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Publishable Executive Summary

AIMS5.0 is a pan-European initiative to boost industrial competitiveness through inter-disciplinary innovations, establishing sustainable Electronic Components and Systems (ECS) value chains and therefore contributing to European Digital Sovereignty by addressing urgent issues like Security of Supply, Monitoring and Crisis Response, and Chip Shortage.

This deliverable is part of Work Package 4 (WP4) to build an Open Access Platform (OAP), which will enable the exchange of knowledge graphs within the supply chain of the semiconductor industry domain. The vision is that users can contribute to the platform by adding information and collaboratively refining it while ensuring the information is valid and accurate. Additionally, the OAP should support ontology learning, validation, and manual post-processing. In charge of WP4 are Infineon Technologies AG, DAC.digital, Fern Universität Hagen, and NXP Semiconductors.

Initially, the first deliverable (D4.1) centered on introducing Infineon Technologies AG (IFAG) and the semiconductor industry. Afterward, a closer look was taken at the Digital Reference (DR) and their existing areas, which mainly revolve around sustainability. The discussion delved into greater detail regarding various applications, including conventional and battery-powered vehicles, solar photovoltaic technology, wind turbines, and transportation. Additionally, demonstrations were provided to showcase the practical applications of these technologies.

As a part of the AIMS 5.0 European Funded Project several deliverables in the form of reports are to be submitted. This document, D4.2, Digital Reference 2, is an extension of the first deliverable, D4.1, Digital Reference 1. The purpose of D4.1 was to evaluate and the extension for sustainability for the internal semiconductor supply chain. D4.2 will cover the extension of sustainability for the external supply chain.

D4.1 section 6 discusses the CO2 burden of the internal supply chain in regards of the semiconductor industry. The purpose of the D4.2 is to elaborate further on the external supply chain, for example in the automotive or in renewable energy generation supply chains. In addition to the burden, we also propose a more prospective view and focus on the potential for CO2 savings within the external supply chains with the application of semiconductors within the specific industries, for example the automotive and renewable energy generation industries.

In addition, D4.2 will discuss the status of the Digital Reference, as well as future extensions to be integrated. A discussion on the Open Access Platform with the focus groups defined together within Work Package Four will also be presented. The primary goal should be to expand the DR to cover the external supply chain. Therefore, the deliverable presents and explains the findings from the three focus groups of the OAP, which were developed collaboratively with project partners. The three focus groups include Production Planning, Quality Management, and Sustainability.

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1. Introduction

1.1 Objective and scope of the document

AIMS5.0, a collaborative Innovation Action aims at strengthening European digital sovereignty in comprehensively sustainable production, by adopting, extending, and implementing AI-enabled hardware and software components and systems across the whole industrial value chain to further increase the overall efficiency. The project is a large and complex European innovation action, requiring adequate management and quality assurance structures. The key characteristics of the Chips JU project are:

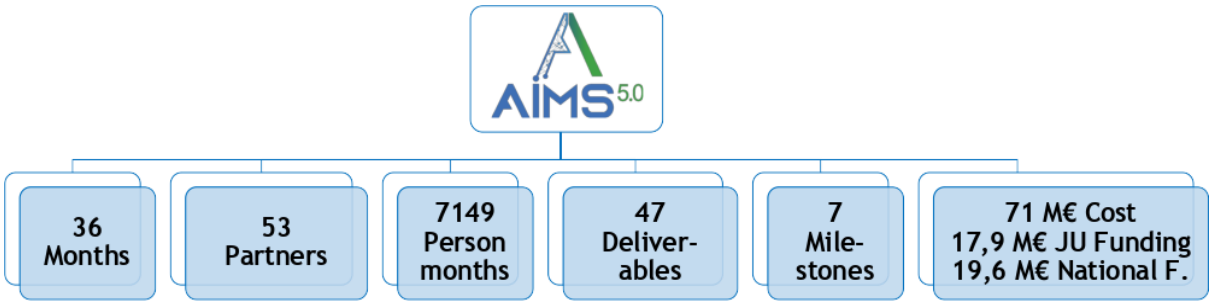

Figure 1: AIMS5.0 key characteristics

The Work Package 4 (WP4) discussed in this deliverable strives to build an Open Access Platform (OAP), which will enable the exchange of data via semantic web technology within the supply chain of the semiconductor industry domain. The so-called Digital Reference (DR) serves as the basis structure of this OAP. The DR is a Semantic Web-based ontology that represents entities being relevant for semiconductor manufacturing and manufacturing employing semiconductors.[1]

The objective of Deliverable 4.2 is to enhance the work already accomplished in Deliverable 4.1 by refining it further. The main objective is to extend the scope of the Digital Reference (DR) to encompass the external supply chain. An external supply chain refers to the network of individuals, organizations, and resources involved in the production and delivery of goods and services outside of a particular company or organization. This includes suppliers, manufacturers, distributors, retailers, and customers who are all involved in the process of bringing a product to market.

As a result, the deliverable outlines and clarifies the results from three focus groups of the OAP, which were formed in collaboration with project partners. These focus groups consisted of Production Planning, Quality Management, and Sustainability.

1.2 Structure of the deliverable report

This deliverable is structured as follows, an introduction to the automotive and the renewable energy generation supply chains with the inclusion of semiconductors will be explained. Thereafter, a brief introduction to the digital reference in addition to the updates to the digital reference will be elaborated on. In addition, the current and future work with the specification of the open access platform with its three focus groups will be highlighted.

2. Introduction to the External Supply Chain including semiconductors.

Within deliverable 4.1 the internal semiconductor supply chain as well as the manufacturing process was described in detail. Within deliverable D4.2 the external supply chains of the automotive and renewable energy generations industries will be explained.

2.1 Renewable Energy Generation Supply Chain

The renewable energy supply chain involves several activities regarding the production and distribution of renewable energy. There are different renewable energy supply formats for example wind, solar, hydro, and geothermal sources, each source has its individual supply chain. With various decarbonization policies and the transformation to low carbon economies, the prevalence of renewable energy is ever growing. For D4.2, where the evaluation also includes the semiconductors involvement in the supply chain, solar photovoltaic (PV) supply chains will be introduced.

Photovoltaic (PV) systems are among the most popular solutions for reducing carbon emissions and increasing the proportion of renewable energy in the grid. Yet, the renewable sector faces a significant challenge in maintaining equilibrium between supply and demand. The energy produced by PV modules can vary significantly based on weather conditions. However, smart grid management combined with energy storage system can help overcome the obstacle of phasing out fossil fuel-based energy sources. PV panels generate electricity in the form of direct current (DC) that needs to be transformed into alternating current (AC) before it can be integrated into the grid for local consumption or transmission to the usage point. This conversion from DC to AC is facilitated by solar inverters (Infineon Technologies). The PV supply chain can be seen in figure 2 showing all the various stages of production.



