions and relations in standards, which can lead to less ambiguity and easier applicability in industry.
- The conversation then moved towards the challenge of getting standard organizations to understand the value of ontologies, with the example of a failed project from 20 years ago to manage the environmental impact of products over their life.

3.2.2 Upper Ontology and Standards for Materials Science

3.2.2.1 Upper ontology and standards for materials science

Speaker: Gerhard Goldberg

- Discussed the need for a unified way of representing materials science and the need for ontologies that capture scientific knowledge.
- Presented the need for a concept vocabulary for materials ontologies, and explains how this would help the work of translating material representations into a language that is understandable by those in the materials science field.
- Covered a question from the audience about discrepancies between a material's description in a material science ontology and its actual performance.
- Discussed how space and time are represented in materials science and how different definitions of molecules can be handled.
- Also explained how verification and validation are handled in materials science.
- Mentioned the different definitions of materials, the importance of understanding the "cause and effect" of a material's performance, and the need for integrated process information when managing materials.

3.2.2.2 Addressing Materials Science upper level ontological needs with the EMMO

Speaker: Emanuele Ghedini

- Described the email ontology, which is a system for capturing material information in a way that makes it easier to understand and use.
- The EMMO ontology is based on fundamental scientific concepts, such as causality, meteorology, and civics, which allows for multiple perspectives to be described.
- The EMMO is a 4D ontology that allows for the representation of causal relationships at a very high level.
- Discussed the need for a fundamental level of material description in order to be able to speak the language of material scientists.
- It explains that the material entity is represented by classes in the EMMO using a nominalist approach.
- The perspectives discussed in this presentation are essential for material scientists, as they allow for formalization of the relation between the whole and the parts, as well as the hierarchies of granularity.
- EMMO is a standardized, multilingual framework for describing physical objects and their properties.
- It can be used to capture the semiotic information associated with physical objects, and it can be used to connect models of different generality levels.

3.2.2.3 Panel discussion on upper ontology and standards for materials science

Participants: Gerhard Goldbeck, Emanuele Ghedini, Norman Swindells, Alexandru Todor, Silvana Muscella

Summery:

- The host provided information on the ontology and standards for materials science, discussing the concepts of syntax, semantics, and reductionism.
- Panellists went on to say that ontologies must be aligned with one another in a way that matches the classical separation between top-level and mid-level ontologies, and that questions have been raised about how to deal with different definitions of the same concept.

- The panel discussed materials science ontologies and introduce themselves.
- The panellists discussed the importance of standardization in materials science, and outlined the requirements for a material science ontology.
- Mentioned the need for a unified language for materials science, the importance of standards, and the challenges of standardizing ontologies.
- Discussed the need for standards in materials science, and identifies two standards as examples – the International System of Quantity and the Vocabulary of Metrology.
- They argued that there is a need for more than one standard in materials science, and suggests that a standardized way of documenting knowledge may be the best way to achieve this.
- They discussed the benefits of standardized terminology in materials science and the need for it to be implemented in order to achieve effective communication and collaboration.
- Discussed the need for a TLO and the importance of standards in materials science.
- Discussed the challenges of developing standards for materials science, and how a publicly available specification would help to achieve world consensus.
- It was also discussed the importance of having a deep understanding of computer software in order to establish standards.
- They discussed the need for an ontology that is aligned with standards of materials science, and the need for developers to adopt different ontology development strategies in order to facilitate this alignment.
- The first thing to consider when trying to develop interoperable materials science ontologies is the level of compatibility among the ontologies.
- On top of this, the Ontology for Materials and their Standards project is working to provide a framework for aligning top level ontologies.

3.2.3 FAIR Domain Ontologies for Industry

3.2.3.1 **Introduction and how to make ontologies Fair?**

Speaker: Yann Le Frank

- Gave a brief overview of the session, which will cover the topic of making ontology FAIR (Findable, Accessible, Interoperable, and Reusable).
- Briefly described his experience in semantic web and data, including her involvement in fair principles and their implementation through various EU projects.
- Introduced the FAIR principles, which are a set of guiding principles that make data findable, accessible, interoperable, and reusable.
- The 15 principles are distributed around five topics: findability, accessibility, interoperability, and reusability.
- Described the importance of having rich metadata and using vocabularies and ontologies that align with FAIR principles.
- The speaker and their team conducted a landscape analysis of domain ontologies for the industry, gathering information from experts, organizing workshops, and using surveys.
- The goal is to share this information to help the industry become compliant with at least some of the FAIR principles.
- Discussed the results of their study on the Fair Domain Ontologies for Industry.

3.2.3.2 A concrete step toward FAIR ontologies: publishing ontologies in a specialised ontology repository

Speaker: Arkopaul Sarkar

- Discussed the IndustryPortal, a repository dedicated to the industrial domain and all related ontologies.
- Emphasised the importance of fairness in ontologies and the need for the Industry Portal to be findable, reusable, accessible, and integrable.
- The tool provides a fairness score for the ontologies on the industry portal on four different axes, giving a core score and extra score based on the number of fair questions answered.
- The tool provides both global Fair scores and normalized scores, and there is an explanation for each test to guide ontology developers on how to improve their ontologies.
- Discussed a tool called O'Faire that is used in the industry portal to integrate different metadata standards and measure different ontologies.
- The tool provides three levels of evaluation - Not Fair, Fair, and Fairer - and enables automatic evaluation.
- However, the speaker mentioned the need to go beyond the evaluation of ontology artifacts and evaluate the content of the ontology itself.
- The speaker also mentioned other matrices popular in the literature for ontology evaluation, such as accuracy, adaptability, completeness, and fitness, and third-party services that can be integrated to provide scoring against these metrics.

3.2.3.3 Manual evaluation: using the FAIR semantics recommendations

Speaker: Yann Le Frank

- The speaker discussed how their team analyzed and evaluated the compliance of ontologies with the mandated, recommended, and optional recommendations of the Semantics Recommendation using 13 questions that are answered with either a yes or no to develop a fair score and a global score.
- They assessed 44 ontologies from different domains and found that Physics and Chemistry ontologies scored the highest fair and global scores, while Mechanical Engineering ontologies scored the lowest.
- However, none of the ontologies analyzed passed the threshold of 100% compliance with mandatory recommendations.
- Discussed the feedback received from using the FAIR evaluators tool, highlighting that it is straightforward to use and provides a clear indication of what is missing from the harvest records.
- He also talked about the FED initiative, which is community-driven by openness, emphasizing that they build data and ontologies following openness principles.

