True Demand-Driven Semiconductor Supply Chains for Europe

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SC4EU

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Publishable Executive Summary

This deliverable presents innovative solutions to address critical vocabulary standardization challenges in semiconductor supply chains, focusing on two pioneering tools: the Vocabulary Development Support Tool (VDST) and the OntoQuest vocabulary game. These tools serve as demonstrators under the **SC4EU** project, a forward-looking initiative aimed at transforming demand forecasting and supply chain management through the creation of a true demand platform. By emphasizing transparency and efficiency, the project seeks to alleviate long-standing issues like the bullwhip effect and supply-demand misalignment.

The **SC4EU** project's comprehensive approach integrates cutting-edge techniques, including anonymous data sharing using Multi-Party Computation, semantic data processing for granular and high-quality insights, and close collaboration between semiconductor companies and research institutions. It also emphasizes human-centered methodologies, employing gamification to incentivize data sharing and improve stakeholder engagement.

By resolving semantic barriers, the VDST and OntoQuest demonstrators strengthen the **SC4EU** project's foundation, supporting its vision for a resilient, data-driven, and collaborative semiconductor supply chain ecosystem. These innovations highlight the transformative potential of semantic standardization and collaborative technologies in optimizing global supply chain operations.

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Abstract

This deliverable outlines the first demonstrators developed by the project consortium during the first year. Notably, proposed demonstrators focus on vocabulary development. Note, further demonstrators are in development, which will be described in upcoming versions of this deliverable.

The **SC^{4}EU** project seeks to advance demand forecasting and supply chain management within the semiconductor industry by establishing a **true demand platform**—a cutting-edge service designed to enhance transparency and efficiency in supply chain operations. The project adopts a multi-faceted approach to mitigate challenges such as the bullwhip effect and supply-demand misalignment, emphasizing on:

- anonymous data sharing with use of Multi-Party Computation,
- semantic data processing to obtain high quality data of fine granularity,
- close cooperation of semiconductor companies and research institutes,
- focus on human factors,
- application of gamification and related techniques for data sharing incentivisation.

The tools developed under this deliverable directly contribute to the project's goals by addressing semantic challenges that often hinder seamless communication and data exchange. The **VDST**, integrated into the **Open Collaboration Platform (OCP)**, standardizes terminologies across stakeholders, ensuring clarity and precision in supply chain interactions. Meanwhile, the OntoQuest vocabulary game engages participants in the refinement of the Digital Reference model, a comprehensive ontology for semiconductor supply chains, through gamified, collaborative feedback processes.

Together, these demonstrators not only enhance the **SC^{4}EU** project's capacity to manage semantic complexities but also provide a strong foundation for achieving its overarching objective: a resilient, data-driven approach to semiconductor supply chain optimization.

Structure of the deliverable report

The **Demonstrators Specification Report A** is structured to provide a comprehensive overview of the **SC4EU** project and its associated demonstrators. Chapter 1 introduces the **SC4EU** project, outlining its objectives and the role of demonstrators in achieving these goals. Chapter 2 presents a preliminary list of demonstrators, detailing their specifications, current development status, and alignment with project objectives. Chapter 3 concludes the report by summarizing key insights and next steps. Finally, Chapter 4 provides a list of abbreviations used throughout the document for clarity and reference. This structure ensures a clear and organized presentation of information, facilitating understanding and further action.

1. Introduction

1.1 SC4EU Overview

SC4EU, a collaborative Innovation Action aims at strengthening European digital sovereignty by the mitigation of the chip shortage through reduction of bullwhip effect in the semiconductor industry and supply chains containing semiconductors. This will be reached via a "truer"-demand signal gained from an **anonymous MPC (Multi-Party Computation) survey** on coarse granularity which will be broken down via Artificial Intelligence (AI) methods to fine granularities following the semantic web based digital reference structure.

