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Deliverable 11.3
“Dissemination and standardisation report Y2 and plan for Y3 and beyond”

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Abstract
This document constitutes deliverable D11.3 of the Arrowhead fPVN project.

“Dissemination and standardisation report Y2 and plan for Y3 and beyond”

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Keywords	Dissémination, communication, standardisation, IoT Catalogue
Abstract	This document constitutes deliverable D11.3 of the Arrowhead fPVN project. “Dissemination and standardisation report Y2 and plan for Y3 and beyond”.

Table of contents

1. Abbreviations

Abbreviation	
N/A	

2. Introduction

This document presents a comprehensive report on the dissemination, standardization, and exploitation activities undertaken during the second year of the project. It underscores the importance of maintaining robust monitoring and evaluation practices throughout the project’s duration to maximize the impact of its outcomes. The report provides a detailed analysis of both completed and ongoing activities, which serve as a foundation for planning future actions.

To ensure continuous improvement, the document emphasizes the ongoing assessment of communication and dissemination effectiveness, the identification and tracking of standardization opportunities and contributions, and the exploration of innovation pathways within the potential market for project results.

Additionally, project partners provide updates on their individual and joint strategies aimed at maximizing impact. These updates reflect a commitment to adaptability and flexibility, fostering added value in project outcomes. The impact creation activities described in this deliverable fall under Work Package 11 (WP11), which plays a horizontal role across the project. WP11 supports all other work packages by identifying opportunities for impact and translating project results into meaningful contributions in communication, standardization, and exploitation domains.

This deliverable is the third in a series of annual reports documenting the project’s progress in impact creation. It will be succeeded by Deliverable D11.4, which will report on progress and updated plans for the final year of the project.

The document is structured around the two main categories of impact creation activities, each addressed in a dedicated chapter. In this respect, chapter 3 details the communication and dissemination activities, ranging from event participation and organization to publications of different nature. The different communication channels (website, social networks, newsletters, etc.) are described and their impact analyzed as well. An update of the communication plan for the next project year is included. The following one summarizes the active involvement and the contributions made to different standardization bodies and industry groups, including the discussion of ongoing activities and further contributions.

3. Dissemination, communications and standardisations activities

3.1. Communication activities highlights

3.1.1. Objectives

This chapter outlines the dissemination and communication activities conducted during the second year of the project. The primary objective is to ensure that the project’s expected results are communicated broadly and effectively to relevant stakeholders and the wider public. The activities reported include, but are not limited to, participation in conferences, workshops, and other relevant events; the preparation and publication of scientific papers, articles, and general communication materials; as well as the establishment and reinforcement of collaborations and synergies with related initiatives and projects.

3.1.2. Content

3.1.2.1. Project website updates

The Arrowhead fPVN project website, available at https://fpvn.arrowhead.eu/fpvn-arrowhead/, has been operational since June 2023 and is jointly managed by LTU, UPB, and BEIA. The website provides a comprehensive overview of the project, including detailed information on its various work packages.

A key feature of the website is the **Dissemination** section, which systematically catalogs project outputs and partner contributions. This section facilitates easy access to references and supports efficient citation, reinforcing the project’s commitment to transparency and open access. All dissemination materials produced by partners are made publicly available to the greatest extent possible, in alignment with the project’s open science and communication principles.

Furthermore, the website functions as a central hub for project news and updates. It integrates content from the project's social media presence on platforms such as X (formerly Twitter), LinkedIn, and YouTube. News items are created and published on the website and are subsequently promoted across these social media channels to maximize visibility and engagement.

3.1.2.2. ARROWHEAD fPVN dedicated events

During the second year of the Arrowhead fPVN project, the consortium has conducted a series of internal and external workshops, as well as general assemblies. Effective internal communication remains essential, particularly in the early stages of collaboration, to align strategic objectives and ensure a cohesive approach toward achieving project impact.

Throughout this period, the consortium has organized several key meetings, These gatherings have served as important milestones for consolidating ideas, reviewing progress, and coordinating next steps across the consortium. During the second year of the project the consortium has held one workshop on November 2024, in Budapest, the Review meeting in June 2024, in Brussels, a general assembly in May 2025, in Emden.

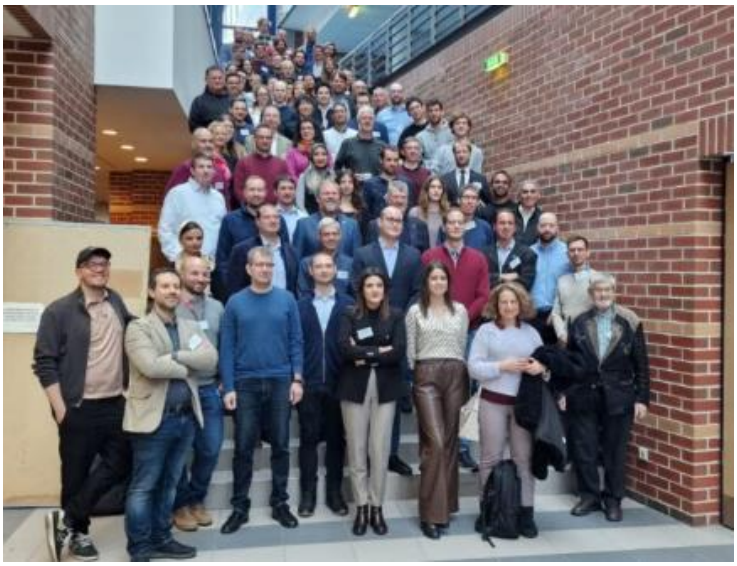

Fig. 1 – Workshop November 2024

Fig. 2 – Review meeting

Fig. 3 – GA Budapest – June 2024

Fig. 4 – GA Emden – May 2025

3.1.2.2.1. ARROWHEAD fPVN workshops

- ***Joint Finnish-Swedish Arrowhead fPVN Project Technical Meeting Held at New Stora Enso Headquarters***

In September 2024, the Arrowhead fPVN project marked a significant milestone with a full-day technical meeting at the newly inaugurated Stora Enso headquarters. This event underscored the robust Finnish-Swedish collaboration driving the project forward. The primary focus was on refining the integration between Information Technology (IT) and Operational Technology (OT) architectures to address the specific challenges presented by Stora Enso's use cases. Discussions delved into enhancing system interoperability, efficiency, and security within industrial settings. A notable outcome was the identification of seven potential exploitation pathways emerging from the project's developments, highlighting its commercial and technological relevance. This meeting exemplified the project's commitment to continuous technical refinement and its dedication to delivering impactful solutions in industrial automation and connectivity.