Figure 2: Redaction of the PV supply chain process [8].

The PV value chain begins with sourcing silicon and refining it into high quality polysilicon. Polysilicon is converted into ingots and sliced into wafers. Wafers are converted to solar cells through a series of chemical and physical processes such as screen printing of silver contacts. Module assembly involves electrically connecting all the cells together, sandwiching them between layers of glass and encapsulating them in an aluminum frame. Finally, inverters convert the electrical energy generated to electrical energy we can consume [5]. Infineon Technologies are a large supplier of electrical inverters such as their IGBTs, MOSFETs, CoolGaN™ and CoolSiC™ MOSFETs [6].

The landscape of the solar PV supply chain has changed drastically in the last 15 years. China's solar PV industry scale-up has been rapid – from zero to 300GW capacity in 15 years [7]. Today China's share in all the manufacturing stages of solar panels (polysilicon, ingots, wafers, cells and modules) exceeds 80% which is more than double China's share of global PV demand [8]. China has been instrumental in bringing down the levelized cost of Solar (LCOS), however, at the same time the level of concentration in global supply chains is a potential risk that governments need to address.

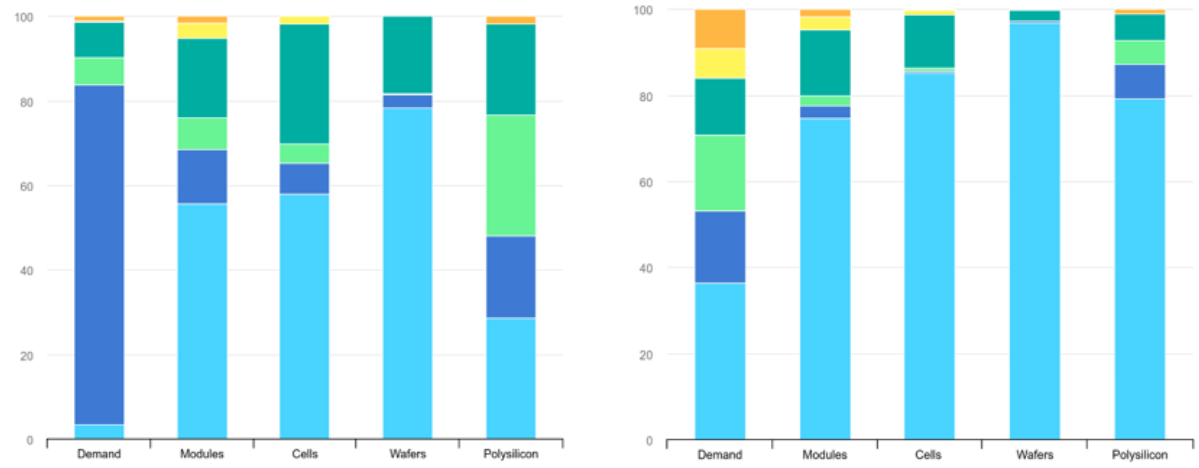

Figure 3: Solar PV manufacturing capacity share by country/region. 2010 on left, 2021 on right [8].

2.2 Automotive Supply Chain

The automotive supply chain is a network of organizations, resources, and activities involved in the design, production, and delivery of vehicles to end customers. Various suppliers and stakeholders, including semiconductor manufacturers, are involved in the value chain of the automotive supply chain. Understanding the complexity of not only the semiconductor supply chain but also the entire automotive supply chain is crucial to understanding the interworking parts to produce a product, in this case an automobile. Figure 4 depicts the value chain members of the generic automotive supply chain [9].

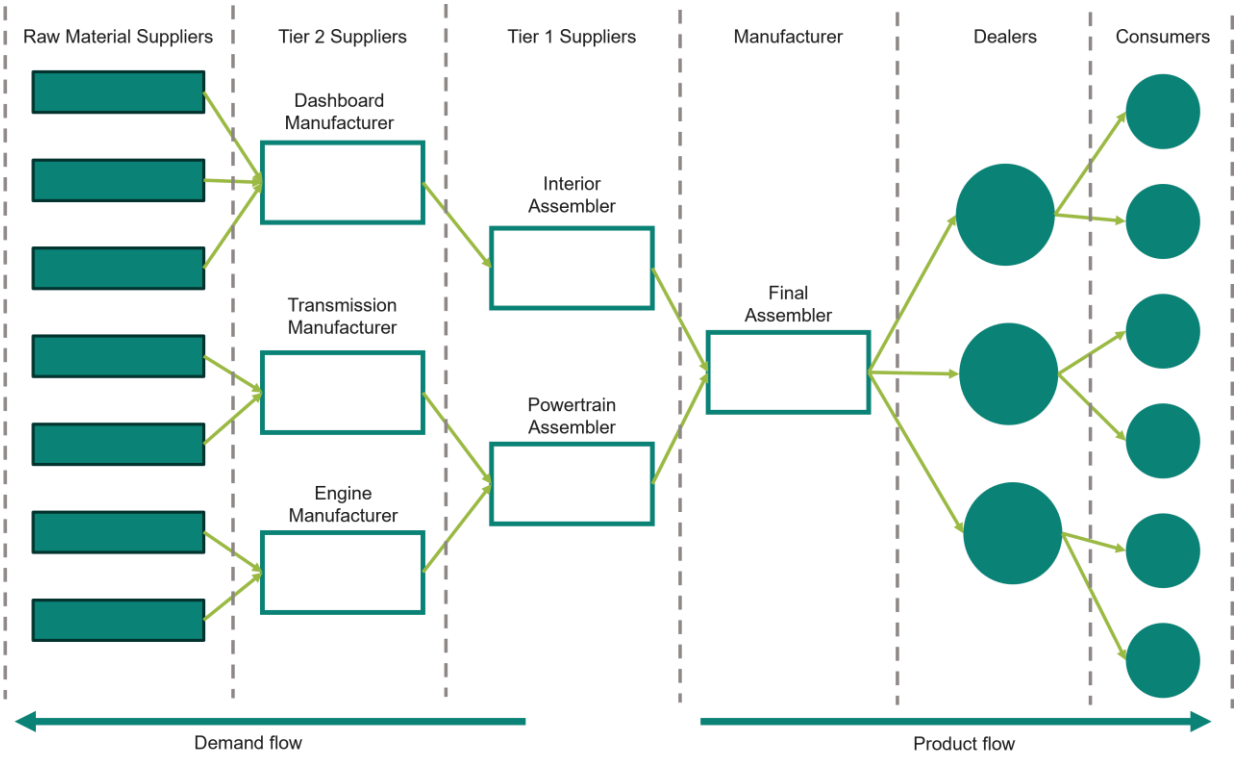

Figure 4: Redaction of the simplified automotive supply chain with various stakeholders on the supply and customer.

