EMMC-CSA

European Materials Modelling Council

H2020-NMBP-CSA-2016

NMBP-24-206

Network to capitalize on strong European position in materials modelling and to allow industry to reap the benefits

Start date of the project: 01/09/2016
Duration: 36 months

Title of Workshop	**EU Industry Days 2019**

TECHNICAL REPORT

Date		5-6 February 2019
Venue		The Egg, Brussels, Belgium

Organiser	European Union
Contributing beneficiaries	GCL

This event has received funding via the EMMC-CSA project from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 723867

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1. Executive summary

1.1 Description of the meeting and objectives

EU Industry Days 2019 was held from 5-6 February 2019 in Brussels. The conference focused on key industrial challenges such as sustainability, digitalisation, investment and globalisation. The event aimed to demonstrate how EU industrial policy benefits European citizens and to provide input for future policy making. There were around 1,500 participants from across Europe and beyond, including stakeholders representing industry, trade unions, national and regional authorities, and civil society.

EMMC organised a Stakeholder Session "Data for Materials and Manufacturing". The main question to answer was, how to increase European capacity to extract knowledge from materials and manufacturing data? A huge wealth of data remains untapped within silos, unused for impacting on innovation in materials and manufacturing. A strategic approach to digitalisation is required involving stakeholders from materials, manufacturing and digital technologies: an alliance pursuing the goal of a common semantic basis ensuring access to and interoperability of data.

***Webpage*: https://ec.europa.eu/info/policies/business-and-industry/eu-industry-days-2019_en**
***Session Recording:* https://player.cdn.tv1.eu/player/macros/eu/eid-1200datainmat_060219**

1.2 Major outcomes and recommendations

The impact and opportunities associated with data in materials and manufacturing, chemical and other process industries is an area of increasing importance. It is highlighted, discussed and advanced in widely including EMMC, Factories of the Future PPP and EFFRA, SusChem and SPIRE.

Delivering on these opportunities within Industry 4.0 requires adding meaning to data (semantics), enabling interoperability and linking up silos. The huge benefits of structured data, common knowledge frameworks and interoperability were demonstrated and the importance of supporting uptake of such digital technologies in industry emphasised. Benefits include higher efficiency of materials use, improved manufacturing value chain interactions and new business model opportunities. Current lack of semantics and interoperability are key barriers to accessing the value hidden in raw data (estimated to be 36 billion Euros) and to improved decision making. Ontologies are a core element of a set of solutions proposed by the panel and endorsed by audience contributions. All stakeholders are encouraged to collaborate and create a harmonised semantic knowledge framework open to everyone. Investments in a workforce trained in digital skills including semantic technologies is needed. The importance of overcoming 'non-technical' challenges such as legal, regulatory, security, data-sovereignty was highlighted. Building a system of trust and rewards for data sharing is required. Such a system, together with widely agreed ontology would enable Digital Marketplaces as an efficient way of realising Industry Commons. An audience poll showed a big gap between the need for and current capability in data interoperability and semantic technologies. It confirms the need for action in this important field underpinning successful digitalisation of materials and manufacturing. Strong interest was expressed in working across domains in an alliance for digital materials and manufacturing.

The major outcomes of the Session are:

1. There is a large need for an integrated knowledge framework to generate value from data (**ontology**)
2. The need for an ecosystem to share **data** was ubiquitous. The audience is convinced that exchange and collaboration have to be based on a **common** ontology.
3. **Non-technical issues** such as trust, security, skills and building an eco-system of communities need to be addressed with equal importance.

- **Data:** The present net value hidden in raw data is estimate to be 36 billion Euros and a report of the World Economy Forum states that 70% of data are not used today.
    - Before talking about what to do with data one needs to be able to access the data in the first place and there are still data in non-digital space such as isolated excel spreadsheets. Data needs to be made accessible and stored, whereby the latter requires infrastructure. Only then data analytics can commence.