Fig. 5 – Arrowhead fPVN technical meeting

- ***AIMS5.0 & Arrowhead fPVN Deep Tech Workshop***

In November 2024, the Arrowhead fPVN and AIMS5.0 projects co-hosted a Deep Tech Workshop at the Budapest University of Technology and Economics (BME). This collaborative event convened experts from both initiatives to delve into advanced technological topics, including the AI Toolbox and AI-Gym, data model translation, technology governance, Eclipse Arrowhead 5.0, AI-supported engineering, and the Arrowhead Domain-Specific Language (DSL). Discussions were enriched by poster sessions addressing the technological needs of use cases from both projects. The workshop fostered a robust exchange of ideas, strengthening the synergy between Arrowhead fPVN and AIMS5.0, and advancing their shared objectives in industrial automation and smart manufacturing.

- ***THTH Webinar***

On May 29, 2024, THTH, in collaboration with its member companies and over 40 international partners, hosted a joint webinar as part of the European Arrowhead fPVN project. This online event brought together leading experts and organizations to explore critical developments in industrial data interoperability, digitalization, and collaborative process standardization.
The program featured presentations from key industry players including Neste, AFRY, Semantum, BASF, Evonik, CFIHOS, and Stora Enso, with discussions spanning topics such as:

- Criticality classification and data requirements
- Intelligent P&ID conversion
- Digital Product Passports and the Digital Data Chain Consortium
- DEXPI process specification and continuous data model maintenance
- CFIHOS framework updates

Use cases from investment projects within the Arrowhead fPVN scope. The event reinforced the vital role of standardization and system integration in enabling future-proof, interoperable industrial environments.

- **Workshop 1 - Arrowhead fPVN and DISC 2025-01-08 / Arlanda Stockholm**

The First Meeting in the cooperation between Arrowhead fPVN project and Norwegian project **DISC**/DIGITALISATION–INDUSTRIALISATION–STANDARDISATION-COLLABORATION.

Fig. 6 – Arrowhead fPVN technical meeting

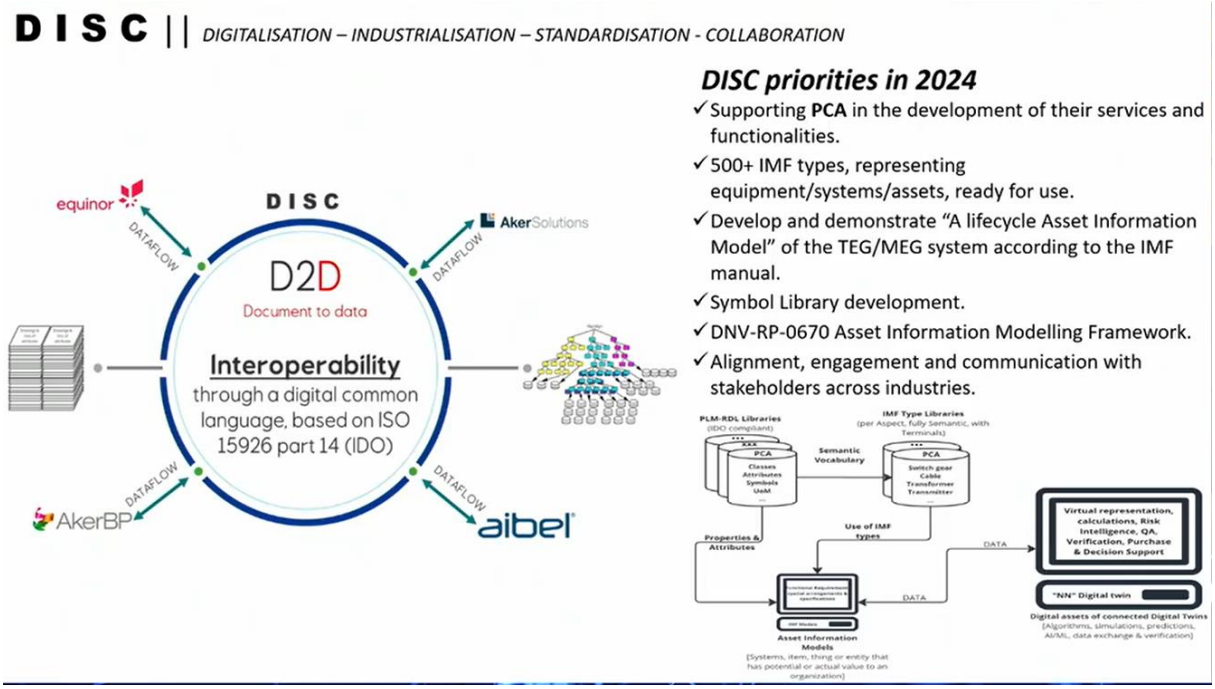

Fig. 7 – DISC priorities

The Arrowhead fPVN and the DISC projects have overlapping objectives and scope. Initial contacts with the two projects indicate substantial interest in cooperation. To start this cooperation, we organize a physical meeting at Arlanda, Stockholm 2025-01-08, 09:30-16:00.

From the Agenda

- - Presentation of Arrowhead fPVN
  - WP9: Process Industry
  - · WP3: Major standardized data models
- Presentation of DISC
  - · Overview
  - · IMF
  - · DEXPI data
- Status and plans for ISO 23726: Ontology based interoperability
- Way forward – Possible joint WGs
  - · Align DEXPI to IDO
  - · Align ISO 10303-239/242 to IDO
  - · Establish necessary reference data for the Process Plant use-cases in close cooperation with WP9 in Arrowhead.
  - · Align CFIHOS to IDO
  - · Guidelines for modelling according to IDO

- **Workshop 2 - Arrowhead fPVN, DISC and CFIHOS Semantics 2025-03-19 to 20 / Aker Solutions, Oslo**

Fig. 8 – Arrowhead fPVN Workshop

Continue the work that started at the Stockholm meeting 2025-01-08

Objectives of the meeting:

- Report on progress since the meeting at Arlanda
- Review of the plans for the five WGs established at the Arlanda meeting
- Agree on the way forward

The Working groups started the operational work during the meeting and have online meetings to continue the work.