The different value chain members for the automotive supply chain can be generalized as follows, raw material suppliers, tier 1 suppliers, tier 2 suppliers, automotive manufacturers,

dealers, and customers (Source). Each value chain member has its individual manufacturing times needed for the final assembly of the automobile. It is important to consider the times needed for production for all components, with emphasis on the semiconductor as it has long cycle times for production. The crisis of the "Chip Shortage" that spurred from the COVID 19 pandemic is a good example for the need for the complex understanding of the interconnections across the value chain. The "Chip Shortage" lead to massive financial loss as automotive manufacturing production came standstill due to the nature of the semiconductor manufacturing cycle times [9].

The automotive supply chain is different to the solar PV supply chain with regards to production line and country/region share. Globally there are more companies involved in the automotive value chain compared to the PV value chain. Accordingly, the industry is changing rapidly with the emergence of the electric vehicle. A simplified model of the automotive supply chain can be seen in figure 4 above. In addition to the complex value chain seen above, the following graphic found in figure 5 shows examples of various companies along the supply chain, which increases not only the supply network complexity but also increases competition amongst the various stakeholders in the value chain.



Figure 5: Depiction of various supply chain value members for the integration into products from the automobile sector.

3. Digital Reference (DR)

Although D4.1 included an introduction to the Digital Reference (DR), a brief explanation of the DR is provided in this document to enhance comprehension in this subsequent section. The DR is a Semantic Web-based ontology that represents entities being relevant for semiconductor manufacturing and manufacturing employing semiconductors [1]. The DR is a successful application of the Semantic Web, resulting from the predecessor Productive4.0 project [2]. Productive4.0 was a European research project in which 109 partners were involved to achieve improvement in digitizing European industries.

In Figure 6, the current state of the Digital Reference (DR) is demonstrated. Currently, there are fourteen domains, referred to as lobes in the DR, that are connected by dots to indicate the relationship among them. The DR primarily pertains to the supply chain, production, and development processes of semiconductors. It is an evolving reference model that is continuously being improved and expanded, particularly through the former funded project SC3 project [3].

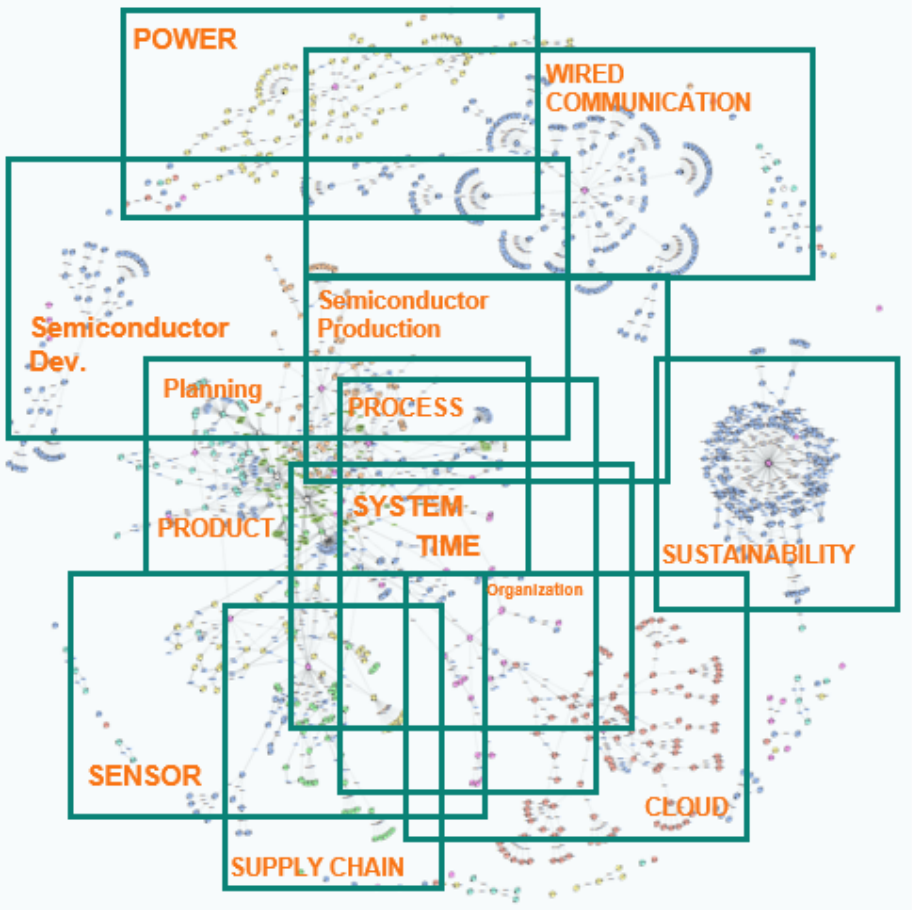

Figure 6: Digital Reference (DR) and its Lobes [4].

Deliverable 4.1 aimed to describe ontologies that facilitate the determination of potential carbon dioxide (CO2) emissions savings achievable through improved IFAG products in various use cases. These cases include conventional and battery-powered vehicles, solar photovoltaic (PV) technology, and wind turbines. Additionally, the DR was expanded to include topics such as internal and external transportation. The deliverable also highlighted that IFAG's sustainability analyses indicate that CO2 emissions differ depending on the location of IFAG facilities and their respective energy mixes. Consequently, ontologies that break down the key

variables for analyzing CO2 footprints in different locations can provide valuable insights. This indicates that D4.1 focused on the internal supply chain and the sustainability lobe of the DR.

D4.2, in contrast, centers on expanding the DR on externally supply chain fields. The focus groups mentioned earlier were particularly instrumental in developing a range of new applications. This guarantees that future AIMS5.0 applications can be implemented by OAP partners. Moreover, this constitutes an expansion of the external supply chain as these potential results foster collaboration among various companies. Consequently, in the future process of this WP4, several DR lobes, including the Planning Lobe, Production Lobe, Product Lobe, and Sustainability Lobe, will be expanded, and analyzed through the three focus groups together with the partners.

3.1 Updates to the Digital Reference since D4.1

The extension of the DR since introduced in digital reference 4.1 include the additions of several lobes, specifically the planning lobe and the electric vehicle (EV) battery management system (BMS) lobe.