- Raw data need to be linked to knowledge otherwise nobody can get insight. Linking data is a big issue, as it is paramount to gain even more information. They main issues preventing usage are data interoperability and silos.
- Raw data can be only the starting point of sharing and as value needs to be added, one also needs to consider how to share models, simulations, ontologies, explanations of A.I. algorithms, etc.
- The sources of data have to be identified. Also, there need to be incentives why someone should share their data at all.
- Data have to be collected and managed. A sophisticated mechanism for sharing the data is still missing.
- Europe wide data usage is still in its infancy. It is very important to find out where the data should be used and which operational business issue should be achieved? Also, what kind of data is needed? Are they in house or do they have to be brought in from elsewhere? How are different data combined with each other, if they are from different sources? Can ontology and semantics be brought in?
- Legislation around data usage will be required. It needs to be established who can use which data, who will monitor the data usage, who is liable w.r.t. the quality of data.
- Data networks across Europe will have to be established and they need to serve a more hierarchical use but also on-the-fly collaboration in a dynamic environment which will be likewise important. Thus, better and more powerful tools will be required.
- Investments in standards and technical solutions are important as well as regulations to allow data providers to control which data they are willing to share.

- **Semantic technologies (Terminology, Taxonomies and Ontologies)** are paramount to make Digital Materials and Manufacturing possible. They need to be carefully developed and they should be agreed on by all stakeholders.
  - Ontologies are powerful solutions to get data out of silos, with the objective to not destroy the silo but making data FAIR.
  - The EMMC has taken a lead in the materials and modelling field with the development of EMMO (European Materials Modelling Ontology).
  - There are a number of other initiatives and developments and it will be pertinent to build collaboration networks as a variety of stakeholders with different domains are involved.
  - All stakeholders are encouraged to collaborate and create a harmonised semantic knowledge framework that defines principles and processes to create interoperable ontologies and these ontologies would be open to everyone. Thus, all stakeholders should be encouraged to work on this together.
- **Non-Technical Issues**: Addressing a range of non-technical issues is key to success. These include building a system of trust and reward, addressing legal and regulatory challenges, security and data sovereignty issues as well as building communities and a skilled workforce (see below).

- **Communities:** The initiative Industrial Ontologies Foundry (IOF) is there to advance the interoperability in several manufacturing fields. The European Union has brought many fruitful associations to life such as A.SPIRE, PPPs. Each of these should still serve the domain it was created for to not water down the outcomes. However, these association should be come more transparent so synergies can be found. Larger international associations will play a role in driving digitalisation further.
- Public-private partnerships, or PPPs, are established for dedicated industries to co-create processes and inspire knowledge. PPPs should remain domain specific to preserve a high value of domain knowledge, but made transparent and leverage synergy, preferably without duplicating efforts.
- **Skills:** Ontologies are complex artefacts and there is not a lot of training provided when people become software engineers, database experts, data analysts etc. It is relevant to know how to use an ontology in data analytics processes and how to integrate it with relevant software.
- More digital, semantic technologies and big data skills have to be established within the stakeholder community. EU lacks these skills and training is required. The various panels identified employers as the main responsible for training provision. However, also schools should play a major role in training a new digital aware generation.

- **Need for action:** An audience poll showed that there is considerable gap between need for and current capability in data interoperability and semantic technologies. It confirms the need for actions in this important field underpinning successful digitalisation of materials and manufacturing.
- **Current Actions**: EMMC has spearheaded the development of the European Materials Modelling Ontology covering all types of materials and models. IOF aims to create a set of core and open ontologies that spans the entire domain of digital manufacturing. SusChem has put the spotlight on digital technologies. EFFRA has prepared a road-map including insights about Data analytics, artificial intelligence, machine learning and deployment of digital platforms in manufacturing. EFFRA and BDVA (Big Data Value Association) have signed a MoU that highlights the importance of data in manufacturing.
- **Alliance for digital materials and manufacturing:** There is strong support to work on an alliance of stakeholders and interest groups including IOF and EMMC to further the aims of digital materials and manufacturing based on semantic technologies. Many participants showed interest and provided their contact details for further involvement.