3.2.3.4 Automated evaluation: Foops!, An ontology pitfall scanner for the FAIR principles

Speakers: Maria Poveda

- The speaker discussed how the ontology community has been working to make their ontologies more accessible and understandable by others.

- Then introduced an ontological scanner that can be used to validate ontologies based on the four principles of FAIR, which include findability, accessibility, interoperability, and reusability.
- This tool is meant to help ontology creators improve their work and make it more useable by others.
- Explained the results and categories of the FAIR evaluation.
- Each category has multiple tests, and the tests are related to the FAIR principles.
- The findings include whether the ontology is in RDF, uses accessible and broad language for knowledge representation, and has minimum metadata.

3.2.3.5 Ontology FAIRness evaluator in the Agroportal semantic resource repository

Speaker: Clement Jonquet

- Discussed the rationale behind their work on ontology repositories and the assessment of their fairness.
- The goal was to measure the level to which ontologies make fairness evaluation possible and to design a methodology that can be implemented in AgroPortal to automatically assess the level of fairness of a semantic resource.
- Their approach aims to provide a new vision of showing the fairness level of ontologies in AgroPortal.
- Discussed the requirements for the fairness assessment grid and how they evaluated whether something is fair or not.
- The second requirement was a projection of the fair principle for semantic resources.
- The third requirement was a way to describe the metadata of the semantic artifacts using mod 1.4, which is a specification they have been working on for about five years.
- Discussed the use of FAIR domain ontologies for industry and how they can be used to describe metadata for resources.
- Mentioned the use of Agroportal, which is a tool that helps evaluate the level of fairness of a given ontology and the average level of fairness for all the ontologies in agriculture.
- Overall, the offer methodology and Agroportal help to harmonize and unify metadata in an authority repository and evaluate the level of fairness of ontologies.
- Discussed a web service that evaluates the level of fairness of ontology properties based on a methodology that is independent of the implementation of the tool.
- Discussed the importance of harmonizing authority metadata for the Fair principles to be effective.
- Discussed their work on aggregating the DCAT standard with Mod to create a profile for semantic artifacts such as ontologies and describable vocabularies.

3.2.3.6 Ontology harmonisation in OntoCommons

Speaker: Yann Le Frank

- Mentioned works on version 2 of the FAIR recommendation schema within the context of the Fair Impact project.
- Discussed the importance of harmonizing different tools used in the concept of fairness and making them machine actionable.

- Mentioned the upcoming work on alignments with existing metadata, which will involve mappings and models of the mapping to have fair mappings.
- The session ends with an invitation for questions and comments from participants, with a focus on discussing openly any concerns or questions regarding Fairness.

3.2.3.7 Panel discussion on FAIR metadata for ontologies

- The panelists Discussed the difficulties of finding ontologies due to missing metadata, particularly in the case of the BIO portal where not all ontologies are documented.
- The speakers also brought up concerns about the quality of ontology content and how it is not covered by the FAIR recommendation.
- Ultimately, the panelists emphasized that the only way to assess ontology quality is through personal evaluation and that the subjectivity of quality highlights the need for a Fair Metrics and Quality for Data task force.
- The panellists discuss the issue of tracking quality in ontologies, drawing parallels with software engineering.
- The concept of FAIR principles is discussed in terms of data management and quality.
- While there may be confusion that FAIR aims specifically to take care of data quality, it is emphasized that FAIR is instead a set of guidelines for data management that make it easier to work with data effectively.

3.2.4 Domain ontology harmonisation for industry

3.2.4.1 Ontology harmonisation in OntoCommons: A view on manufacturing resources

- In the framework of OntoCommons (OC) , a number of domains have been identified to collect "domain requirements".
- In the first part of the talk Arkopaul Sarkar presented the activities of the Focus group in Manufacturing set up within OC WP3 (Domain ontologies) to collect manufacturing domain specific requirements.
- The LOT methodology (https://lot.linkeddata.es/) has been used, in an adjusted form, and both functional (i.e., a competency question) and non-functional requirements (e.g., opinion, best practice) have been considered.
- 11 industrial use cases coming from OC industrial partners brave been analysed by involving internal and external experts for the various domains (e.g., domain experts, ontologists, system designers, etc.). 144 competency questions have been collected from such analysis.
- Some highlighted points: (1) existing popular standards are ISA 95 and ISA 88; (2) multiple modelling languages are used; (3) modelling in continuum and discrete manufacturing are different; (4) the interaction of the human being must be taken into consideration.
- Overall, the competency questions concern three groups of entities: (1) Physical Entity (e.g., raw material); (2) Processual Entity (Activity) and Intentional Entity (e.g., Function). A fourth category; (3) Social Entity (e.g., Model, Documents), enables communication about all the other entities.
- A set of ontologies to be harmonised has been identified (see slides for full list).
- In the second part of the talk, Dr. Emilio Sanfilippo presented an approach to the definition of Manufacturing Resources from a theoretical side.

- In the literature, there are multiple interpretation of the term "manufacturing resource" that may even be contradictory (e.g., manufacturing resource could include the raw materials and product or not) and therefore preventing interoperability.
- A formal comparison in FOL of three different views has been carried out (see Sanfilippo et al, Applied Ontology, vol. 16, no. 1, pp. 87-109, 2021).
  - View 1: Resource is something that you use.
  - View2: Resource are not attached to manufacturing plans.
  - View3: Resources are entities to achieve goals.
- The key findings of this comparison process were that (1) there is not a golden a approach and it is dependent on the application context and (2) that the role is a defined context.
- The proposal to enable interoperability was to use bridge concepts for alignment.
- Finally, the work in progress on OntoCommons "bridge concepts" is presented. The template for bridge concepts is available on the project GitHub (https://github.com/OntoCommons/OntologyFramework/blob/dev/bridge-concept-template.md)

Q&A:

Q: What is being unified in your formal comparison approach?

A: The three ways of understanding resource w.r.t. events, plans, and goals.

Q: Did you have test data? How can you verify the approaches with actual data?

A: We had an industrial case study where data was collected on production planning (at the research level, not commercial). For OC in general, the plan is to get data whenever possible, especially from the industrial partners involved the use-cases (ongoing communications).