3.1.1 The addition of the Planning lobe to the DR

As mentioned in D4.1, semiconductor supply chains are complex and lengthy. Managing and overseeing semiconductor supply chains presents significant challenges given the extensive scale of production facilities and supply networks within the semiconductor sector, the persistent presence of unpredictability, and the rapid pace of technological advancements [11][12]. Consequently, a multitude of information systems are integral to the decision-making processes for planning and control within semiconductor supply chains [13][14][15]. The planning ontology integrated into the DR covers various planning complications associated to semiconductor supply chains. The planning ontology is designed to represent the planning activities specific to the semiconductor industry, which encompasses a variety of planning functions within semiconductor supply chains. Its goal is to standardize the concept of semiconductor planning, enabling a cohesive exchange of planning-related data and the automatic creation of planning models. This necessitates the ability to model different planning scenarios and, more broadly, supports the development of planning systems for semiconductor supply chains [10]. The semiconductor planning lobe encompasses planning objects, planning purposes, planning constraints, decision making units, planning situation, planning instance, plan, plan execution, lot sizing rule, process, part, bill of material, demand, available capacity, substitution, and binning. These entities enable oversight of the various functions found within the complex manufacturing of the semiconductor, figure 7 shows the extension of the DR with the Planning lobe.

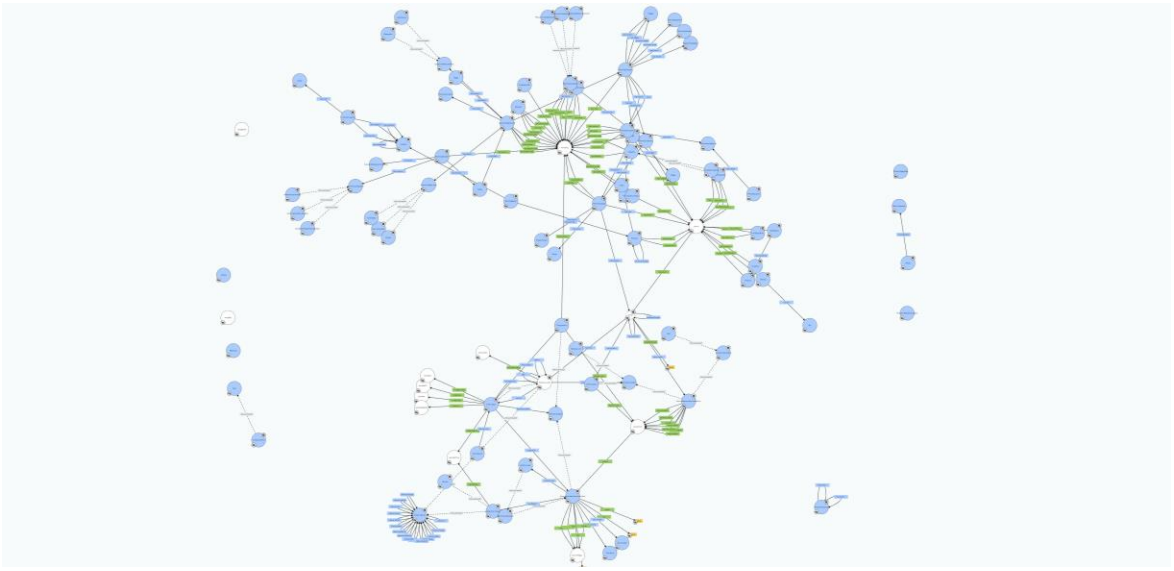

Figure 7: The Planning Ontology as a part of the Digital Reference.

3.1.2 The addition of the Battery Management System to the DR

As mentioned in D4.1, Resource scarcity, climate change and growing energy demands accentuate the need for sustainable mobility choices worldwide. The answer lies in low- and zero-carbon mobility concepts that are fit for the future. A climate-friendly mobility ecosystem hinge, however, on energy efficiency across the entire power chain from generation through distribution right up to the point of use. The fast-growing adoption of BEVs and increasingly rapid build-out of the enabling charging infrastructure present their own logistical challenges. This rapid BEV increase requires higher component capacities for its manufacturers. The battery management system (BMS) is a key component within the BEV that oversees monitoring each of the cells included in a battery pack and ensuring that they are operated within the safe operating range. It monitors and reacts to the State of Health (SoH), State of Charge (SoC) and Depth of Discharge (DoD) with the assistance of balancing ASICs. It is also able to operate under low-current consumption mode to ensure holiday parking. Furthermore, it prevents illegal manipulation of both the system and battery packs via integrated security on the AURIX™ microcontroller. The DR has been extended by the inclusion of the BMS ontology.

The BMS ontology aims to explore the impact of the Battery Management System (BMS) in terms of reducing the carbon footprint, particularly in electric vehicles, by overseeing and managing lithium-ion batteries to promote safer usage and prolong their lifespan. Within the BMS DR extension, the constituents of the primary application as well as the potential CO2 savings of the device will be included, enabling the digital reference to provide insights into the contributions of a set of semiconductors used in BMS to CO2 savings and the role of each semiconductor. The BMS ontology can be seen below in figure 8 and within the DR in figure 9.

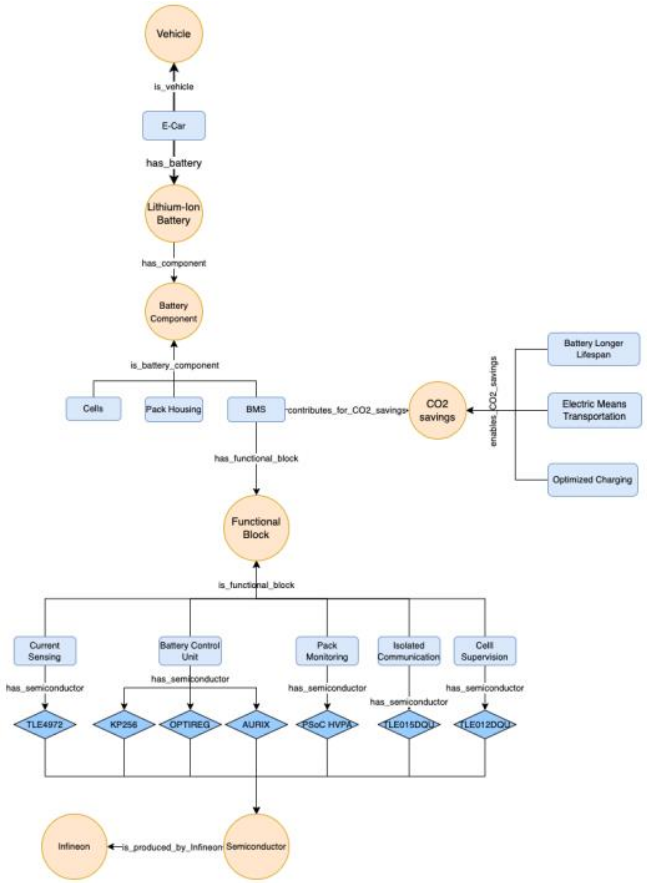

Figure 8: BMS ontology in the form of a drowling.