- **Workshop 3 - Arrowhead fPVN, DISC and CFIHOS Semantics 2025-05-06 to 07**

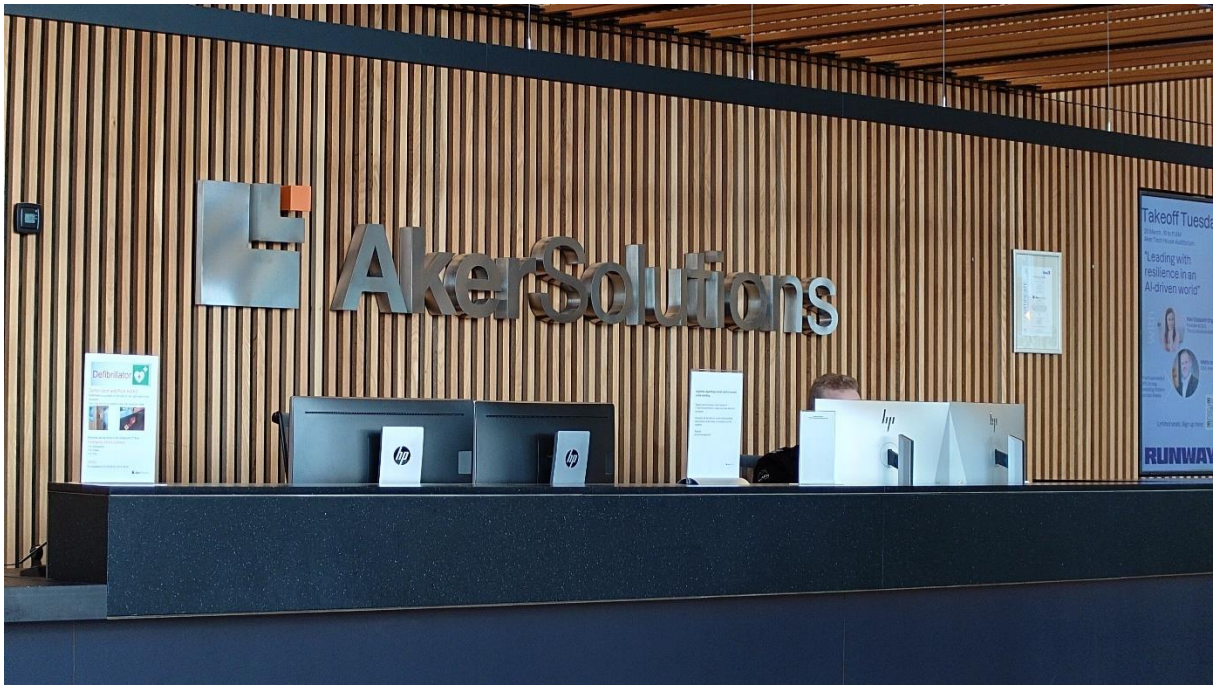

Fig. 9 – Arrowhead fPVN Workshop

The work will continue during the next planed Workshop in Oslo at Aker Solutions. Participation in Events/conferences/fairs

- ***ETTI Day, March 2025, Bucharest***

The Arrowhead fPVN project was prominently represented at this flagship event organized by the Faculty of Electronics, Telecommunications and Information Technology (ETTI) at the University Politehnica of Bucharest. The team presented key technological advancements, engaged in panel discussions with academic and industry stakeholders, and disseminated promotional materials. The event facilitated several new stakeholder connections, including representatives from local SMEs and industrial automation firms, who expressed interest in future collaboration and adoption of fPVN innovations.

- ***POLI International Fest, March 2025, Bucharest***

As part of the University Politehnica of Bucharest’s international engagement initiative, Arrowhead fPVN participated with a dedicated booth and live demonstrations of key use cases in industrial automation. The event attracted students, researchers, and visiting delegations from across Europe, enabling the project to showcase its contributions to digital transformation and smart production systems. A highlight of the engagement was a roundtable session on cross-border collaboration where Arrowhead fPVN's role in flexible production networks was acknowledged as a reference case.

- ***MedFest, February 2025, Bucharest***

This health innovation expo provided a unique platform to highlight the intersection between secure IoT-enabled production systems and medical device manufacturing. The Arrowhead fPVN team focused its contribution on cybersecurity challenges and real-time interoperability in medical production chains. The presentation sparked strong interest from representatives of national health tech startups and policy makers concerned with digital trust and resilience in healthcare-related production environments.

- ***ICIN 2024, March 2025, Paris***

At the International Conference on Intelligence in Next Generation Networks, the Arrowhead fPVN project was featured in a technical session on edge-cloud convergence. A scientific paper was presented, detailing architectural insights into microservice orchestration for flexible production. The session attracted academics, standardisation bodies, and network engineers, opening discussions on integrating Arrowhead frameworks into emerging 6G and industrial edge network scenarios.

- ***SCIC 2024, December 2024, Bucharest***

The 12th Smart Cities International Conference provided an opportunity for Arrowhead fPVN to link its flexible production network concepts with the broader smart city infrastructure narrative. The project contributed to a thematic session on decentralised industrial services in urban ecosystems. Municipal leaders and urban innovation labs showed significant interest in the project's service-oriented automation paradigm, with follow-up discussions planned around energy-efficient, localised production systems.

- ***Bitcoin Conference, March 2025, Bucharest***

Despite its fintech focus, this high-profile event enabled Arrowhead fPVN to explore intersections between blockchain-based traceability and secure supply chain orchestration. The team participated in a panel on industrial blockchain use cases, emphasizing the need for interoperable frameworks in traceable manufacturing. Notably, the presentation captured the attention of distributed ledger technology providers, leading to exploratory talks on integrating fPVN architecture with permissioned blockchain solutions.

- ***HiPEAC 2025, January 2025, Barcelona***

The Arrowhead fPVN consortium was present at Europe’s premier computing systems conference, showcasing its achievements in real-time embedded systems for industrial automation. A joint presentation with academic partners emphasized the integration of Arrowhead service-oriented architecture with multicore edge computing environments. The event provided deep technical feedback and fostered new research collaborations with embedded systems researchers and EU-funded HPC projects.