3.2.4.2 Industrial Ontology Foundry

Speaker: Barry Smith

- As starting point the origins of IOF, based on BOF, have been identified.
- BFO started in connection with the Human genome project (1990-). Later on, other ontologies connected to it (an interoperable set) were created (e.g. Gene Ontology, Obstetric and Neonatal Ontology (OBO), Ontology for Biomedical Investigations (OBI), etc.).
- Different levels of ontologies are defined (i.e.., Top, Middle, Domain) and all the ontologies are designed in coordination with the other to allow interoperability. BFO is at the top of the hierarchy, the Ontology for Biomedical Investigations (OBI) in the middle, etc.
- BFO is small by design, to be applicable to many domains. Beside OBO Foundry, many other communities have created suites of ontologies using BFO. About 500 domain ontologies, mostly from the life sciences, use BFO.
- BFO-2020 is the latest version, has been developed over 16 years and includes concepts for material entity, information entity, attributes, and processes.
- BFO-2020 is included in ISO-21838, whose part 2 describes BFO, which is one of TLOs satisfying the requirements for TLOs, given in part 1.
- A related ontology is the middle level ontology, Common Core Ontology (CCO). CCO was originally funded from an ARPA US grant, for the challenge to rapidly integrate data from various and unknown domains).

- The IOF started it work in 2016 and is about to release the first suite of ontology including IOF core as mid-level ontology and a set domain ontology.
- Example of concepts from the IOF core are presented (e.g. material, quality, role, function, capability, etc.). See the presentation for details.
- Finally, a recent book is briefly presented "Why machines will never rule the world: Artificial Intelligence Without Fear", By J. Landgrebe and B. Smith. (1st ed.). Routledge. https://doi.org/10.4324/9781003310105]. The last chapter is about AI in industrial manufacturing.

Q&A:

Q: What is the connection of IOF-core to industry standards? How the industrial sta¡ndards can be used along with the IOF models?

A: There is a very close connection. However, ISOs are developed individually and are dictionary-like (not really semantic), so they have to be adapted.

3.2.4.3 The influence of the widespread adoption of JSON-LD--based international standards

Speaker: Noel Vizcaino

- Regarding metadata serialisation XML played a strong role, but JSON replaced it largely, especially for APIs (this was a downgrade in disguise). Then the JSON-LD was introduced, and major search engines agreed to use it for web metadata. Currently it is the most advanced RDF serialization, in the future YAML-LD* will follow.
- JSON-LD is a foundational standard, and it connects to others. JSON-LD defines an RDF document that is also a superset of JSON (thus compatible). It came with a vocabulary (schema.org). The key point is that any JSON with a JSON-LD context becomes semantic linked data. JOSN-LD is a lingua franca for metadata.
- JSON-LD can be imported directly into graph-databases, is compatible with REST and GraphQL.
- JSON-LD is used in many W3C standards, Google Datasets, it is FAIR by design, and used in many domains (financial, geospatial, life sciences (see https://bioschemas.org/), etc) worldwide, also in public administration (e.g., US) and science (e.g., CERN).
- Examples of JSON-LD from different domains are shown and online tools to validate and change visualizations are exemplified (e.g., JSON-LD playground https://json-ld.org/playground/).
- The adoption of JSON-LD has implied a change of paradigm in software engineering. In the past, the "database" was at the bottom of the design, now the "domain" took that role, being now at the core. Ontologies will be integral part of scientific software development.

Note: A new ISO Graph Query standard is being developed.

Q&A:

Q: How can JOSN-LD help the foundation of new standards in ontology development?

A: It facilitates harmonisation, alignment, composing and making things semantic. Also, one can define contexts for examples. The wide adoption led to many data being available in this format, also for this it cannot be ignored.

3.2.4.4 Panel discussion on Domain ontologies for industry

Panellists: Chris Partridge (Boro Solutions Ltd, UK), Markus Stumptner (Univ. of South Australia), Alejandro Salado (Univ. of Arizona, US), Will Sobel (MTCOnnect Institute, US)

Q: Ontologies can be conveniently based on standards, here we focus on their harmonization. How can harmonization help and impact industry?

Note: *See previous talk of Dr Leal in the Session on Upper Ontologies An Standard for multiple examples on ontologies based on standards.*

Discussion

Some comments and further questions arise during the discussion:

- Which harmonization? For example, TLO-harmonization is independent of the data. Another situation is when different data give different views of the world. There is a "cleansing" process that could also fall under "harmonization".
- How big is the overlap? Different views of the world (for the same domain) or more or less complementary domains? The second case is typically easier. (Note: of course, for upper ontologies everything will overlap).
- From the user perspective: very complex systems interoperate, however there are still many processes in which manual steps are necessary to pass information from one to the next.
- Different domains are at different maturity levels, this might affect ontologization too.
- Within standardization bodies, "harmonization" is meant as a way to make standards work together.
- It is useful to look at harmonisation from the use-case/business-case perspective. For example: how can we integrate two or use one within the other, to augment it, etc.
- Competency questions are crucial for the development of ontologies, however they are not shared when publishing results. Maybe sharing them would help in clarifying the ontology coverage.
- In summary, there are many different aspects of "harmonization", it is not just a single activity.

Q: How should we proceed to harmonize ontologies? How to proceed for the harmonisation of what we have in place?

Discussion

- Some comments and further questions arise during the discussion:
- Start with data, unless you don't have any data.
- Usually, data is "put under"/"linked to" an existing TLO. Actually, in some cases the underlying data should be adapted/changed if one really takes seriously the TLO, but this would have a high cost.
- Basing the harmonization work on use-cases might compromise flexibility/broadness.
- How much does the choice of committing to one specific TLO limit your interoperability? Suggestion: in the terms of TLOs, we might expect more TLOs coming up. So, when harmonizing the available ones, we should do it without "shutting down" other possibilities.

- We should ask ourselves "what" and "why" we are harmonizing. Keep in mind that standards become legacy quite fast without passing the test of time.
- The solution would be to develop methods/processes to efficiently harmonize TLOs with each other.