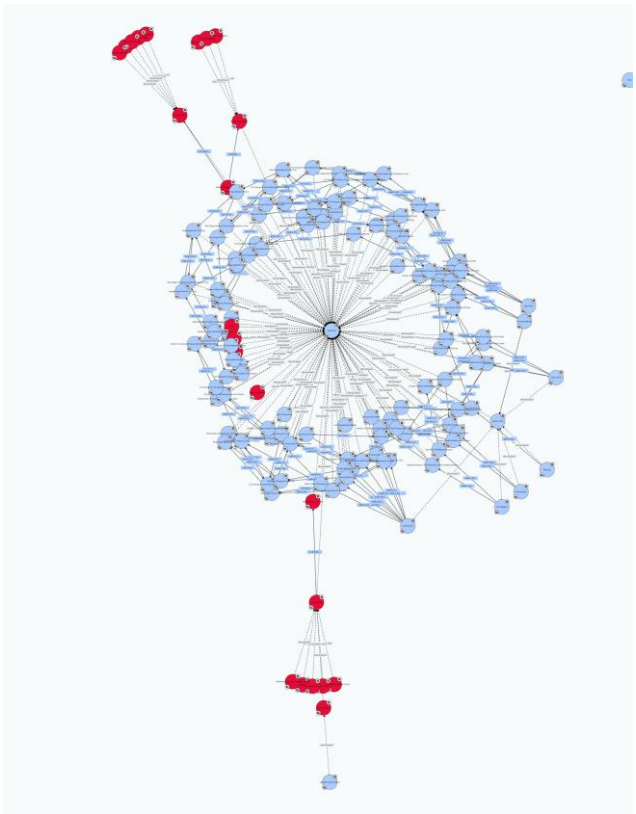

Figure 9: BMS ontology in the Sustainability lobe of the Digital Reference.

3.2 Further Extension to the DR

The following section will explain three focus groups, Planning, Sustainability, and Quality Management, in which Work Package Four is currently working on. The focus groups will include ontologies in which the DR can be extended upon, however they are still currently being defined. In addition to the three focus groups the BMS ontology can be extended upon within the DR.

3.2.1 Extension of the BMS ontology with the integration of the E-charging Station Ontology

Within the BMS ontology that has already been integrated into the DR, a specific class is the e-car as a vehicle. This can be further elaborated by the charging infrastructure integration with the E-Charing Station Ontology depicted in figure 10 below.

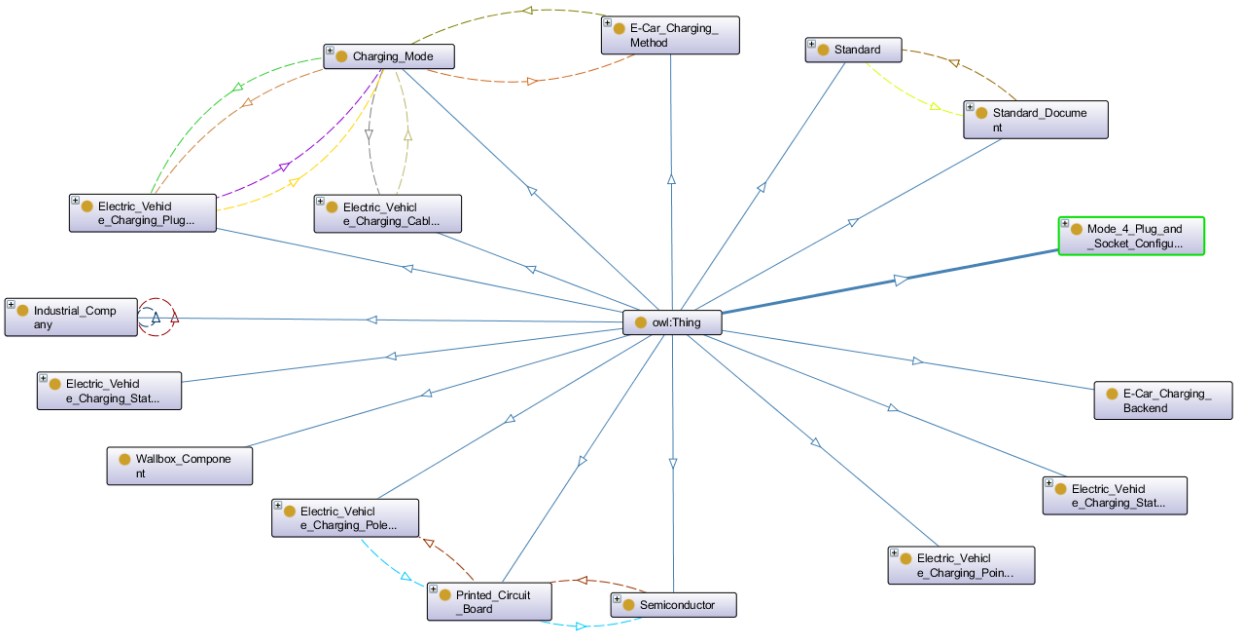

Figure 10: Generic Ontology for the E-Charging Station.

The ontology includes various entities concerning the charging infrastructure of the electric vehicle for example, charging methods, charging cables, socket configurations, semiconductor inclusion, wallbox components, charging stations, and plug types. Having the integration of the E-charging ontology to the DR will give more oversight of different products, for example various semiconductors, that will be integrated into the electric vehicle.

3.2.2 Digital Reference lobes validation and resulting extensions.

To ensure high quality of the Digital Reference, we propose a standardized validation process of its lobes. The goal of this validation procedure is to provide a comprehensive, unbiased semantic description that can applied for various data-related tasks in practice.

The proposed validation process consists of the following 8 levels:

Validation Level 1: Ontology existing – precisely define the domain knowledge area of interest, gather key terminology and search for existing semantic model that could potentially be re-used.

Validation Level 2: Automatic semantic check – in case of multiple partially overlapping or related models it is important to identify all entities carrying the same meaning. Ideally, this process should be done automatically and precisely to facilitate both ontology comparison (level 1) and mapping of data coming from different sources (level 6-8).

Validation Level 3: Lobe under constant review and historized via blockchain hashes – since knowledge constantly evolves and especially industrial and technological landscapes are changing quite dynamically, the lobes of the Digital Reference should be under supervision and undergo continuous improvements. Lobe owners (experts in the represented knowledge domains) should be responsible for extensions and updated if each of the lobes. The history of changes should be traceable and secured with blockchain. In essence, this level contains all steps proposed of the Digital Reference update process.

Validation Level 4: Lobe documentation - each of the lobes should be in detail documented and verified. Any inconsistencies revealed in the process of detailed documentation should be improved.

Validation Level 5: Community validation – detailed documentation of the lobe should be presented to a broader community. In this way consensus on the proposed definitions and representation can be reached.

Validation Level 6: Link to a database – for each of the Digital Reference lobes relevant data sources should be identified that can be then mapped on the model. The representation level of the Digital Reference should be sufficient to facilitate work with all identified data with or without application of additional intermediate semantic level.

Validation Level 7: Successfully applied in one use case – in case of successful data mapping one use cases should be defined and demonstrated, proving that Digital Reference supports knowledge acquisition in the lobe's expertise area.