2. Progress report (main activities)

2.1 Stakeholder Session "Data for Materials and Manufacturing"

2.1.1 Panellists are setting the scene

Where we want to get to is to increase interoperability, make information more transparent, to provide technical assistance to support decisions based on data of materials and of processes, decentralised decisions, and finally, systems to make decisions on their own.
The work of the EMMC is very important, as it brought standards to materials modelling, i.e. materials modelling terminology and classification and development of the European Materials Modelling Ontology.
What should be addressed is how we can have more integrated knowledge and what is the foundation for that? As we are dealing with humans and machines, how can we find an interface? How can we exchange data with technology, but also bring the human factor in as sustainability can not be maintained by a solely technical solution?

Riikka Virkkunen, VTT, Factories of the Future and EFFRA representative, addressed challenges and opportunities in manufacturing. Considering for example the Internet of Things (IoT), the factory emerges as a huge place where value can be created from IoT and data (an estimate of 1.2-3.7 trillion USD, Mac Kinsey Report 2015, https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world).
Factory operations have two times more of that value compared to many other settings. There are success stories from industry that show the practical advantage of data. For example, VTT and a Finnish paper mill have set up an advanced analysing system to optimise the paper mill's processes in terms of materials usage and quality. After installing the system, the pulp mills are saving 700 truckloads/year/mill in transporting materials. Further, users of the pulp are also benefitting, as they are saving in material and energy usage, and they always receive the same quality of pulp. Another example was provided from the steel industry were data is collected during the manufacturing process, and shared in the value chain. The material end users, for example, in the car industry can reach best quality and exploit data in their product development. Yet another important digital manufacturing area is additive manufacturing where the interplay between materials and manufacturing is very tight. Therefore, design for additive manufacturing is heavily relying on data, modelling and simulation. Additive manufacturing spare parts is also attracting domain as digital models can be stored rather than physical ones which allows quick supply of critical parts and totally different business models. Despite these success stories, the question may be raised, where the barriers are and why is digitalisation of manufacturing has not happened extensively. It is very important to identify where the benefits are and which operational or business issue should be archived. Also, what kind of data is needed: is the data available in-house or does it they have to be brought in from elsewhere? Only then comes the question how data from different source can be combined with each other and what kind of ontologies and semantics should be brought in. A sophisticated mechanism for sharing data are still missing.

Martin Winter, CEFIC, is involved with A.SPIRE, which is a European Association which is committed to manage and implement the SPIRE Public-Private Partnership. It represents innovative process industries, 20% of the total European manufacturing sector in employment and turnover, and more than 130 industrial and research process stakeholders from over a dozen countries spread throughout Europe. SPIRE brings together cement, ceramics, chemicals, engineering, minerals and ores, non-ferrous metals, steel and water sectors, several being world-leading sectors operating from Europe. The mission of A.SPIRE is to ensure the development of enabling technologies and best practices along all the stages of large-scale existing value chain productions that will contribute to a resource efficient process industry. Larger international associations will play a role in driving digitalisation further. 3D printing of catalysts was used as an example for what advanced technologies can thrive within such projects.
Digitalisation can be seen as a toolbox as long as one can add transparency to areas it should work on, such as supply chains. Europe has excellent knowledge in academia, so there need to be faster routes to bring them to industry to catch up with China's leadership in A.I. deployment and this is how certain projects like A.SPIRE can help.

Hedi Karray, INP Toulouse, emphasised the need to move from raw data to knowledge, and to the insight one can infer from this data. The sources of data have to be identified and there is already a big move to collect and manage big volumes of data. There is still a big issue how to link these data together, as the linking is paramount to gain even more information. The present net value hidden in raw data is estimate to be 36 billion Euros and a report of the World Economic Forum states that 70% of data are not used today. The main issues preventing usage are data interoperability and silos. A good example is the Airbus 380 programme where huge costs were incurred due to an interoperability (or lack of common semantics) problem between engineering design teams in Germany and France.