3.2.5 Domain ontology harmonisation for Materials Science

3.2.5.1 **Towards semantic-driven digitisation in Materials Science & Engineering (MSE): Interoperability, Ontologies, and Data spaces**

Speaker: Joana Morgado, Dirk Helm

- Introduced the topic of domain ontology harmonization for materials science and engineering interoperability.
- Showed examples of their work and addressing the issue of harmonization through the ontologies they have developed in the field of materials science, as well as discussing data spaces and marketplaces that they are also working on.
- Explained the challenges of developing new materials, which are expensive, time-consuming, and require a lot of trial and errors.
- However, ontologies can facilitate data interoperability and uniform structure, creating data sets that are compatible and harmonized.
- Discussed the ontology harmonization efforts in the Materials Science field, specifically in mapping Excel data to RDF and aligning with ontologies such as the M1.
- Discussed the development of ontologies to capture the workflow of different steps and calculations used in materials science.
- Emphasised the need for a harmonized model that represents workflows in order to annotate simulations and computations.
- Discussed the work being done to align the method ontology with concepts from other ontologies, particularly the Matlock and Ammo-based ontologies.
- Mentioned the development of a marketplace, a one-stop-shop web-based application that enables users to create and explore data, software, and other services related to materials science.
- The platform uses ontologies to provide a shared schema to represent data and services, ensuring interoperability and facilitating the integration between data and simulation solutions in the marketplace.
- The marketplace enables the creation of workflows and the solving of materials modelling problems, as well as allowing users to register apps that others can access and use.
- The platform includes a search engine that uses ontologies to find the right software or expert for specific materials or processes, allowing for the development of sustainable materials and improved knowledge of the process-structure-property-performance chain.
- The solution to these challenges involves combining integrated computational materials engineering with artificial intelligence and using semantic technologies to exchange and combine data between modelling and simulation.
- Discussed how domain ontologies can be used to organize materials data in a way that is useful for AI and machine learning frameworks.

3.2.5.2 Materials Informatics for advanced materials

Speaker: Pedro Dolabella Portella

- Discussed the MaterialDigital platform, which aims to provide digital representation of materials and their life cycle in order to provide added value to materials engineering and improve the recycling process.
- The platform was funded by the German Ministry of Research and has 13 funded projects in its first phase, covering a wide range of materials and concepts from glass to concrete to sheet metal production.
- The goal of the platform is to connect all these different projects and create a common language for the data and knowledge generated by scientific and industrial communities.
- The speaker's team is working on creating primary, secondary, and metadata for the raw data generated by machines during the testing process.
- Explained the importance of metadata for the quality and reliability of data in the materials science field.
- They are now working on developing a core ontology for promoting a consistent and standardized language across different projects and domains, such as steel, aluminium, thermoelectric materials, and rubber, to enable communication between their platform and any connected depository.
- Ultimately, the development of the ontology aims to describe and formalize a dictionary, thesaurus, and ontology to identify the particularities of different domains to bring them together.
- The focus is on the process of bringing primary data generated in material science into a machine-readable format that can be unified, structured, and made comprehensible for the whole universe.
- The next step involves describing ontologies that will be connected to other materials science products, making them understandable for everyone.
- Discussed how data is captured and integrated into the material digital infrastructure.
- The importance of intellectual property (IP) ownership of the data is stressed, as well as the rarity of truly free data.
- Discussed the role of different levels of ontology and harmonization, particularly in promoting the interoperability of data sets across different domains.
- They emphasize the need to provide practical guidance for steps and processes to make data available for a large community.
- Emphasised the importance of common language and vocabulary in the field of materials science in order to facilitate the process of digitalization.

3.2.5.3 Panel discussion on domain ontology harmonisation for materials science

Panellists: Heiner Oberkampf, Dirk Helm, Thomas Hanke, Pedro Dolabella Portella

- Panellists discussed the limitations and barriers to the reuse of existing ontologies in the field of materials science.
- One key limitation is the limited availability and access to ontology libraries, which are often not documented adequately.

- Panellists also discussed the challenge of creating ontologies that cover a wide range of applications while still being widely usable, and the need for ontology specificity to avoid overly broad or shallow classification.
- Finally, the conversation moves to the need for a basic ontology structure around testing, including defining subclasses and properties for different materials and tests.
- They also discussed the need to harmonize domain ontology in materials science.
- There is a lack of a community that focuses on domain ontology, and the speakers suggest getting the right people and communities together to do this.
- They discussed the importance of ontology in harmonizing domain knowledge for materials science.
- They think that material authorities may need to consider creating ontologies to standardize their data, and that it may be necessary in the future to deal with issues through the use of ontologies.
- The panellists discussed the process of mapping each word and definition into a balanced ontology representation for the materials science data format 6892.1.
- The panellists discussed the potential for harmonization between materials science and other domains, and how the alignment can be facilitated using a top-level ontology framework.
- The panellists also discussed the difficulty of adding people and connecting to knowledge at the right level in materials science.
- They agreed on using written concepts provided in BFO and AMMO to develop a system of ontologies but acknowledge that there are many discussions to be had about the future of the industry due to the developments with machine learning.
- The ultimate aim is to create standardized systems of ontologies that can be used across the industry.
- The panellists highlighted the usefulness of domain ontology harmonization for materials science.

3.2.6 Keynotes and invited talks summaries.

Title: Lessons learned from applying Ontologies in industrial applications

Speaker: Stephan Grimm

Delivered on 12th September, 9:30AM

- The speaker emphasizes the importance of ontologies in harmonizing and integrating data management across disciplines.
- They mention the range of technology fields that ontologies cover and how they're using knowledge graphs and ontology techniques to integrate various sources of data.
- The speaker also talks about their endeavours to build a company-wide semantic model repository alongside other scientists and semantic technology experts.
- The speaker discusses the use of knowledge graphs and ontologies as a means of integrating data and creating a connected data fabric.
- Knowledge graphs provide a schema for categorizing data and allow for federated querying across multiple sources.
- The use cases for knowledge graphs include improving data quality and enabling more effective AI applications.