The **ambition** of **SC4EU** consortium is to overcome these obstacles and to obtain high-quality, reliable data for semiconductor demand forecasting. In the solution proposed by **SC4EU**, data should be gathered via an anonymous survey based on Multi-Party Computation technology. **Anonymity and security of data flow** will encourage business partners to share their true demand data. Then, the gathered data will be mapped onto ontologies (semantic representations of the semiconductor industry) and processed with AI tools for demand breakdown of fine granularity.

Key Objectives:

The overall goal of the **SC4EU** project is to develop a solution for better demand forecasting in semiconductor supply chains. This objective will be achieved by establishing a true demand platform – a service available to companies included in semiconductor supply chains. On its way to the platform realization **SC4EU** consortium will specifically target the following objectives:

- Establish an improved version of the Digital Reference ecosystem and ensure its maintenance
- Provide secure access to the true demand forecasting services and integrate them with cloud services and other dataspaces
- Integration of collaborative ontology processing tools into the **SC4EU** Ontology Curation Portal and availability of Continuous Integration pipelines
- Provision of an integrated and collaborative ontology editing and visualisation tooling
- Provision and establishment of an integrated SSO solution for all SC3 Portal connected tools
- Development of a consistent, modular and semantic description of semiconductor supply chains that can be used to generate meaningful demand forecasts for the supply chain
- Design and test of demand forecasting methods that especially allow to disaggregate demand information
- Development of the Survey Use Case

Overarching goals of SC4EU project are:

- Mitigation of the chip shortage
- Reduction of bullwhip effect in the semiconductor industry
- True-demand based forecast
- Resilient and sustainable semiconductor supply chains
- Promotion of data sharing.

By addressing these key areas, **SC4EU** will result in a better bullwhip reduced demand forecast on all levels of the semiconductor demand and of demands for supply chains containing semiconductors.

Short description of Work Packages:

The project is structured into **eight interconnected work packages** (WPs) to ensure efficient coordination, development, and dissemination. **WP1** focuses on management and coordination, ensuring seamless collaboration across all stakeholders and WPs. **WP2** establishes an improved, user-centered Digital Reference ecosystem with enhanced user administration capabilities. **WP3** targets the ongoing curation and visualization of the Digital Reference Ontology, building on prior developments while adapting processes to new project needs. **WP4** focuses on the development of modular semantic supply chain descriptions and tailored demand forecasting methods to disaggregate supply-demand data. **WP5** aims to create a true demand survey platform, enabling the collection and evaluation of anonymous demand and supply data. **WP6** supports this by designing a framework for anonymous surveys and multi-party computation to ensure confidentiality. To improve participation, **WP7** develops strategies and incentives, including survey gaming and tricks, to encourage data quality and sufficient participant engagement. Finally, **WP8** drives dissemination and international cooperation, promoting the platform, sharing project outcomes, and planning post-project development to enhance awareness of how data sharing can improve semiconductor demand forecasting.

The table below presents additional descriptive information about the **SC4EU** project, intended to be communicated to the project's target groups & stakeholders.

Table 1: The SC4EU Project

SC4EU Project Description
SC4EU in the center of semiconductor demand forecasting will result in a better bullwhip reduced demand forecast on all levels of the semiconductor demand and of demands for supply chains containing semiconductors. By that reduced chip shortage in boom phases and less oversupply, unused capacity and waste in phases of low demand.
Expected outcomes
▪ **Improved decision-making:** Sharing data can lead to better and more informed decision-making. By having access to a wider range of data sources, companies can gain a more comprehensive understanding of market trends and consumer behaviour, which can inform their strategic planning and product development. ▪ **Enhanced efficiency:** Data sharing can help companies streamline their operations and increase efficiency. By sharing data on processes and supply chains, companies can identify areas for improvement and optimize their workflows, resulting in cost savings and improved productivity. ▪ **Collaborative innovation:** Data sharing can facilitate collaborative innovation and cross-industry partnerships. By pooling data resources, companies can leverage their collective expertise to develop new products and services that might not have been possible otherwise. ▪ **Competitive advantage:** Companies that are able to effectively share and utilize data may gain a competitive advantage over their peers. By leveraging data insights, they can identify new business opportunities, optimize their operations, and develop innovative products and services that set them apart from their competitors.