Validation Level 8: Successfully applied in several (>3) use cases – finally, application of each of the lobes to multiple use cases should be demonstrated. Preferably, data used at this stage comes from multiple and different sources.

First, we aim at validating existing lobes of the Digital Reference (level 3-8), however the proposed process should in the future facilitate the entire extension and application process (from the idea to data processing, including level 1 and 2).

So far, Wired Communication and Sensor lobes of the Digital Reference have been validated with the proposed procedure. Each of them was subjected to level 4,6 and 7 of the proposed validation process. As a result, missing parts of the knowledge domain areas have been identified, modeled, and proposed as coming Digital Reference updates. Moreover, for both lobes use cases have been specified and successfully demonstrated.

3.2.2.1 Wired Communication Lobe

Over the years, Cloud Computing (CC) has become the dominant business model, delivering services with off premise data centers running in a scaled infrastructure, making high performance computing accessible. That paradigm is rapidly changing with the emergence of Internet of Things (IoT) devices, moving the world to an Internet of Everything (IoE) dominated era. New paradigms are arriving, such as the Fog Computing (FC), Edge Computing (EC) or the Mist Computing (MC), that make services move to decentralized locations. To migrate from a

centralized (Cloud) world to a decentralized one, huge amounts of data must be handled, requiring new software, hardware, technologies, and ways of structuring data. In the Industry 4.0 (I4.0), most of the communication of semiconductor manufacturing equipment is done in a wired way, and its behavior defined by the SEMI Equipment Communication Standard (SECS)/Generic Equipment Model (GEM) standard. Modelling the standard in the huge Digital Reference (DR) ontology can be of much help on the migration to a wireless environment.

SEMI E30 - SECS/GEM SEMI E30 - SECS/GEM is a standard used in automation for semiconductor, electronics, photovoltaic, and Surface Mount Technology (SMT) industries [65]. It defines a communication model for semiconductor manufacturing equipment. This is the center of operations, defining the behaviors of equipment, state machine and rules like which SECS-II messages should be used, when, and what the result should be. It also defines many functionalities: Status Data Collection, Trace Data Collection, Alarm Management, Spooling, Remote Command... It defines three variables accessible by the host:

- Status Variable: A read-only global variable defined in the equipment. Whenever there is a processing, the equipment will update the respective status variable to reflect the latest data.
- Equipment Constant: A read-write global variable defined in the equipment. Host can set or modify the equipment constant variable which may affect the setting that in turn change the way equipment's behaviors.
- Discrete variable: A local variable that only exists in collection event.

After identifying important classes to reuse (based on the Digital Reference context), the most important terms for the Digital Reference extension were analyzed and enumerated. The important terms the ontology include are the following ones:

- SEMI
- SEMI Standard
    - SEMI E30 - SECS/GEM
    - SEMI E5 - SECS-II
        - SEMI E5 - SECS-II Message
            - Stream ID
            - Function ID
            - Name
            - Transaction ID
            - Mnemonic
            - Single/Multiblock
            - Host/Equipment
            - Message Direction
            - Reply
            - Description
            - Structure
            - Exception
    - SEMI E37 - SECS-I
        - T3 Reply Timeout
        - T5 Connection Separation Timeout
        - T6 Control Transaction Timeout
        - T7 Not Selected Timeout
        - T8 Network Inter-character Timeout
    - SEMI E4 - SECS-I
- TCP/IP
    - Connection Mode
    - Local IP Address and Port Number

- Remote IP Address and Port Number
- RS232

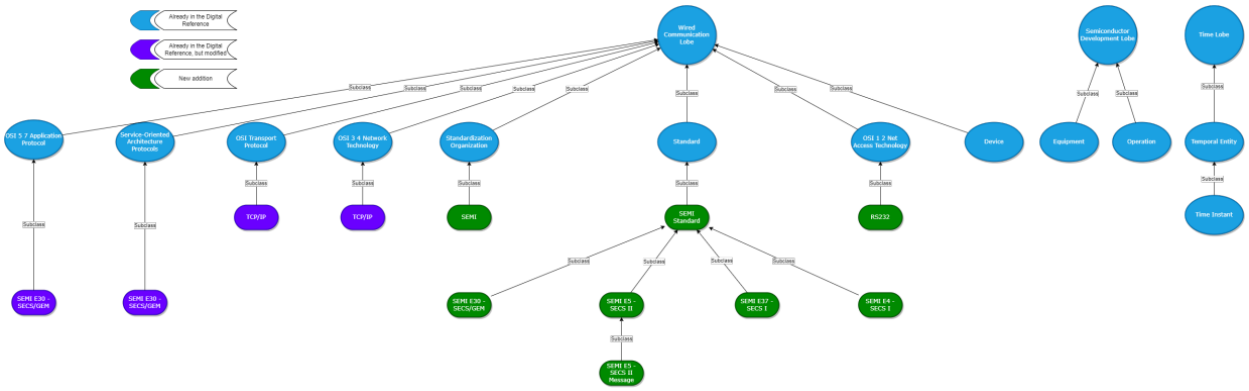

Figure 11: Wired Communication lobe extension.

3.2.2.2Sensor Lobe

After analyzing the Sensor lobe of the Digital Reference with respect to the VCNL 4020 Fully Integrated Proximity and Ambient Light Sensor documentation and data available of this type of sensors, it has been concluded that there are elements in the data set that are highly important values that are currently not mapped for data storage. Therefore, several classes have been added to the model to prepare the ontology to store relevant data in the ontology as shown below.

- Register - register is an essential feature of a sensor, which is intrinsically linked and cannot exist without the sensor. Registers allow configuration and adjustment of sensor inputs and outputs, as well as the definition of controls, thresholds, and other critical parameters, making it easy to adapt sensor performance to various applications and specific needs. This class is not directly connected to other classes but is a class that comes directly out of the Sensor lobe. By analyzing the data set, the following elements have been identified. And it has been decided to create the following sub-classes that allow storing the corresponding information for each sensor.
  - Input Register. An Input register is a subclass of register and focuses on setting up registers related to the input of data or information into the sensor. These 48 2.4. Fully Integrated Proximity and Ambient Light Sensor input registers can be used to adjust and optimize the sensor's performance in data acquisition and processing, making it easier to adapt the sensor to different applications and specific needs.
  - Output Register. An Output register is a subclass of register and focuses on configuring registers related to the output of data or information from the sensor. These output registers allow you to customize and optimize the way the sensor transmits or presents the data it collects, making it easier to adapt the sensor to different applications and specific needs.
  - Control Register. A Control register is a subclass of register and focuses on setting up control-related registers and configuring interrupts on the sensor. These control registers allow the management of events and actions to be adjusted and optimized in response to certain conditions, facilitating the adaptation of the sensor to different applications and specific needs.
  - Threshold Register. A Threshold register is a subclass of register that focuses on setting up registers related to activation or detection thresholds on the sensor. These threshold registers allow you to set the

thresholds that activate or trigger specific sensor responses, making it easier to adapt the sensor to different applications and specific needs.