- The speaker discusses digital companions and gives an example of an assistant they developed for a product used in factory automation called the TR portal.
- The speaker also introduces the concept of Industry 4.0, or making factories and machines autonomous, through the use of ontologies and reasoning and inference capabilities.
- Ultimately, using knowledge crops and ontologies can lead to an autonomous plan for production, where the system revises plans automatically.
- The speaker discusses the need for company-wide harmonization of data models or information models.
- The speaker proposes the use of a semantic model repository that covers a broad spectrum of areas, from technical machinery to engineering, operations, and maintenance, among others.
- The speaker explains the motivation behind the ontology library, which is to reduce modelling efforts, speed up data integration, and enable reuse of artifacts across different phases.
- The speaker talks about the technology and infrastructure they are using for their repository, including their use of semantic technology, such as RDF triple stores, and their focus on building industry-specific models.
- They emphasize the difficulty in encouraging typical developers to reuse ontologies, as many tend to start modelling from scratch instead of integrating existing models and emphasize the need for clear documentation and API specifications to encourage reuse.
- Furthermore, the speaker talks about the complexity of utilizing semantic web technology to build ontologies, highlighting incompatibilities and the need for coherence in language frameworks.
- The speaker discusses some of the difficulties and barriers of adopting RDF and OWL technologies in companies.
- The speaker suggests that in the current solution, simple class realizations of technologies in common models are the best method.
- Finally, the speaker emphasizes the importance of applying formal ontology in this community, mentioning the use of abstract upper ontologies and patterns for creating coherent ontologies.
- The speaker discusses the use of ontological categories for data management and the promise they hold for harmonizing data across industries.
- The overcomplication of application models due to unnecessary ontological distinctions and difficulties in determining which distinctions to apply to different use cases are also areas of concern.
- The questions raised from the audience relate to the development of the platform based on the northgraph model and how to decide the level of detail to capture from heterogeneous data.
- The speaker discusses how to decide which information to integrate based on individual domain, use case, and project.
- He also mentions the implementation of an upper-level ontology, such as ISO 15926 Part 14, to integrate different data types.

Title: An Industry Ontology for the identification of Medicinal Products (IDMP)

Speaker: Heiner Oberkampf

Delivered on 13th September, 9:15AM

- The speaker shared that he is there to discuss the IDMP Oncology project and how it has grown over the recent months.
- He provides an overview of the project, the ISO standard related to it, and the ontology that was used in the modelling process.
- He discussed the IDMP, which is a five-part standard driven by regulatory requirements from the European Medicines Agency and the FDA that will be enforced for all drug submissions starting next year.
- That's why an ontology augmented the ISO standard to ensure the standard's interpretation's consistency was created.
- The ontology aims to align different functions within a Pharma company, such as research, risk, clinical, chemical development, regulatory, and manufacturing, and allow them to work efficiently while still connecting to the same standard.
- The project's immediate goal is to use the standard to align different functions within a Pharma company.
- The keynote speaker discussed the process of creating an accurate ontology for answering competency questions that span different functions.
- The speaker talked about various ontological concepts used in regulatory science.
- The speaker discussed the roles and implementation components of investigational drugs in clinical trials.
- To answer competency questions related to the drugs, an ontology is built, and data is collected from FDA or other standard public sources.
- The speaker also gave examples of how this process works with companies like Fire and Novartis.
- The speaker discussed the importance of contextualized names and identifiers for accurate data mapping and integration in data pipelines.
- The speaker also talked about the ontology minimum viable product aligned with different experts and governance, and how different stakeholders were involved in decision-making.
- However, the modularized approach taken for ISO standards will capture the manufacturing area for valuable use cases in the pharmaceutical industry.

Title: Collaborative Development of Industrial Ontologies for Standardization

Speaker: Elisa Kendall

Delivered on 12th September, 3:30PM

- Collaborative development is essential for successful industrial ontology projects: Industrial ontology projects require collaboration between subject matter experts and ontology engineers to ensure that the resulting ontology accurately represents the knowledge in a specific domain or industry.
- Industrial ontologies can help standardize data and improve interoperability across systems: By providing a common vocabulary and structure for representing knowledge, industrial ontologies can help ensure that data is consistent and can be easily shared between different systems.

- Ontologies can be used to represent knowledge in a specific domain or industry: Ontologies are formal representations of knowledge that define concepts, relationships, and axioms in a specific domain or industry.
- Ontology development requires collaboration between subject matter experts and ontology engineers: Subject matter experts provide the domain-specific knowledge needed to develop an ontology, while ontology engineers provide the technical expertise needed to represent that knowledge in a formal language.
- A shared understanding of the objectives of the project is essential for success: All stakeholders must agree on the goals of the project to ensure that everyone is working towards a common goal.
- Establishing priorities and setting incremental objectives that can be achieved in a reasonable amount of time is important: Breaking down the project into smaller, achievable goals helps keep everyone focused and motivated.
- Rules of engagement, including policies that everyone agrees on that govern the development, are necessary: Clear rules help ensure that everyone is working together effectively and efficiently.
- A common methodology is also required for successful collaborative development: A common methodology helps ensure consistency across different parts of the project.
- Sufficient commitment by stakeholders, including funding and other resources, is necessary for success: Without sufficient resources, it will be difficult to complete the project successfully.
- Foundational concepts must be use case and competency question driven to avoid significant rework later on in the project: Ensuring that foundational concepts are driven by use cases and competency questions helps ensure that they are relevant and useful.
- Development methodologies for industrial ontology projects are necessarily more rigorous than those for typical corporate or application-specific ontology projects: Due to the complexity of industrial ontologies, more rigorous development methodologies are required.
- Automation plays an important role in industrial ontology development due to the highly distributed teams collaborating around the clock: Automation helps ensure that changes made by different team members are integrated smoothly.
- Continuous integration and publication are required to maintain synchronicity across multiple simultaneously evolving sub-domain areas: Continuous integration and publication help ensure that everyone is working with the most up.

Title: How an evolutionary framework can help us to understand what domain ontology is (or should be) and how to build one

Speaker: Chris Partridge

Delivered on 13th September, 4:15PM

- The speaker talked about the evolution of information and the history of how disciplines acquire history over time.
- He also pointed out that information as a domain still lacks a proper historical context and there needs to be a new framework to compare practices against.
- The speaker also discussed domain ontologies, taking Gruber's definition of it and stating that it should focus more on application systems rather than just textual standards.

- The speaker's aim was to persuade the audience to see the importance of a wider context and historical evolution in the domain of information.
- The speaker talked about the difficulties of achieving semantic interoperability and the management response of creating a maturity model for data sharing.
- The speaker also discussed how domain ontologies are expected to expand the alleyways and make the bridges as wide as the continents so that interoperability can be achieved.
- However, he noted that domain ontologies are difficult to get working in an industrial context, and that hand tuning is often necessary.
- The speaker discussed the evolutionary stages and classifications of language.
- The speaker also talked about the disruptions that occurred with the introduction of writing and how the history of information explains a lot of what was going on in their projects.
- The speaker discussed the history of literacy as a communal practice that involves collating and creating access to historical textual information, as well as creating new text and information.
- The speaker argued that domain ontologies are the same phenomenon repeated at the next level of technology, and they make a distinction between data processing and data sharing.
- They defined data processing as information that is structured in a way that allows it to be processed by computers, while data sharing involves the ability to share data and collaborate with others.
- The keynote speeches, the speaker discussed how data has evolved from the earliest writing, where pictures of objects were used to depict meanings, to today's data models.
- The speaker emphasized the importance of formalization in data processing and explains how sharing is a crucial component in achieving the goal of data collation and shareability.