Uli Sattler, University of Manchester, defines an Ontology as something that provides models and shared understanding to get data out of silos and to make better use of them. Ontologies are more than just controlled vocabularies, they are rich logical theories. There are examples of ontology use around in day-to-day life. Governments are making use of terminologies in death certificates where annotations are used to enable statistics on a national level. Causes of death can decide, where to poor public money into, i.e. cancer or heart attack prevention or similar.
Ontologies allow to model domains in a multidimensional way. A few small hierarchies are built and linked via relations - this avoids a term explosion and makes content manageable. The success of ontologies is around terminology building and maintenance. For example, Statoil in Norway together with Siemens built visual query interfaces to allow gas and oil domain experts to query data in their domain ontology without them being ontology experts. This is an example how a semantic net can lead to better decisions.

2.1.2 Response from the Audience

Dr Amaya Igartua, EuMaT (European Technology Platform for Advanced Engineering Materials and Technologies) contributed an example in tribology where ontologies have to address materials, materials characteristics (e.g. defined by EMMO) but also the materials during its production and usage (damage, transformation, ageing, …). Tribologists need materials' properties but also their transformation. There is a need for a manufacturing ontology. The question arises how one can select/integrate the right ontology(ies) as the materials have to be seen as materials *per se*, but also might transform during the whole life cycle (manufacturing, use, recycling, …). These are both challenges but also opportunities. It is of interest to look at the value chain from design to the final product and collect data; the challenge is then to make data understandable between different stakeholders. Each of the stakeholders have their own ontology, and these ontologies suffer often from not being interoperable. This problem does not only arise with materials. The findings can be described quite easily but it becomes complicated when the process leading to these finding, should be described. Processes are important as they define the output. The process needs to be described in an interoperable way as well and standard ontologies do not make this very easy. People do work around this problem and more work will be required. In the EU -TRIBOMAT Project, we are facing this challenge.

Sergio Gusmeroli, Politecnico di Milano and Big Data Value association (BDVA), has looked into 56 research and innovation challenges (inspired by the five BDVA research agenda topics of data management, processing, analytics, security and visualising) for the joint communities which have been specified and classified in the three Grand Scenarios of Smart Factory, Smart Product and Smart Supply Chain scenarios. They produced a paper, Big Data Challenges in Smart Manufacturing: a discussion paper for BDVA and EFFRA Research & Innovation roadmap alignment (http://www.bdva.eu/node/1002), which aims at identifying major research and innovation challenges for data-oriented Factories of the Future in 2025. It originates from a cross-domain collaboration between the Smart Manufacturing Industry subgroup of the BDVA cPPP (Big Data Value Association contractual Public Private Partnership, http://www.bdva.eu/) and the Connected Factories cluster of the FOF cPPP (European Factories of the Future Research Association, http://www.effra.eu/).

They identified technical challenges and non-technical challenges, with current focus being on the latter. These challenges include legal and regulatory ones, who is the owner and who is the provider of data, security and data sovereignty issues such as what are the rights of the data provider with respect to data consumers and passage and usage of data. These challenges also include trust and reward from an academia perspective, i.e. raise the questions why should one share data at all. There is also a focus on skills as digital and big data skills have to be established within the stakeholder community.

Three different scenarios are looked into when it comes to data monetisation for consumers: Open data scenario, data market place scenario and trusted network of closed data. However, more scenarios are needed as consumers will consume data differently.

Raw data can be only the starting point of sharing and as value needs to be added, one also needs to consider how to share models, simulations, ontologies, explanations of A.I. algorithms, etc.
Trusted networks are hierarchical (e.g. automotive, aerospace manufacturing chains) and control can be better enforced. One can monitor who is using what data, and when and how, and also control and check access. This model is not very compatible with the aims and opportunities of digitalisation (based on de-centralised and quasi-autonomous decisions) and will not work for on-the-fly collaboration in a dynamic environment which will be important. Thus, better and more powerful tools will be required.