Innovation of the proposed approach
▪ anonymous data sharing with use of Multi-Party Computation, ▪ semantic data processing to obtain high quality data of fine granularity, ▪ close cooperation of semiconductor companies and research institutes, ▪ focus on human factors, ▪ application of gamification and relate techniques for data sharing incentivization.
Identified stakeholders / partners
▪ Industry representatives with a grand coverage of the European semiconductor industry ▪ Scientific / academic community ▪ Representatives from the overall data community / economy such as data scientists, data- and knowledge engineers will be involved as partners not as stakeholders.

2. Preliminary list of demonstrators, specifications and status

2.1 OntoQuest Vocabulary Game – Enhancing Ontology Development through Gamification

Demonstrator	Presentation, Live Demonstration
Duration	10-15 minutes
Goal	The goal of this demonstrator is to showcase OntoQuest, a vocabulary game designed to support the development of ontologies, particularly the Digital Reference model. Industrial vocabularies are characterized by high terminological specialization and complexity, which can lead to inconsistencies and communication difficulties. In corporate contexts, the same terms may be used differently across departments, or similar concepts may be referred to by different names. Structured knowledge representations, such as taxonomies, semantic networks, and ontologies, can facilitate vocabulary development and organization, increasing the efficiency of knowledge management. In complex areas like semiconductor supply chains, efficient knowledge management is crucial for transparent information flow, accurate decision-making, which can contribute to overall supply chain resilience. Semantic modelling requires close collaboration between ontology engineers and knowledge domain experts. This collaborative process can result in high-quality semantic descriptions when efficiently managed. Therefore, it is essential to encourage experts to work together on providing ontology and vocabulary feedback. In the context of the **SC4EU** project, semantic models play a vital role in the overall data flow, supporting anonymous survey data processing, data integration from open sources, and data visualization. The quality of the applied models directly impacts the project outcomes. The underlying top-level ontology for **SC4EU** is the Digital Reference model, a holistic ontology for semiconductor supply chains and supply chains containing semiconductors. To facilitate collaborative ontology development, we propose OntoQuest, a game that engages a broad community to work together on improving the Digital Reference model. OntoQuest offers short game rounds, allowing players to interact with the model in various ways, such as verifying existing definitions, adding missing definitions, and providing abbreviations or name variants. Participants collect points and badges as incentives for providing feedback. In the future, it will also be possible to provide feedback on the ontology structure. This game supports **SC4EU**'s gamification efforts to make improvements to the semiconductor supply chain more interactive (WP7 and related tasks) and complements SC4EU vocabulary development efforts in WP3. While the WP3 vocabulary development service captures and defines new terms to extend semantic descriptions, OntoQuest enables continuous evaluation in a constantly changing business environment.
Specification	In this demonstration, the current version of the game is being presented, which is structured according to the Digital Reference model's thematic areas,

or "lobes." Users can choose which lobe to provide feedback on and decide the duration of the game round (number of definitions). For each displayed term, users can provide feedback on the definition, accept it, change it, or propose a new version. All inputs are saved in a database and undergo human verification before being incorporated into the semantic model.

During the demonstration, a short overview of the concept is presented, followed by a live demonstration of a short game round. All attendees also have the opportunity to play the game online.