Title: Industrial Ontology Foundry (IOF) – An open, shared reference ontology for industrial manufacturing community

Speaker: Serm Kulvatunyou

Delivered on 14th September, 9:15AM

- He outlines the mission of the IOF which is to advance data interoperability and develop reference ontology.
- The speaker also talks about the history of the IOF and the need for an ontology due to the lack of continuous support to develop and document engineering technology over the past 20 years.
- He shares his thoughts on what should happen next, particularly with the IOF core and IOF architecture.
- After the IOF core version one data was released, additional terms were added to the ontology to facilitate the domain later.
- Today, the IOF has about 180 participants from over 50 organizations and has a governance board, technical oversight board, working groups, and task group.
- The speaker explains the different groups within the Ontology Summit, including the governance board, technical oversight board, and working groups, which are responsible for developing domain and reference ontologies.
- There are a total of eight working groups, though only two have been active recently.
- The speaker provides an overview of each group's scope and maturity, with the architecture scope being very active and the IOF core almost ready for release.

- The speaker then summarizes the work done on the IOF core, which started with 20 terms but has expanded to 50 classes and object properties in order to axiomatize classes and balance with the axioms.
- The speaker discusses the progress made in various supply chain-related ontologies, including the IOF core, supply chain ontology, maintenance ontology, and product pending and scheduling ontology.
- The supply chain ontology has added various classes and object properties to model different aspects of the supply chain, including multi-party relations, transport policies, and more.
- The maintenance ontology has realized the need for additional notions to support their entities, while the product pending and scheduling ontology is still being developed, with a focus on defining a 3D process model beyond what is supported by the PSL and Common Core.
- The speaker explains the work done on the capability of explaining the capability of resources and processes and stresses the need to model a lot of digital artifacts to be able to establish digital trade and digital twin.
- The speaker discusses the various developments and components that have been set up to aid in the development and publication of the iOS core, including simplifying the architecture passcode and specifying the various axioms in the allocation.

Title: Ontology applications in petroleum industry

Speaker: Mara Abel

Delivered on 14th September, 05:00PM

- The speaker introduces himself and explains how she initially planned to present, but due to the audience's lack of understanding of ontology engineering, she decided to give a brief overview of several projects that utilized ontology to show its usefulness.
- She then details one of these projects, Digital Queen, and discusses its wide evaluation in petroleum exploration.
- The speaker introduces herself and her work as the leader of the research group in computer systems for petroleum exploration and production.
- She then asks the audience about their knowledge of certain concepts related to ontology and their practical use in computer science.
- The speaker discusses their experience in developing an expert system using ontology and its various applications in solving real problems in different domains.
- The speaker also highlights the challenges faced in the petroleum industry, including data interoperability and the reluctance of software providers to open their models.
- The speaker addresses the issue of communication barriers between different parties involved in oil drilling projects.
- The speaker discusses projects developed by Petrobras and its use of machine learning to extract patterns and collect information, as well as the company's struggle with recovering restructured information, such as documents, spreadsheets, pictures, images, maps, and technical reports from federal agents.
- They have also developed a CI/CD framework for ontological development with automated Sparkle queries and Reasoner to ensure logical consistency and 100% test coverage.
- They plan to bring in serialization technology for diffing ontologies and continue to explore the use of OWL expressions to interpret the ontology in the future.

- The speaker talks about the need for a set of tools to generate individuals for testing and to make things more domain expert friendly.
- She also highlights the challenge that ontologists often speak in a secret language that can be off-putting and discusses Melinda's approach to small modular ontologies.
- The speaker discusses the challenges of developing ontologies and the need for dedicated resources including ontologists and modelers to effectively manage the interface with domain experts.
- The speaker also suggests the need for cross-cutting concerns to be elevated to core and highlights the benefits of having a central architect or modeler with cross-domain vision to effectively manage and refactor ontologies.
- The speaker points to the EDM council for more information on the ontology portal and the college development tools funded by NIST, such as the serialization tool that normalizes repositories for easier reviews.
- The speaker discusses the need for validation and logical consistency in the framework, as well as the importance of testing the Sparkle queries with test data to ensure that the maximization works as intended.
- The speaker emphasizes the need for an open-source tool ecosystem around ontological development, similar to what exists for machine learning and data science and calls for the community to step up and contribute.

4.Conclusions

The OntoCommons Focused Workshop 3.1, entitled "Domain Ontologies for Research Data Management in Industry Commons of Materials and Manufacturing (DORIC-MM)", aimed to support the semantic landscape analysis in the materials and manufacturing (MM) field. It has brought together ontologists and MM domain experts in two interactive on-line events, a half-day one in March and a full-day one June 2021, with 115 and 76 registered participants, respectively, and a wide representation of roles, domains, and countries, therefore achieving the participation targets. The June event was proudly co-located with the 18th European Semantic Web Conference (ESWC 2021), allowing to connect with the wider Semantic Web academic community. *Via* discussions and making use of different collaborative tools, on the whole this activity has notably allowed to gather: a list of relevant domain ontologies, which have entered the associated project deliverable D3.2; a list of relevant initiatives (communicated to WP1, Cooperation); desiderata (those on tools have been communicated to WP4, OntoCommons Ecosystem Toolkit); example of use cases (as brief texts); ideas on semantic and usage landscape (what is there) and gaps (what is missing) in four domains (Namely: Physics and Chemistry, Mechanical and Industrial Engineering, Thermal and Process Engineering, Material Science); opinions and ideas about standardization, semantic technologies, and strategies (in general and for the MM field). Also, a large sub-set of the participants contributed to domain-focused expert meetings, whose outcomes are also detailed in D3.2.

Frontal presentations given in the March event have introduced community-building initiatives, such as OntoCommons itself, the IOF and the EMMC ABSL. In the June event, there was an introductory keynote on interoperability; three talks, by BOSCH, SIEMENS and DNV, presented the state-of-the art of semantic technology from an industrial perspective; a talk (by representatives of WP2, Top Reference Ontology) discussed how to build domain ontologies from widely accepted standards and how to connect to a TLO; moreover, six talks, based on workshop papers, have addressed, *via* specific examples, conceptual, technical, and cultural/political aspects, such as ontology design, ontology extension, technology uptake.