Oscar Lázaro, INNOVALIA and Boost 4.0 Lighthouse Initiative (https://boost40.eu/objectives/), heads an initiative that will lead the construction of the European Industrial Data Space to improve the competitiveness of the European Industry with a particular focus to Automotive Industry. Boost 4.0 will work to accelerate the adoption of Big Data and advanced analytic solutions in the European Industry with a look at the impact of the Big data across the different phases of the product and service lifecycle. Boost realizes this through a structured adoption and alignment of global standards, open APIs, secure digital infrastructures, trusted Big Data Middleware and digital manufacturing platforms. The consortium consists of 50 companies from 16 countries – including Volkswagen, Volvo and Siemens among others. The funding by the EU amounts to 20 million Euro, plus 100 million Euro in private investment. They aim to build pilots that remove barriers and uncertainties and realise there is not a single ontology that can serve Industry 4.0 effectively across the full lifecycle. It is better to put ontologies together and build a clear value proposition out of them for a mission focused operation.

European Factories of the Future Research Association (**EFFRA**): As there is no ultimate ontology, use cases are important to show how data are used and which ontology has been used and worked. This can be inspirational for others. From these use cases, interoperability, security and standards are extracted as main information and also what the added values were. Thus, these dimensions already form the framework of an ontology.

2.1.3 The Panellists offering solutions and actions

There will be not only one single solution as the area is quite complex. Several EU initiatives and programmes have a very important role. Vision papers and concrete examples are very important to share concerns and success stories. Investments in standards and technical solutions are important as well as regulations to allow data providers to control which data they are willing to share. SMEs are expected to have difficulties with adoption but digital innovation hubs and data

shares around the hub can help them to become part of the digitalisation process. A sort of platform economy built up from different sectors may aid as well.

Before talking about what to do with data one needs to be able to access the data in the first place and there are still data in non-digital space such as isolated excel spreadsheets. Data needs to be made accessible and stored, whereby the latter requires infra structure. Only then data analytics can commence.

Materials and Manufacturing is complex. It comprises understanding of the materials, the processes these undergo during manufacturing and the end product and its life cycle. To digitalise the process from cradle to grave, or with the advent of circular economy, from cradle to cradle, interoperability between all stages is key. Several EU initiatives and programmes have a very important role. Vision papers and concrete examples are very important to share concerns and success stories.

IT/OT convergence is needed and it is defined as the integration of information technology (IT) systems used for data-centric computing with operational technology (OT) systems used to monitor events, processes and devices. Both is need to make adjustments in enterprise and industrial operations. Only 10 years ago theses were completely separated. Public-private partnerships, or PPPs, are established for dedicated industries to co-create processes and inspire knowledge. PPPs should remain domain specific to preserve a high value of domain knowledge, but made transparent and leverage synergy, preferably without duplicating efforts.

Ontologies are a solution to get data out of silos, with the objective to not destroy the silo but making data accessible and usable. The idea is to have hybrid knowledge graphs with local and external data, so that private paths in the graph can be established. What is needed is getting a big view of all existing data and from this big view one can create data sets for machine learning, visualisation and ways how to find the correct data. It is possible to share models without sharing data. The initiative Industrial Ontology Foundry (IOF) is there to advance the interoperability in several industry fields. To create “the big ontology” step by step one wants to create small models first which need to be interoperable. In the higher framework one tries to define principles and processes to create interoperable ontologies and these ontologies would be open to everyone. Thus, all stakeholders should be encouraged to work on this together.

Ontologies are complex artefacts and there is not a lot of training provided when people become software engineers, database experts, data analysts etc. It is relevant to know how to use an ontology in data analytics processes and how to integrate it with relevant software.
Ontologies not only need to be designed but also need to be maintained and should be used. The landscape is moving fast and in terms of training a lot more is needed.