- ***EFECS 2024, November 2024, Ghent***

As a strategic European forum for electronic components and systems, EFECS 2024 offered a prime stage for Arrowhead fPVN to engage with policymakers, industry leaders, and funding agencies. The project hosted a live demo and participated in a Chips JU panel on cyber-physical systems. Discussions centered around the industrial scalability of the Arrowhead framework and its alignment with EU digital sovereignty and resilience goals.

- ***PLM Road Map & PDT Europe 2024, October 2024, Gothenburg***

In October 2024, the Arrowhead fPVN project was showcased at the PLM Road Map & PDT Europe 2024 conference in Gothenburg, Sweden. The project team presented their advancements in autonomous and evolvable information interoperability within flexible production value networks, emphasizing the integration of existing standards with modern technologies like microservices and semantic models. This approach aims to enhance manufacturing productivity and flexibility through a digital data-driven infrastructure. The presentation sparked engaging discussions among industry experts and academics, highlighting the project's potential to transform traditional PLM and ERP systems.

- ***PIDMIC 3.0 at ACHEMA 2024***

PIDMIC 3.0 at ACHEMA 2024 was a key side event focused on advancing data integration in the process industry. Held June 11–12 in Frankfurt, it brought together experts to discuss practical applications, standards like ISO 15926, and the integration of models such as CFIHOS and DEXPI. The event took place during ACHEMA 2024, the world’s leading trade fair for the process industries, which featured over 2,800 exhibitors and 900+ talks on innovation themes like Digital, Green and Hydrogen.

- ***DEXPI General Meeting Q4 2024***

The DEXPI Annual General Meeting for Q4 2024 took place on November 11, 2024, in Frankfurt am Main. This gathering brought together member organizations and industry stakeholders to discuss progress in standardizing data exchange across the process industry. Key topics included the release of DEXPI P&ID Specification 1.4, updates on the DEXPI Process Specification for PFDs and BFDs, and the roadmap toward DEXPI 2.0—a unified model integrating process and plant data. The meeting also served as a platform to align ongoing initiatives with international standards like ISO 15926 and to foster collaboration among software vendors and engineering firms.

- ***DISC Show and Tell***

The DISC Show and Tell 2024, held in early September at Equinor's Business Center in Stavanger, Norway, brought together over 150 professionals from leading energy companies, including Aker BP, Aker Solutions, Aibel, and Equinor. The event focused on showcasing advancements in digital project documentation, emphasizing the use of ontologies and digital standards developed by the POSC Caesar Association (PCA). These innovations aim to replace manual processes with automated, machine-readable formats, enhancing efficiency in the energy sector. Itera presented a proof-of-concept demonstrating the integration of as-built

information into digital twin applications, facilitating equipment monitoring during commissioning and operational phases. Their efforts were recognized with an award for "Innovative and seamless utilization of multiple standards all the way to the digital twin.

- ***VeryDeepTech #1 workshop***

Feb 5-6 a VeryDeepTech workshop was organised in Lulea, again in cooperation with AIMS5.0. Here fundamentals for cyber architectures was detailed and a set of concrete investigation and development actions was defined.

- **THTH webinar 2025**

THTH is one of the actors preparing pilot projects for the process industry, especially from a Finnish perspective. In addition to Finland, Sweden and Norway are also involved in the same Arrowhead fPVN process industry digitalization challenges. To accelerate development, Arrowhead fPVN and the Norwegian DISC project decided to join forces to create suitable standardization and business ecosystems for company pilot projects in different countries.

- ***DEXPI General Meeting Q1 2025***

The DEXPI General Meeting for Q1 2025 convened in early March, bringing together member organizations and industry stakeholders to discuss advancements in data exchange standards within the process industry. Key topics included progress on the DEXPI 2.0 roadmap, updates to the P&ID Specification, and alignment with international standards such as ISO 15926. The meeting served as a platform to foster collaboration among software vendors and engineering firms, aiming to enhance interoperability and efficiency in digital engineering workflows.

- ***The 8th IEEE International Conference on Industrial Cyber-Physical Systems (ICPS 2025)***

The 8th IEEE International Conference on Industrial Cyber-Physical Systems (ICPS 2025), held in May 2025 in Emden, Germany, brought together researchers, industry leaders, and innovators from around the world to share advancements in industrial digitalization. Under the theme “The Ongoing Digital Transformation,” the event focused on cutting-edge developments in cyber-physical systems, artificial intelligence, industrial automation, and digital twin technologies. Attendees explored a wide range of topics including ICPS architectures, autonomous systems, edge computing, and data-driven decision-making, emphasizing scalable, interoperable, and secure solutions for next-generation industrial applications. The program featured technical paper sessions, special tracks, tutorials, exhibitions, and and Industry Forums with practical demonstrations and case studies from leading European CPS industries. Here Arrowhead fPVN in cooperation with AISM5.0 was responsible for the organisation of one Industry Forum session addressing uptake of new technologies in industrial production featuring presentation from Volvo, Xarepo and SEIIA. This Industry Forum session addressed uptake of new technologies in industrial production.
At the ICPS conference Professor Jerker Delsing, LTU, was one of the special invited keynote speakers.

Fig. 10 – ICPS 2025

3.2. Publications

3.2.1. Scientific works

- **Title:** Virtualizing Operational Technology by Distributed Digital Twins

Author: Aziz Abdullah
Link: https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1818261&dswid=4779
Abstract:
Industrial digitalization, stemming from the convergence of Information Technology (IT) and Operational Technology (OT), is a transformative force in modern industries. The Industrial Internet of Things (IIoT) and Industrial Cyber-Physical Systems (ICPS) empower industries with enhanced production processes, data-driven insights, and advanced automation. Accompanying these trends, digital twins bridge the gap between the physical and digital realms, promising dynamic representations of entities. This convergence holds great promise for fostering efficient and agile industrial ecosystems.