- Status Register. A Status register is a subclass of register that focuses on setting up registers related to sensor or system status, providing up-to-date information about sensor conditions and operation.

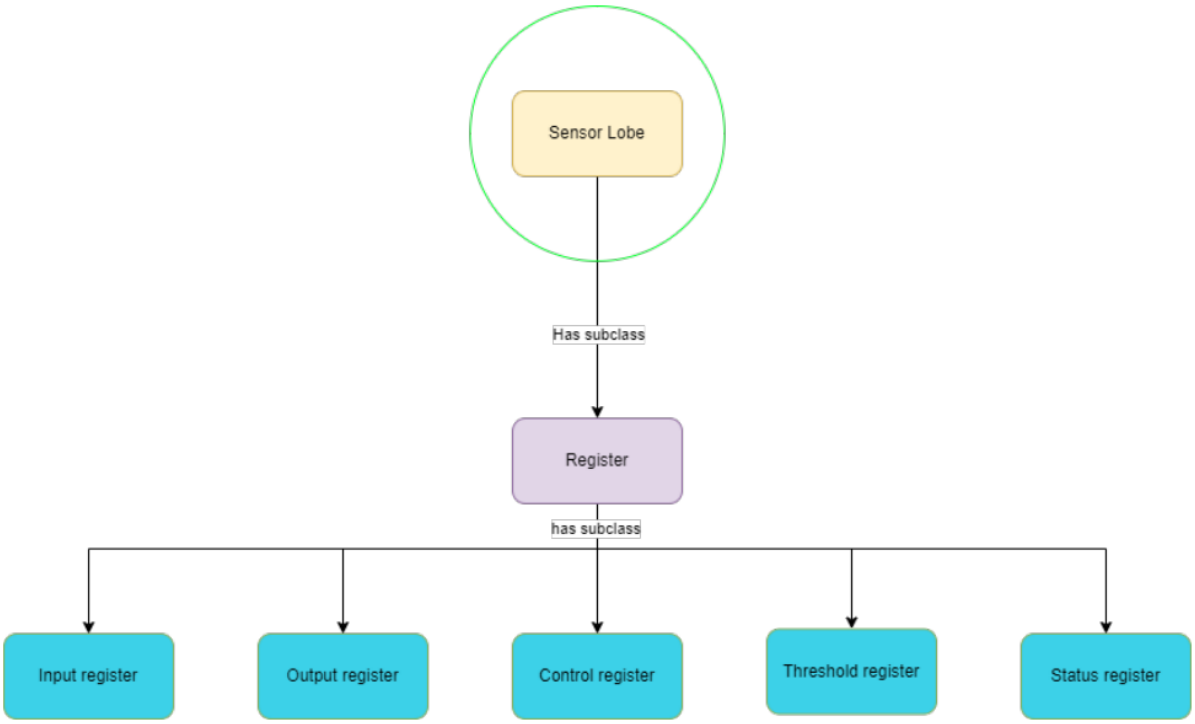

Figure 12: Register class and its sub-classes.

4. Open Access Platform (OAP)

4.1 Introduction and Status of the OAP

The main dissemination of the WP4 is to establish an Open Access Platform (OAP). The OAP will enable the exchange of data via semantic web technology within the supply chain of the semiconductor industry domain. The so-called Digital Reference (DR) serves as the basis structure of this OAP, which was already defined in the chapter before. The main goal of the OAP is to prove that the semantic web based on the DR enables a seamless data exchange, the use of those data in a conventional way and via software or human agents.

The OAP is being developed collaboratively by DAC and IFAG Munich. Throughout the project, several requirements and specification were formulated, and an initial structure of the OAP were established. The status of the structure can be seen in Figure 13. The OAP is functionally divided into one platform to share structural Input in form of knowledge graphs, which is an Ontology combined with data (Online Platform). The other part of the platform will be used to transfer data securely on the OAP (User Platform). Currently, Work Package Four has aligned on a test use case to enable the upload and download of different qualified synthetic data (QSD) which have been generated using different methods. The intention is to construct a simple platform, which allows upload and retrieval of data from different parties, thereafter complexity will evolve with time.

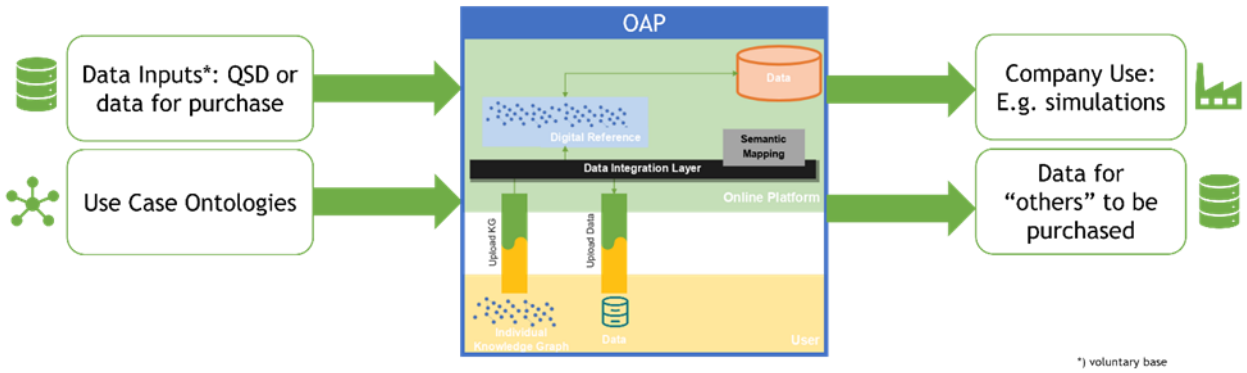

Figure 13: Structure of the OAP.

4.2 Three Focus Groups

As part of the project, the partners cooperated to establish so-called three Focus Groups for applications on the OAP. These groups are dedicated to certain topics that should be implemented and executed in the OAP. Below, an in-depth presentation of the three focus groups is provided. This will allow for comprehensive discussion of the results that have been developed in the following chapter.

4.2.1 **Planning:**

The planning group is the primary focus of Work Package Four as the planning ontology has been integrated into the DR. The Planning Focus Group is a under the lead from FUH and IFAG Munich. The current work of Work Package four is the facilitation of the OAP generation in the context of planning and control for semiconductor manufacturing. QSD in the context of the planning group have been generated and the OAP is to allow for upload and retrieval of the data where unique identification is associated to both the upload as well as the retrieval. The

QSD has been generated using two different simulation software, Anylogic and Autoshed AP. Data that is uploaded and retrieved in the OAP should be able to be loaded respectively into either simulation software. The further work on the planning group is to upload different planning ontologies from various partners to assure the upload and retrieval of the data within the ontology.