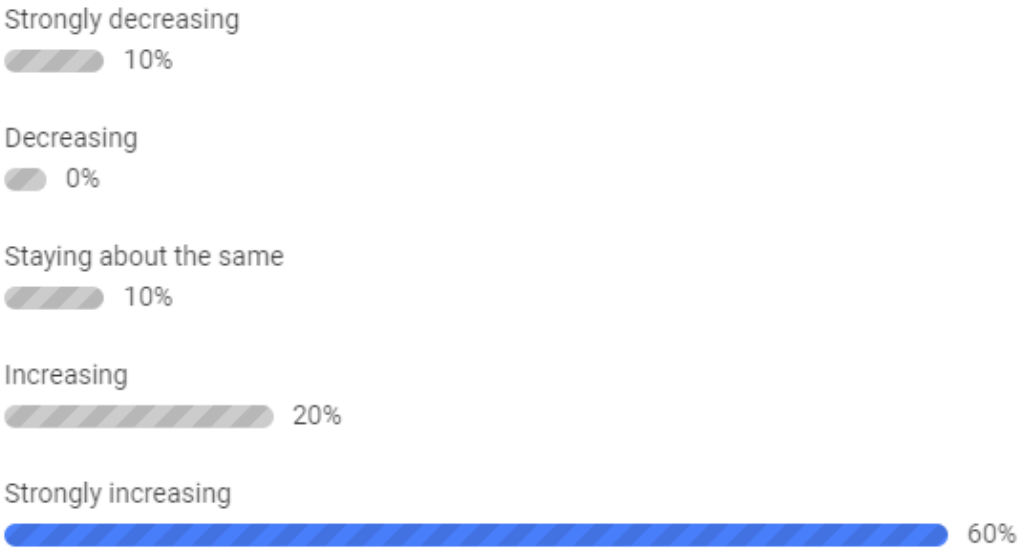
2.1.4 Response from the Audience and final panel comments

Many projects developed ontologies and they died once the projects were accomplished. To avoid this the core development of an ontology should be in a small group that understands the ontology well and can actively use it. Only then it should be permitted to go beyond this small group and scale up slowly. It is beneficial not to develop the "the ontology of all things" straight away.
Members of the audience voiced some scepticism when it came to using ontologies in manufacturing to define a project. They see regulation dependent on local knowledge, and cannot envisage an ontology to bridge this gap.
The panel suggested to **emphasise on shared conceptualisation**, and that shared understanding is needed. Building this understanding is very complex so **collaboration will be important**.
The development of **standardised tools** is required but needs time, so a **common roadmap** is important. Otherwise new semantics may emerge and the stakeholders drift towards individual rather than global solutions. Thus, **different stakeholders need to come together** and find an agreement.