However, amidst the promise, a series of challenges loom large across a multitude of domains. These challenges span a multitude of domains. The convergence of IT and OT engenders a spectrum of complexities, including interoperability issues, data integration dilemmas, and the imperative need to tackle the historical hardware-centricity of industrial systems. This includes enhancing energy efficiency and security in the digital realm and addressing fundamental issues within the fabric of modern industries.

The scope of our research addresses these multifaceted challenges by encompassing three overarching research questions. The first explores the integration of IIoT architectures and data integration models, striving to augment interoperability and data exchange for industries, offering practical benefits. The second delves into the realm of ICPS and industrial automation, investigating how Digital Twins can optimize energy efficiency, security, and service availability. The third widens the horizon by examining the potential of distributed digital twins as proxies to foster composability and adaptability, bridge the physical-virtual gap, and meet the evolving needs of industrial IoT and cyber-physical systems.

Our thesis unfolds with five key contributions, each addressing fundamental challenges in industrial digitalization. First, we present a synthesized IIoT architecture tailored for the mining industry, aligning seamlessly with IoT and Industry 4.0 standards and frameworks. Second, we explore data integration through service-based and event-driven communication models across

industries. We provide a qualitative analysis of these models to present guidelines for designing data integration solutions according to needs.

In the third contribution, we focus on digital twins for Industrial Cyber-Physical Systems (ICPS) and introduce the concept of a digital twin as proxy. This concept enables the virtualization of tangible devices and assets from the OT domain to the IT domain. This contribution addresses energy efficiency, security, and service availability challenges. Building on this, our fourth contribution implements and integrates the concept of the digital twin as a proxy with the Eclipse Arrowhead Framework, extending its applicability to industrial automation and reinforcing our response to the second research question.

Our fifth contribution further envisions the virtualization of the OT within IT. Grounded in service-oriented and microservice architectural principles, we propose the concept of purpose-oriented composable digital twins by utilizing distributed digital twins as proxies. This concept offers a forward-looking solution to address evolving needs. Together with the third and fourth contributions, our work ensures a comprehensive and forward-looking impact on the discourse of industrial digitalization.

- **Title:** Data-Driven Optimizations in Production Value Networks

Author: Javed Salman
Link: https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1919523&dswid=-1439
Abstract:

Industry 4.0 is transforming traditional production systems into dynamic and adaptive value networks. However, this shift reveals significant challenges in achieving seamless interoperability, workflow optimization, and effective value chain analysis within complex production environments. This thesis contributes to addressing these challenges through a structured approach, supporting data-driven and adaptive decision-making to optimize operations in dynamic production value networks. The research commences by architecting microservice-oriented systems that facilitate the integration of legacy and brownfield technologies with Industry 4.0-compliant environments. By leveraging the Eclipse Arrowhead framework, the thesis demonstrates how diverse systems can exchange data and collaborate at runtime, establishing the foundation for cohesive and interoperable production networks. Building on this interoperable structure, the thesis explores AI-driven optimizations across key areas, including workflow optimization, predictive maintenance, and demand response. These approaches support operational efficiency and adaptability in production value networks. Case studies showcase collaborative learning models for condition monitoring and an edge-based framework to optimize energy use, demonstrating tangible improvements in efficiency and resilience.

Finally, a significant contribution of this thesis is the introduction of tools for visualization and analysis of value chains. Using the Reference Architectural Model for Industry 4.0 (RAMI 4.0), the research provides methods to map and evaluate value creation within dynamic production networks. By integrating activity-based costing with microservice architectures, it offers granular insights into cost and value dynamics at runtime, enabling agile and informed decision-making in complex industrial environments.Through these contributions, the thesis advances the understanding and implementation of data-driven optimizations in production value networks, supporting agility and sustainability while contributing to the transition to circular business models by enabling value chain analysis across the product lifecycle. The thesis serves

as a bridge between theoretical frameworks and practical applications, providing valuable insights for both academia and industry, and paving the way for more efficient and sustainable production ecosystems.

- **Title:** Optimizing Smart Industries: Strategies for Efficient System of Systems Development

Author: Tripathy Aparajita
Link: https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1810424&dswid=4736
Abstract:
The era of extensive digitalization marked by the fourth industrial revolution has ushered in significant advancements in technologies like automation, artificial intelligence, and the Internet of Things (IoT). These innovations are revolutionizing manufacturing processes. Industry 4.0 (I4.0) and the subsequent Industry 5.0 (I5.0) emerged as comprehensive representations of the physical world in the information world, with goals to establish smart factories and promote human-machine coexistence. However, the implementation of I4.0 and I5.0 applications faces challenges related to engineering effort, interoperability, and efficient service discovery and binding.

This thesis seeks to address these challenges by exploring potential strategies to develop an efficient System of Systems (SoS) that comprises individual, autonomous systems collaborating to achieve a shared goal. This research examines methods to enhance the efficacy of SoS by refining its engineering procedures, promoting interoperability between standardized protocols, and employing dynamic adaption mechanisms. It aims to achieve automatic service discovery and interoperability between diverse industrial standards by integrating the Eclipse Arrowhead Framework. This IoT framework facilitates secure and seamless communication and collaboration among devices, machines, and systems.

Moreover, this work delves into saving energy consumption in distributed SoS environments. The thesis aims to optimize energy usage patterns, diminish peak loads, and bolster energy distribution and stability. This is achieved through the Demand Response (DR) mechanism combined with the Eclipse Arrowhead framework. The overarching objective is to pave the way for flexible production processes characterized by minimal resource waste, optimized energy consumption, and sustainable solutions. Through this endeavor, the thesis contributes to shaping a more efficient, interoperable, and sustainable manufacturing landscape in the context of Industry 4.0 and beyond.

3.2.2. Conference papers

- **Title:** U**nveiling Synergies**: Integrating IEEE 1451 and ISO 15926 for Advanced Interoperability in Smart Manufacturing and Transportation

Authors: Vahid Tavakkoli; Kabeh Mohsenzadegan; Witesyavwirwa Vianney Kambale; Kyandoghere Kyamakya
Link: https://ieeexplore.ieee.org/abstract/document/10848585
Abstract:
In smart manufacturing and transportation systems, seamless interoperability is crucial for efficient data exchange and informed decision-making. This paper explores integrating IEEE 1451 and ISO 15926 data models to enhance interoperability in these sectors. We align sensor and actuator models to bolster interoperability and assess leveraging these standards within the

Arrowhead flexible Production Value Network (fPVN). We propose innovative solutions, including an ontology mapping tool for seamless data integration, a wrapper service for real-time data translation, and a lightweight semantic reasoner at the fog computing layer. These solutions bridge the gap between theoretical constructs and practical applications, overcoming interoperability barriers, enhancing decision-making, and refining operational effectiveness. Our study shows significant potential for improving system cohesiveness, efficiency, and robustness tailored to Industry 5.0. This research provides a foundation for future implementations in smart manufacturing and transportation, paving the way for advanced, responsive, and sustainable industrial ecosystems.