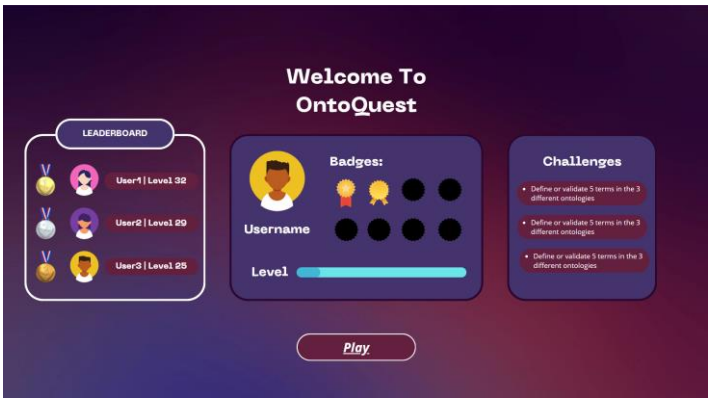

Figure 1: OntoQuest User Interface

Figure 2: OntoQuest: possible interaction with vocabulary terms

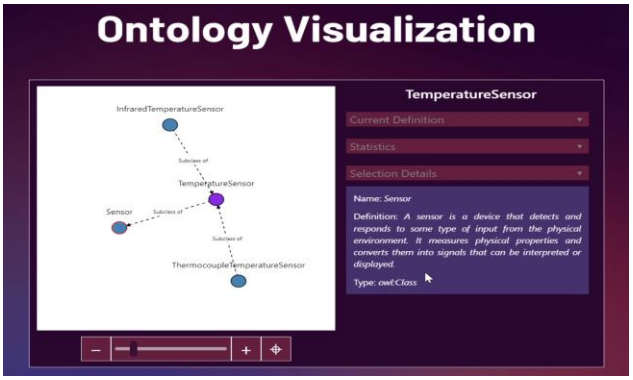

Figure 3: OntoQuest: Ontology-driven architecture

2.2 True Demand Knowledge Graph

Demonstrator	Video
Duration	5-10 minutes
Goal	The objective of this demonstration is to showcase the concept behind the True Demand Knowledge Graph, one of the modules within the designed True Demand Framework, which serves as the primary outcome of the **SC4EU** project. The True Demand Knowledge Graph is a semantic data repository, implemented as a graph database, capable of aggregating data collected across various project components. This knowledge graph is established upon semantic models, specifically survey ontologies developed based on the Digital Reference model structure. Data collected through the **SC4EU** anonymous survey is mapped onto this developed model, enabling the representation of complex relationships and dependencies within the data. Furthermore, the True Demand Knowledge Graph supports the breakdown of demand data from a coarse to a highly granular level by providing a sub-model capable of distributing quantities across technology nodes and respective market sectors. By leveraging semantic technologies, used also in other linked data repositories, this knowledge graph can help provide a more comprehensive view of the semiconductor demand landscape. It achieves this by seamlessly integrating and providing access to external RDF data on relevant factors, such as trade information, geographical, political, and climate factors. Thus, the True Demand Knowledge Graph serves as a powerful semantic data repository within the True Demand Framework, enabling the aggregation and analysis of complex data relationships. By integrating external data sources and applying semantic technologies, it offers a more comprehensive view of the semiconductor demand landscape, supporting informed decision-making and strategic planning within the industry.
Specification	In this demonstration, we present a short video showcasing the concept of the True Demand Knowledge Graph. We illustrate the data flow from the demand questionnaire to a comprehensive analysis of multiple data sources, highlighting the potential of semantic data linking approach. This architecture is currently under development and will be further refined, expanded, and presented in greater detail during the subsequent phases of the project.

2.3 WP2 Demonstrator Description: Vocabulary Development Support Tool (VDST) in Semiconductor Supply Chains

In semiconductor production and trade, supply chains are composed of numerous organizations and units that must collaborate effectively. A critical aspect of this collaboration is the seamless exchange of information. However, one of the main challenges that arises in this context is the use of a standardized vocabulary—a consolidated set of terms and definitions. Without this harmonization, inaccurate communication can lead to misunderstandings, inefficiencies, and friction losses between supply chain partners.