4.2.2 Sustainability

The Sustainability Focus Group is driven by IFAG Munich. Most importantly, it is recommended to proceed with the findings of Deliverable 4.1 and conduct additional analyses in collaboration with the partners. Therefore, potential collaboration for the scope 1,2,3 emissions for a common OEM will be examined through ESG teams of NXP and IFAG. However, there are potential crossovers in the different focus groups that could enable the extension towards sustainability. This is for example in addition to the constituents of the planning ontology where production and control are integrated. Elements such as energy consumption for production facilities as well as transportation routes could be the bridge between the elements of semiconductor manufacturing with respect to the planning ontology and the sustainability focus group.

4.2.3 Quality Management:

The last Focus Group, Quality Management, is worked out by NXP and IFAG Munich. Focus is set on traceability of products to better handle customer complaints with root cause prediction with the OAP. As an overview, traceability is the ability to follow the journey of something (in that case products) from its origin to its current state, which is important for the quality control. The traceability focus group is centered around tracking history, location, and status of products and components throughout its lifecycle from raw materials to finished goods through the semiconductor supply chain then integrated further into an Original Equipment Manufacturer. Figures 14 & 15 show the general idea for the ontology for the traceability focus group.

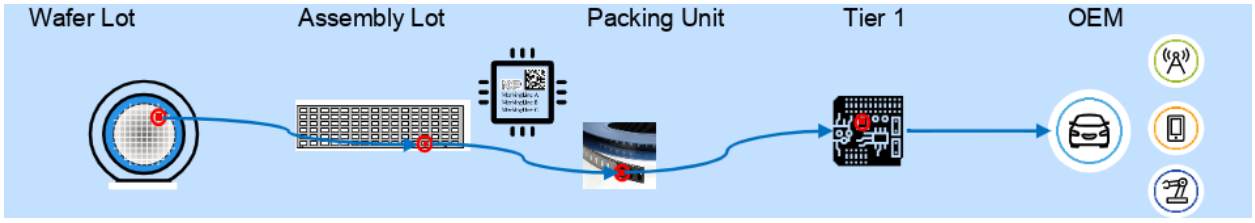

Figure 14: Example for the application of the Traceability focus group for the application for the OAP.

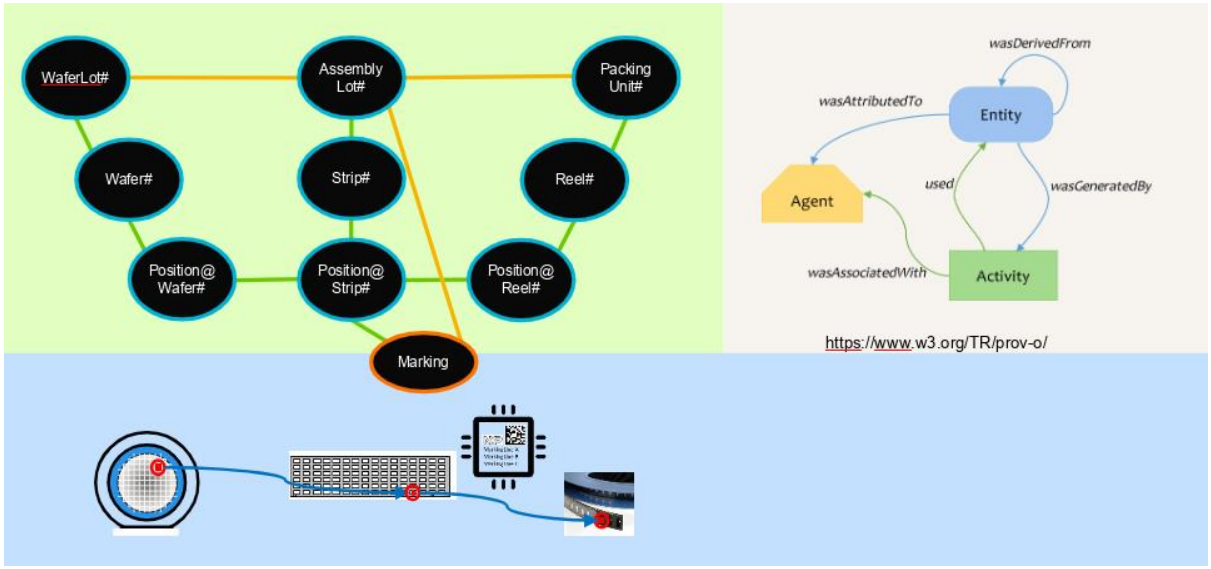

Figure 15: Drowling from the Traceability focus group for the application of the OAP.

5. Conclusions and outlook

Within this deliverable, D4.2, the external supply chains of both the automotive and renewable energy generation in the context of PV were introduced. Furthermore, the digital reference was re-introduced and the extensions of the planning ontology as well as the BMS ontology were explained. In addition, the extensions of the BMS ontology via the E-charging ontology was discussed. The status of the open access platform was also introduced as well as the three focus groups, Planning, Sustainability, and Quality Management, that work package four is currently focused on. Further work within the three focus groups to enable the generation of the OAP as well as the future extension of the DR in the realm of the three focus groups is foreseen in the generation of company specific ontologies that can be uploaded and populated with qualified synthetic data to the open access platform.

The end goal of the open access platform is to enable secure data share that is semantically linked to the digital reference via ontologies for all participating partners. Further work with in Work Package Four will be centered around improving the open access platform and its linkage to the digital reference.

The next deliverable within Work Package Four will be D4.3 which will cover the remaining classes and characteristics missing to come up with a complete ontology to allow the generation of computer based efficient CO2 balance.

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7. Appendices

7.1 Appendix A - Abbreviations

Table 1: Abbreviations

Abbreviation	Meaning
AC	Alternating Current
AIMS5.0	Artificial Intelligence in Manufacturing leading to Sustainability and Industry5.0
BEV	Battery Electric Vehicle
BMS	Battery Management System
CC	Cloud Computing
DC	Direct Current
DoD	Depth of Discharge
DR	Digital Reference
EC	Edge Computing
ECS	Electronic Components and Systems
ESG	Environmental Social Governance
EV	Electric Vehicle
FG	Fog Computing
GEM	Generic Equipment Model
IFAG	Infineon Technologies
IoE	Internet of Everything
IoT	Internet of Things
LCOS	Levelized cost of solar
MC	Mist Computing
OAP	Open Access Platform
PV	Photovoltaic
QSD	Qualified Synthetic Data
SECS	SEMI Equipment Communication Standard
SMT	Surface Mount Technology
SoC	State of Charge
SoH	State of Health
WP4	Work Package Four