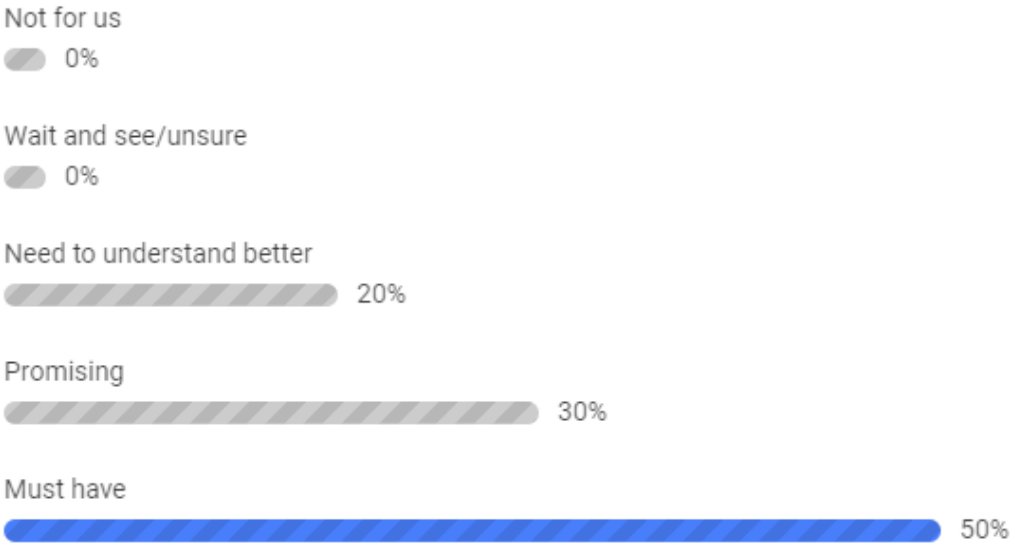
2.1.5 Poll Results

Six questions where put to the audience and the answers are shown in screenshots below. Results demonstrate strong attention to and need for digital materials and manufacturing, data re-use and interoperability, accompanied by a relatively high level of knowledge about digital technologies in general. However, capabilities regarding data interoperability and knowledge about semantic technologies and ontologies are currently rated as rather low. The considerable gap between need for and current capability in data interoperability and semantic technologies confirms the need for actions in this important field underpinning successful digitalisation of materials and manufacturing.

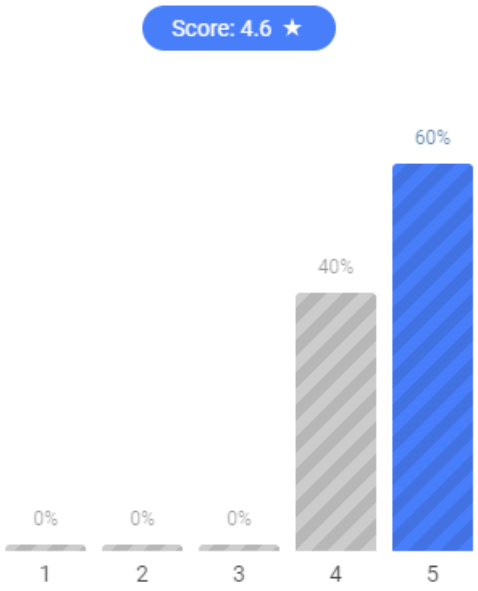
What is the trend for your organisation's attention to digital materials and/or manufacturing technologies? 10



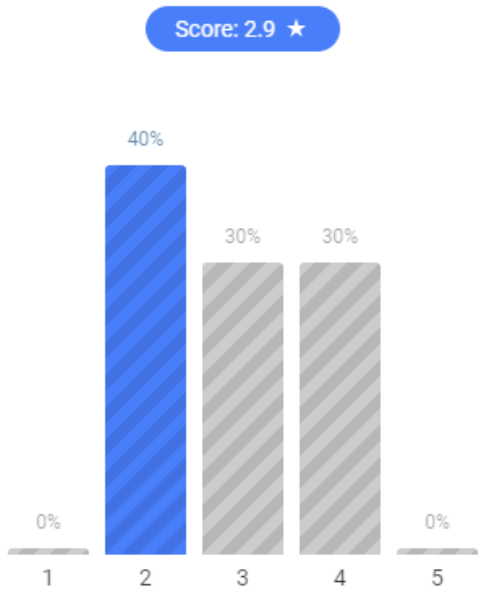
What is your organisation's view about digital materials and/or manufacturing? 10



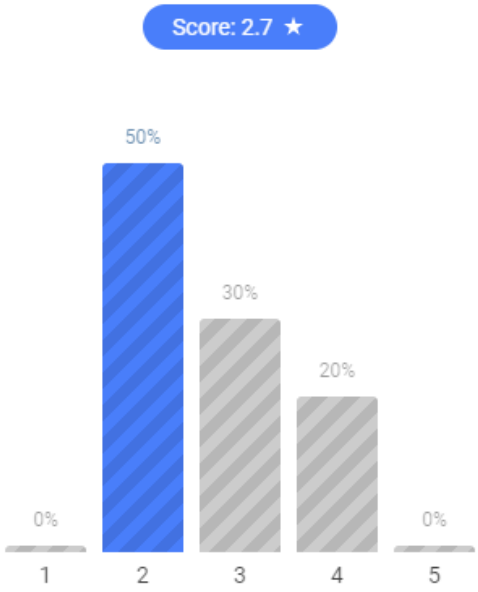
How would you rank your organisation's need for data re-use and interoperability? Rank from 1 (low) to 5 (high) 10