This demonstrator showcases the **Vocabulary Development Support Tool (VDST)**, which has been integrated into the **OCP (Open Collaboration Platform)** to address this challenge. The VDST ensures that organizations within the supply chain use a common vocabulary, making it possible to exchange information clearly and accurately. This tool is essential for integrating data from different sources and aligning communication across multiple stakeholders in the supply chain. By creating a shared vocabulary, the VDST minimizes confusion and supports the accurate analysis of phenomena like the bullwhip effect, which can disrupt supply chain dynamics.

Examples of Vocabulary Challenges Addressed:

1. Software Architecture Discussion:

   In a project meeting involving developers, knowledge engineers, and domain experts, confusion arose when discussing terms like "Frontend" and "Backend". These terms have different meanings in software development and supply chain analysis. To resolve the ambiguity, the group agreed to refer to "Frontend" as "Graphical User Interface" and "Backend" as "Software Backend". The relevant definitions were then added to the VDST, providing clarity for future discussions.

2. Different Terminologies for Similar Concepts:

   During online discussions, participants used different terms to describe similar concepts, such as "Future Demand" versus "Forecast", or "Sales and Marketing Forecast" versus "Unconstrained Demand". Additionally, terms like "Desired Inventory Coverage" and "Desired Inventory Reach" were used interchangeably. These terms were documented in the VDST with alternative labels, ensuring that participants understood the distinctions and could use the appropriate terms in their specific context.

Current Status: The VDST is public available: https://service.tib.eu/ocp/vocabulary_support. By now it contains 177 entries from a range of **SC4EU** project members.

3. Conclusions

This deliverable possesses the notable ability of overcoming, to a large extent, the fundamental issue of vocabulary standardization and semantic consistency within the whole semiconductor supply chain. The Vocabulary Development Support Tool (VDST) and the OntoQuest vocabulary game are examples of practical solutions with a creative approach that result in the improvement of communication and collaboration among various stakeholders.

The VDST has a core function as a part of the Open Collaboration Platform (OCP), giving a standardized and regulated method to the organizations involved in the effort to handle the terminologies. By eliminating vague or unclear aspects and adding unambiguous definitions, the VDST helps to the fluent information exchange, thus, cutting the inefficiencies and friction losses. The current version of this tool with 177 standardized entries from **SC4EU** project members is proof of its potentiality to extend to the rising needs of the supply chain. The tool is not only an aid to the organization in keeping the operation clear but also helps in the study of complex phenomena like the bullwhip effect, which is the key to supply chain stability.

Along with VDST, the OntoQuest vocabulary game brings a fresh, innovative approach to ontology development and refinement, which has a component of a game in it thus making it a gamified process. This interactive tool unifies domain experts and other stakeholder groups in a teamwork-oriented process of validating, improving, and widening the Digital Reference model, which is a crucial part of the **SC4EU** semantic framework. Gamification is one of the tools that the OntoQuest uses to make sure that people participate and give their inputs, which in turn ignites the constant development of semantic models in a dynamic business environment. The game has been developed in a way that is in line with **SC4EU** 's other efforts in gamification and vocabulary development, thus, indicating its importance in the long-term project goals.

These two tools complement each other and thus tackle the issue of terminology complexity and the tight focus of industrial vocabularies, thereby providing the necessary ground for strengthened knowledge management, transparency, and decision making. Their creation and later insertion into the system highlight the role of common terminology and joint ontology management in achieving supply chain endurance and nevertheless, efficiency. Subsequently, the established school of thought together with the frameworks from these demonstrators will be of great help in providing credible results for proactive moves in semantic problems across other sectors.

4. Appendix A - Abbreviations

Table 2: Abbreviations

Abbreviation	Meaning
SC4EU	True Demand-Driven Semiconductor Supply Chains for Europe
VDST	Vocabulary Development Support Tool
OCP	Open Collaboration Platform