- **Title:** Co-pilots for Arrowhead-based Cyber-Physical System of Systems Engineering

Authors: Csaba Hegedűs; Pál Varga
Link: https://ieeexplore.ieee.org/abstract/document/10575845
Abstract:
One benefit of Large Language Model (LLM) based applications (e.g. chat assistants or co-pilots) is that they can bring humans closer to the loop in various IT and OT solutions. Co-pilots can achieve many things at once, i.e. provide a context-aware natural language interface to knowledge bases, reach various systems (via APIs), or even help solving multi-step problems with their planning and reasoning abilities. However, making production-grade chat assistants is a topical challenge, as fast-evolving LLMs expose new types of application design and security issues that need tackling. These especially rise to power when we try to apply these solutions to industrial automation use cases, as they need additional explainability and reliability engineered into the architecture. This paper describes the envisioned use cases and the findings of proof of concept copilots for the Cyber-Physical System of Systems (CPSoS) engineering domain. The paper suggests three types of copilots to support the stages throughout the CPSoS engineering lifecycle – and shows Proof-of-Concept scenarios for the Eclipse Arrowhead engineering process.

- **Title:** Integrating IEEE 1451 and IEC 61499 Standards for Enhanced Interoperability in Smart Manufacturing and Transportation Systems

Authors: Vahid Tavakkoli; Kabeh Mohsenzadegan; Witesyavwirwa Vianney Kambale; Kyandoghere Kyamakya
Link: https://ieeexplore.ieee.org/abstract/document/10858972
Abstract:
Achieving interoperability in smart manufacturing and transportation systems is crucial for seamless data exchange and optimized decision-making processes. This paper presents an advanced integration approach combining the IEEE 1451 and IEC 61499 standards to address key interoperability challenges within these sectors. The proposed solution includes ontology mapping tools, real-time data translation services, and semantic reasoning at the fog computing layer, specifically designed to align sensor and actuator models. These innovations bridge theoretical frameworks with practical applications, significantly improving data model translation accuracy and real-time processing efficiency. Our findings highlight the potential of integrating IEEE 1451 and IEC 61499 standards to advance Industry 5.0 ecosystems, contributing to smarter, more responsive industrial systems and enhancing operational efficiency and decision-making capabilities.

- **Title:** Adaptive Kalman Filtering in Offset Estimation for Precision Time Protocol

Authors: Gergely Hollósi; Dániel Ficzere
Link: https://ieeexplore.ieee.org/abstract/document/10684400
Abstract:
The synchronization of digital clocks driven by crystal oscillators through packet-based protocols is widely employed across various applications. The IEEE 1588-2019 protocol facilitates the accurate synchronization of follower devices with leader clocks. Nevertheless, the algorithms for clock state estimation face challenges due to the continuous fluctuations in packet delay variations, leading to degradation in the quality of the state estimation. Although Kalman filtering has been introduced for IEEE 1588 to enhance time estimation accuracy, the selection of the measurement noise covariance remains a persistent issue. This article suggests an approach based on adaptive Kalman filtering to estimate measurement noise variance, with a particular focus on maintaining low computational complexity. This aims to establish lower state estimation variance and bias by introducing a novel measurement model with time-invariant measurement noise variance applicable in adaptive Kalman filtering. The proposed method exhibits superior performance compared to state-of-the-art estimation algorithms designed for IEEE 1588 state estimation, as demonstrated through both simulation and real measurements.

- **Title:** ML-Based Translation Methods for Protocols and Data Formats

Authors: Tamas Tothfalusi; Eszter Varga; Zoltan Csiszar; Pal Varga
Link: https://ieeexplore.ieee.org/abstract/document/10327850
Abstract:
In order to exchange information between systems, the information must get encoded into a predefined data format, and it must be transferred in a protocol that the communicating parties have agreed upon. This works well if all parties follow the same protocol standard and use the same data description schemes. If systems use different data formats or protocols, then some sort of translation is required. Protocol and data format translation has been attempted previously through rule-based approaches, ontologies, and also by using machine learning (ML) techniques. Due to the current advances related to AI/ML methods, tools, and infrastructure, the accuracy and feasibility of “translation” with ML-approaches improved significantly. This paper introduces a generic approach and methodology for translating data formats and protocols with ML-based methods and presents our initial results through JSON-XML and JSON-SenML translation.

- **Title**: A model based implementation of an IoT framework

Author: Jan van Deventer
Link: https://www.techrxiv.org/doi/full/10.36227/techrxiv.174195758.81241062
Abstract:
The growing complexity of the Industrial Internet of Things (IoT) necessitates robust methodologies for efficient system development and deployment. This paper introduces a model-based code structure that implements an IoT framework, streamlining system development for engineers, simplifying deployment for technicians, and ensuring compliance with industry standards. Key design principles explored in this work include resilience, interoperability, cybersecurity, and semantic reasoning-critical for building scalable IoT

solutions. To validate this approach, we present a climate control use case alongside industrial system implementations that integrate OPC UA, Modbus, and MQTT.

- **Title:** Models2Code: Autonomous model-based generation to expedite the engineering process

Author: Cristina Paniagua, Fernando Labra Caso
Link: https://incose.onlinelibrary.wiley.com/doi/full/10.1002/sys.21789
Abstract:

Insufficient resources and high costs are hindering industrial development, potentially impeding adaptation to market demands. Overcoming this challenge necessitates advancements in software engineering techniques to streamline processes and meet industrial requirements. Crucially, automating manual tasks and enhancing interoperability between engineering stages can yield efficiency gains. This paper presents a model-based system engineering approach aimed at automating the transition from design to implementation, incorporating autonomous generation and validation features. Implemented as plugins and utilizing model transformation techniques, this solution targets reducing engineering time and facilitating the adoption of new technologies. Developed, implemented, and tested within the Arrowhead framework, the approach is followed by a discussion on its benefits and limitations.