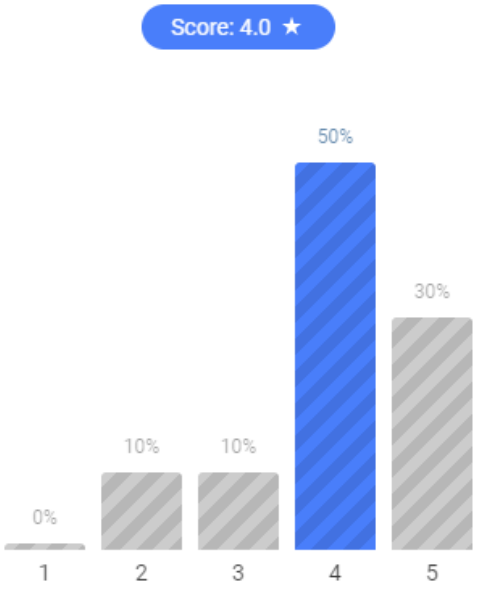
How would you rank your organisation's capability for data re-use and interoperability? Rank from 1 (low) to 5 (high) 10



How would you rate your organisation's knowledge level about semantic technologies/ontologies? Rank from 1 (low) to 5 (high) 10



How would you rate your organisation's knowledge level about digital technologies? Rank from 1 (low) to 5 (high) 10



3. Conclusions

Actions

- Continue to understand the European Data Landscape and nurture efforts of making data accessible and interoperable
- Continue to use the EMMO as "icebreaker" to raise awareness in the community that ontologies will have to be interoperable to fully capture the manufacturing process.
- Be part of EU associations and build strong collaborations.
- Continue to provide training materials on all aspects of digitalisation.
- Make sure to leave nobody behind and find ways that all stakeholders can take part on the digitalisation process.

4. Annex 1: Session Outline

The session was conducted in the form of a panel elaborating on enhancing competitiveness of European manufacturing companies on the basis of knowledge extracted from wide-spanning data sets and on how to promote and realise the benefits of semantic data technologies for enhancing the usability and impact of data for innovation and automation.
Panelists did reflect on the above challenge in a series of impulse statements on following topics
(a) industry success stories, (b) industry needs and key barriers, (c) solution approaches and proposed actions
After each topic, there was a discussion involving key interest groups (e.g. EUMAT, EPPN, EMCC) and the wider audience.
Session flow:
Short introduction of the theme and introduction of panelists by the moderator (5 min)
Individual statements of panelists on success stories, needs, barriers, solution approaches and proposed actions (25 min)
Pre-arranged questions/contributions from stakeholder groups represented in the audience and responses by Panel (25 min)
Open questions from the floor and discussion – 30 min
Wrap-up and closing by moderator (5 min)

5. Annex 2: Participants List (Session Panel)

- Gerhard Goldbeck, Director, Goldbeck Consulting Ltd: Moderator and representing European Materials Modelling Council (EMMC).
- Riikka Virkkunen, Research manager, Digitalizing Industry, VTT and EFFRA Board Member.
- Martin Winter, Innovation Manager, Cefic Innovation, SPIRE Public Private Partnership Advisory Group & Digital Technologies. European Chemical Industry Council.

- Hedi Karray, Associate Professor of Informatics, INP Toulouse- ENIT: Successes, barriers, advancing data interoperability: Industrial Ontologies Foundry.
- Uli Sattler, Professor of Computer Science, University of Manchester: Research and skills challenges: the need for European coordination in ontologies, a priority for AI research/funding, training needs and opportunities.

6. Annex 3: Workshop Photos