The panel discussions have pointed out that the level of standardization level is quite different in the various MM domains, and ways to fund the standardisation process have been proposed. Strategies have been suggested to bridge the gap between domain experts and ontologists, and examples of success stories in this line have been given. The role of industry was discussed from different perspectives. Opinions were gathered on the current practices and desirable ones when building a domain ontology and a system of domain ontologies (which can inform the development of the OntoCommons Ecosystem). Visualization was highlighted as an important aspect, and it was suggested the dynamic visualization techniques could be valuable to represent an ontology ecosystem such as the one OntoCommons is building.

5. Acknowledgements

We would like to warmly thank all the attendees of the 15th March and 7th June events for their impressive participation, all the speakers and panel members for their engagement and support also in the preparatory phases. Last, but not least, we would like to thank all colleagues who supported the event preparation and running.

6.Appendix A: Agenda (details)

Session name	Speaker / Panellists	Time
FOMI'22 (September 12, 2022)		
Introduction to FOMI 2022	Hedi Karray Emilio Sanfilippo	08:45 AM - 09:30 AM
Keynote speech	Stephan Grimm	09:30 AM - 10:15 AM
Functional modelling in engineering: A first comparison of approaches on two problems	Francesco Compagno	10:15 AM - 10:45 AM
Taxonomy of Manufacturing Joining Operations based on Process Characterization	Arkopaul Sarkar	10:45 AM - 11:15 AM
Ontology for Industrial Engineering: A DOLCE compliant approach	Emilio Sanfilippo Walter Terkaj	11:30 AM - 12:00 PM
The industrial Ontology Foundry (IOF)	Milos Drobnjakovic	12:00 PM - 12:30 PM
The CHAMEO ontology: Exploiting EMMO's multiperspective versatility for capturing materials character	Pierluigi Del Nostro	12:30 PM - 01:00 PM
Keynote speech	Markus Stumptner	02:45 PM - 03:30 PM
Towards an ontology of offshore petroleum production equipment	Mara Abel Nicolau Santos	03:30 PM - 04:00 PM
Requirements for an Ontology of Asset Management	Megan Katsumi	04:00 PM - 04:30 PM
Multi-perspective approach to integrate domain-specific semantics into the system model	Elaheh Maleki	04:45 PM - 05:05 PM
KIDE4Assistant: an Ontology-Driven Dialogue System Adaptation for Assistance in Maintenance Procedure	Izaskun Fernandez Patricia Casla Cristina Aceta	05:05 PM - 05:25 PM
OntoCommons (September 13, 2022)		
Introduction to OntoCommons and Roadmap	Hedi Karray	08:30 AM - 09:15 AM
Keynote speech	Elisa Kendall	09:15 AM - 10:00 AM
Upper ontology and standards for industry (Session chair: Joana Morgado)		10:15 AM - 12:00 PM

Ontology and Standards: Considerations from a formal ontologist	Stefano Borgo	10:15 - 10:45
	David Leal	10:45 - 11:20
Panel discussion: Ontology-based standardisation of Industrial data	Host: Hedi Karray Panellists: Serm Kunvantyou, Elisa Kendall, Michela Magas, David Leal, Dimitris Kiritsis	11:20 - 12:00
Upper ontology and Standards for Materials Science		10:15 AM - 12:00 PM
	Gerhard Goldbeck	10:15 - 10:45
	Emanuele Ghedini	10:45 - 11:15
Panel Discussion: Ontology and Standards for Materials Science	Host: Joana Morgado Panellists: Gerhard Goldbeck, Emanuele Ghedini, Norman Swindells, Anne de Baas, Silvana Muscella	11:15 - 12:00
FAIR Domain Ontologies for Industry		10:15 AM - 12:10 PM
Introduction and How to make Ontologies FAIR	Yann Le Frank	10:15 - 10:45
A concrete step toward FAIR ontologies : publishing ontologies in specialised ontology repositories	Arkopaul Sarkar	10:45 - 11:00
Manual evaluation : using the FAIR Semantics recommendations	Yann Le Frank	11:00 - 11:10
Automated evaluation : FOOPS !	Maria Poveda	11:10 - 11:30
OFAIRe and OntoPortal	Clement Jonquet	11:30 - 11:50
Toward the harmonisation of ontology metadata	Yann Le Frank	11:50 - 12:10
Domain ontology harmonisation for Industry (Session chair: Lan Yang, Mirco Soderi)		01:30 PM - 03:15 PM
	Emilio Sanfilippo Arkopaul Sarkar	13:30-14:00
	Barry Smith	14:00 - 14:30
	Noel Vizcaino	14:30 - 14:45
Panel discussion: Domain ontology harmonisation for Industry	Host: Izaskun Fernandez	14:45 - 15:15

	Panellists: Chris Patridge, Emilio Sanfilippo, Will Sobel, Alejandro Salado	
Domain ontology harmonisation for Materials Science (Session Chair: Gerhard Goldbeck)		01:30 PM - 03:15 PM
	Joana Morgado Dirk Helm	15:30 - 16:00
	Pedro Portella	16:00 - 16:30
Panel discussion: Domain ontology harmonisation for Materials Science	Host: Gerhard Goldbeck Panellists: Heiner Oberkampf, Dirk Helm, Alexandru Todor (TBD), Anne de Bass	16:30 - 17:15
Industrial Demonstration		01:30 PM - 03:15 PM
Cirqulor	Roy Brooks	13:30 - 14:00
SimPhoNy: knowledge-graph based interoperability	José Manuel Dominguez	14:00 - 14:30
Airbus	Rebecca Arista	14:30 - 15:15
Coffee break		03:15 PM - 03:30 PM
Keynote speech	Heiner Oberkampf	03:30 PM - 04:15 PM
Keynote speech	Chris Partridge	04:15 PM - 05:00 PM
Vote of thanks	Hedi Karray Arkopaul Sarkar	05:00 PM - 05:15 PM
Industrial Ontology Foundry (September 14, 2022)		
Welcome note and introduction	Dimitris Kiritsis	09:00 AM - 09:15 AM
Keynote speech	Serm Kulvantyou	09:15 AM - 10:00 AM
Coffee Break		10:00 AM - 10:30 AM
Production and Supply-chain (Session chair: Dusan Sormaz and Farhad Ameri)		10:30 AM -
Overview of Progress in IOF PPS ontologies	Dusan Sormaz	10:30 - 10:50
Current State of Supply Chain Refrence Ontology	Farhad Ameri	10:50 - 11:10
Enhance metamodels approach supporting Models for Manufacturing (MfM) methodology	Fernando Mas	11:10 - 11:40