- **Title:** An approach towards demand response optimization at the edge in smart energy systems using local clouds

Author: Salman Javed, Aparajita Tripathy, Jan van Deventer, Hamam Mokayed, Cristina Paniagua, Jerker Delsing
Link: https://www.sciencedirect.com/science/article/pii/S2666955223000308
Abstract:
The fourth and fifth industrial revolutions (Industry 4.0 and Industry 5.0) have driven significant advances in digitalization and integration of advanced technologies, emphasizing the need for sustainable solutions. Smart Energy Systems (SESs) have emerged as crucial tools for addressing climate change, integrating smart grids and smart homes/buildings to improve energy infrastructure. To achieve a robust and sustainable SES, stakeholders must collaborate efficiently through an energy management framework based on the Internet of Things (IoT). Demand Response (DR) is key to balancing energy demands and costs. This research proposes an edge-based automation cloud solution, utilizing Eclipse Arrowhead local clouds, which are based on Service-Oriented Architecture that promotes the integration of stakeholders. This novel solution guarantees secure, low-latency communication among various smart home and industrial IoT technologies. The study also introduces a theoretical framework that employs AI at the edge to create environment profiles for smart buildings, optimizing DR and ensuring human comfort. By focusing on room-level optimization, the research aims to improve the overall efficiency of SESs and foster sustainable energy practices.

- **Title:** AIMS5.0 AI Toolbox: Enabling Efficient Knowledge Sharing for Industrial AI

Author: Gergely Hollósi; Dániel Ficzere; Attila Frankó; Máté Bancsics; Ruba AlMahasneh; Csaba Lukovszki
Link: https://ieeexplore.ieee.org/abstract/document/10575076
Abstract:

Industry 5.0 continues to reshape the industrial processes, the pivotal role of AI services in optimizing operations has become increasingly evident. Although the state-of-the-art AI models are widely employed across diverse application areas, the industrial sector faces numerous challenges in navigating through a plethora of the available AI models and libraries.Indeed, lacking effective employment guidelines for AI models can hinder their utility and decrease their adaption. This paper introduces the AIMS5.0 AI Toolbox, an innovative framework designed to address this challenge by fostering industrial knowledge sharing and distribution. The AIMS5.0 AI Toolbox serves as a comprehensive resource for industrial practitioners. It offers an integrated holistic platform for sharing models, tools, best practices, and guidance specifically directed towards the industrial AI-based consumers. Through its multifaceted approach, the toolbox facilitates seamless exchange of insights and expertise among the industrial actors. In addition, the AIMS5.0 AI Toolbox gives new ways to the process of fast prototyping by leveraging well-established AI-based models and libraries. By incorporating solid best practices and recommendations, the toolbox provides a structured framework for industrial users to harness the power of AI effectively.

- **Title:** Confidentiality Preserving Data Sharing for Life Cycle Assessment in Process Industries

Author: Hansani Perera; Udayanto Dwi Atmojo; Valeriy Vyatkin
Link: https://ieeexplore.ieee.org/abstract/document/10710738
Abstract:
The pulp and paper industry faces significant en-vironmental challenges, such as air pollution, greenhouse gas emissions, and wastewater discharge, requiring smarter and more sustainable operations. Regulatory bodies are imposing stringent measures to mitigate these impacts, prompting the industry to adopt sustainable practices and technologies. Life Cycle Assessment (LCA) models are crucial in this effort, pro-viding a comprehensive evaluation of environmental impacts and aiding decision making for sustainable manufacturing. However, organisations prioritise the confidentiality of their sensitive data, which can hinder collaborative efforts and LCA calculations. This paper addresses organisational requirements for improving confidentiality, tamper-proof data transfer, and ensuring data sovereignty. The ongoing proof-of-concept introduces a novel approach in LCA, employing Secure Multiparty Computation (SMPC) and data spaces to enable confidentiality-preserving LCA. Our solution ensures data sovereignty and accurate LCA calculations, promoting sustainable practices across the value chain. This paper lays the foundation for a collaborative data platform that meets the critical needs of confidentiality, security, and sustainability in the process manufacturing industry.

- **Title:** Multiprotocol Middleware Translator for IoT

Author: Bernado Cabral; Ricardo Venâncio; Pedro Costa; Tiago Fonseca; Luis Lino Ferreira; Ricardo Severino
Link: https://ieeexplore.ieee.org/abstract/document/10741686
Abstract:
The increasing number of IoT deployment scenarios and applications fostered the development of a multitude of specially crafted communication solutions, several proprietary, which are erecting barriers to IoT interoperability, impairing their pervasiveness. To address such problems, several middleware solutions exist to standardize IoT communications, hence

promoting and facilitating interoperability. Although being increasingly adopted in most IoT systems, it became clear that there was no “one size fits all” solution that could address the multiple Quality-of-Service heterogeneous IoT systems may impose. Consequently, we witness new interoperability challenges regarding the usage of diverse middleware. In this work, we address this issue by proposing a novel architecture - the PolyglIoT, that can effectively interconnect diverse middleware solutions while considering the delivery QoS requirements alongside the proposed translation. We analyze the performance and robustness of the solution and show that such Multiprotocol Translator is feasible and can achieve a high performance, thus becoming a fundamental piece to enable future highly heterogeneous IoT systems of systems.

- **Title:** Interoperability for Cyber-Physical Systems: An overview of challenges and research gaps

Author: Siyu Chen, Pal Varga
Link: https://www.researchgate.net/profile/Pal-Varga/publication/378576331_Interoperability_for_Cyber-Physical_Systems_An_overview_of_challenges_and_research_gaps/links/6777e50c00aa3770e0d345a8/Interoperability-for-Cyber-Physical-Systems-An-overview-of-challenges-and-research-gaps.pdf
Abstract:
Cyber-Physical Systems (CPS) can be characterized as the complex integration of computing, communication, and physical processes. CPS have extensive applications in various domains, including industrial automation, vehicular technologies, and smart cities, to name a few. In practical applications, the challenges of interoperability can range from physical-level data fusion to the technical risks faced at the application level. In this paper, we conduct a comprehensive and systematic review of research on interoperability and data integration in the context of CPS. Furthermore, we highlight the main challenges in a summary table and uncover certain unresolved issues. This work aims to provide promising future directions in relation to CPS interoperability, to guide researchers in their upcoming endeavors.