Supporting Product Services Systems over the Operational Life	Oliver Stoll Shaun West	11:40 - 12:00
Panel Discussion: Production Planning and Scheduling	Host: Farhad Ameri Panelists: Will Sobel, Sebastian Scholze, Oliver Stoll, Shaun West	12:00 - 12:30
An ontological approach for Traceability in Agri-food Supply Chains	Farhad Ameri	14:00 - 14:20
An Ontology-based Engineering system to support aircraft assembly process design	Xiaochen Zheng Rebeca Arista	14:20 - 14:40
Panel Discussion: Capability	Host: Arkopaul Sarkar Panelists: Barry Smith, Stefano Borgo, Farhad Ameri, Will Sobel	15:00 - 15:45
What can ontological analyses of value and risk teach us about goals, plans, and prevention?	Jim Logan	16:00 - 16:25
Panel Discussion: Production Planning and Scheduling	Host: Dusan Sormaz Panelists: Fernando Mas, Jim Logan, Mara Abel	16:25 - 16:50
Products, Systems and Digital Twins (Session chairs: Ana Correia and Jinzhi Lu)		10:30 AM -
IOF Systems Engineering	Jinzhi Lu	10:30 - 10:45
Towards an Ontology of the Problem Domain	Alejandro Salado	10:45 - 11:00
Ontologies' role in a digital twin development	Chris Patridge	11:00 - 11:15
Ontology, Modelling and System	Ming Yu	11:15 - 11:30
Converging ontology and MBSE to support aircraft manufacturing system design	Rebeca Arista Xiaochen Zheng	11:30 - 11:45
Panel Discussion: Systems Engineering	Host: Alejandro Salado Panellists: Rebeca Arista, Xiaochen Zheng, Ming Yu	11:45 - 12:30
PSS Ontology – current status and outlook	Ana Correia	14:00 - 14:15
Product Service Systems in Industry	Giuditta Pezzotta	14:15 - 14:30

	Fabiana Pirola	
Digital twin innovation potential for the materials and manufacturing industries	Dan Isaacs	14:30 - 14:45
Digital twin innovation potential for the materials and manufacturing industries	Michel Sauvage	14:45 - 15:00
Products and Services bridge concepts	Francesco Antonio Zaccarini	15:00 - 15:15
Panel Discussion: Products and Services	Host: Ana Correia Panelists: Dragan Stokic, Xiaochen Zheng, Sebastian Scholze, Marcela Vergeti, Gabriela Henning	15:15 - 15:45
Standards-Based Self Aware Manufacturing Systems	William Sobel	16:00 - 16:15
Digital twins and the problem of model-induced escape	Barry Smith	16:15 - 16:30
Impact of digital twin innovation in the industrial sector	Sjoerd Rongen	16:30 - 16:45
Materials, Quality and Maintenance (Session chair: Foivos Psarommatis, Thomas Hanke, Melinda Hodgekiewicz)		
IOF Maintenance Reference ontology	Melinda Hodgekiewicz	10:30 - 10:45
Data cleaning - a practical and value-adding use case for modular ontologies	Melinda Hodgekiewicz	10:45 - 11:00
Are ontologies a practical solution to digitalising maintenance?	Pavan Adapalli	11:00 - 11:15
Ontology-Based Maintenance: The Use Case of BLMGroup in Ontocommons	Francesco Campagno	11:15 - 11:30
he role of ontologies in Industrial environments and challenges	Alessia Focareta	11:30 - 11:45
Panel: Maintenance	Host: Pavan Adapalli Panelists: Melinda Hodgekiewicz, Hedi Karray, Stefano Borgo, Emilio Sanfilippo, Yves Keraron	11:45 - 12:25
IOF Materials Science and Engineering Workgroup	Thomas Hanke	14:00 - 14:15

Matportal.org The Repository for Materials Science and Engineering Ontologies	Alexandru Todor	14:15 - 14:30
IOF/Mat-o-Lab Toolchain	Thomas Hanke	14:30 - 14:45
Panel Discussion: Materials Science	Host: Thomas Hanke Panelists: Gerhard Goldbeck, Alexandru Todor, Henk Birkholz	14:45 - 15:25
Zero Defect Manufacturing is the next standard for quality assurance	João Pedro Mendonça	15:25 - 15:45
The role of terminology standardization in the quality assurance domain	Yusuf Yilmaz	16:00 - 16:15
The role of semantics in Industrial IoT (IIoT) towards Zero Defect Manufacturing	John Soldatos	16:15 - 16:30
Systems modelling with Information Modelling Framework (IMF) and the impact to the manufacturing industry	Arild Waaler	16:30 - 16:45
Keynote Speech	Mara Abel	05:00 PM - 05:45 PM
IOF Governance and Architecture	Will Sobel	05:45 PM - 06:15 PM
Industrial Demonstration (September 15, 2022)		
Welcome and Summary	Arkopaul Sarkar	08:45 AM - 09:00 AM
FOMI poster presentation		09:00 AM - 10:00 AM
Towards An Open Translation Environment for Supporting Translators in The Material Domain	Florina Piroi	09:00 - 09:15
Bring together model and business ontologies for protective coatings	Salim Belouettar	09:15 - 09:30
Use of ontologies to structure and manage digital technical data of industrial assets: First steps towards an ecology of knowledge in multi-energies industry	Jean-Charles Leclerc	09:30 - 09:45
An implementation of OWL-S to Support Semantic Discovery for SWIM	Luís Antonio Rodriguez	09:45 - 10:00
Industrial presentation (Perpetual Lab)	Gianmaria Bullegas	10:00 AM - 10:30 AM
Industrial Presentation (Total Energies)	Jean-Charles Leclerc	10:30 AM - 11:00 AM
Training session 1 - How to develop ontology following OCES methdology	Emanuele Ghedini Arkopaul Sarkar	11:30 AM - 01:00 PM

	Francesco Zaccarini	
Training session 2 - FAIR Implementation Profiles	Barbara Magagna Yann Le Franc	11:30 AM - 01:00 PM