- **Title:** Run-Time Value Chain Analysis and Cost Accounting via Microservices in Agile Manufacturing

Author: Salman Javed; Cristina Paniagua; Imran Javed; Jan van Deventer; Jerker Delsing
Link: https://ieeexplore.ieee.org/abstract/document/10849611
Abstract:
The rapid evolution of manufacturing processes driven by Industry 4.0 demands systems capable of quickly adapting to dynamic market conditions and evolving customer needs. Agile manufacturing emphasizes flexibility, adaptability, and real-time responsiveness, posing challenges in run-time value chain analysis (VCA), including cost flows and production times. This article presents a novel two-stage VCA approach using an activity-based costing mechanism via microservices to address these challenges. The VCA system enables real-time cost accounting and decision-making, supporting both pre and postproduction VCA, contrasting with traditional methods that rely on historical data. The first stage involves top–down cost calculations from resources to microservices. In contrast, the second focuses on constructing efficient manufacturing activities based on product requirements, allowing for granular analysis of costs and production times across microservices, activities, broader

business processes, and finally, cost objects (e.g., customized products, batches of products, or customer invoices). The approach is validated through a proof-of-concept implementation of the VCA system integrated with the Eclipse Arrowhead framework and simulating Fischertechnik indexed line milling, drilling, and conveying operations. The results demonstrate the effectiveness of the proposed method in providing detailed insights into costs and production times, enhancing the efficiency and competitiveness of agile manufacturers.

- **Title:** A Time-synchronized Framework for Bluetooth Low Energy Wireless Sensor Networks

Author: Andrea Pignata; Vittorio Fra; Enrico Macii; Gianvito Urgese
Link: https://ieeexplore.ieee.org/abstract/document/10740423
Abstract:
Nowadays, Wireless Sensor Networks (WSNs) are becoming prominent in fields like medicine and automotive industry. A critical requirement for these networks is consistent time-stamping across all sensors, as minor errors can seriously degrade accuracy, but time synchronization can be bandwidth and computation expensive for IoT devices. This paper proposes a framework for acquiring time-synchronized data from multiple BLE-based sensors, easy to implement without additional hardware. Tests demonstrate this solution maintains a synchronization accuracy of up to 10 ms over 24 hours of data streaming. Compared to non-synchronized solutions, it reduces average delay by 42% and maximum delay by 52%.

- **Title:** Utilizing Generative AI for Test Data Generation - use-cases for IoT and 5G Core Signaling

Author: Tamás Tóthfalusi; Zoltán Csiszár; Pál Varga
Link: https://ieeexplore.ieee.org/abstract/document/10574974
Abstract:
Having the appropriate amount and quality of signaling data to test telecommunication data is a constant challenge for vendors and operators alike. Hence, signaling message generation is often a crucial step during testing. When generating signaling messages, traditional approaches often fall short in meeting the dynamic and complex requirements of 5G core and IoT environments. The current paper proposes to leverage Generative AI, particularly Large Language Models (LLMs), to address these challenges, offering a novel methodology for generating test data that is both diverse and representative of real-world scenarios. Through a series of experiments involving various protocols such as CoAP, HTTP, and data representation formats such as XML, JSON, and SenML, we evaluated the efficacy of LLMs in generating accurate and high-quality test data. Our findings demonstrate that Generative AI can enhance the test data generation process with attention to further needs in improving accuracy.

- **Title:** A Hybrid AI Framework Integrating Ontology Learning, Knowledge Graphs, and Large Language Models for Improved Data Model Translation in Smart Manufacturing and Transportation

Author: Kabeh Mohsenzadegan; Vahid Tavakkoli; Witesyavwirwa Vianney Kambale; Kyandoghere Kyamakya

Link: https://ieeexplore.ieee.org/abstract/document/10773919
Abstract:
Interoperability among diverse data standards is crucial for advancing digital technologies in smart manufacturing and transportation. This paper studies and presents a hybrid AI framework that integrates Ontology Learning (OL), Knowledge Graphs (KGs), and Large Language Models (LLMs) to enhance data translation across different standards. Focusing on IEEE 1451, ISO 15926, and IEC 61499, which exemplify the challenges of translating between distinct data models, we evaluate the performance of OL, KGs, and LLMs in terms of accuracy, scalability, efficiency, robustness, and flexibility. The findings indicate that the hybrid framework effectively leverages OL for semantic structuring, KGs for relational modeling, and LLMs for linguistic and contextual processing. This integration significantly improves the accuracy and adaptability of data translations, offering a comprehensive solution tailored to the complex environments of smart manufacturing and transportation, thereby advancing cross-standard data interoperability.

- **Title:** Towards Seamless Data Translation Based on Data Models: A Hybrid AI Framework for Smart Transportation and Manufacturing

Author: Kabeh Mohsenzadegan; Vahid Tavakkoli; Witesyavwirwa Vianney Kambale; Kyandoghere Kyamakya
Link: https://ieeexplore.ieee.org/abstract/document/10858998
Abstract:
Interoperability between different data standards is essential for advancing digital technologies in smart manufacturing and transportation. This paper presents a hybrid AI framework that integrates Ontology Learning (OL), Knowledge Graphs (KGs), and Large Language Models (LLMs) to improve data translation across these standards. Focusing on IEEE 1451, ISO 15926, and IEC 61499, we address the challenges posed by these data models' unique structures and semantics. Our comparative analysis evaluates the strengths and limitations of OL, KGs, and LLMs across key metrics like accuracy, scalability, efficiency, robustness, and flexibility. The proposed framework leverages OL for systematic structuring, KGs for relational modeling, and LLMs for linguistic processing, enhancing translation accuracy and adaptability. However, integrating these approaches introduces scalability and processing efficiency trade-offs, particularly in resource-constrained environments. This study contributes to developing more sophisticated and scalable data translation models tailored for heterogeneous data environments, with practical implications for smart manufacturing and transportation.

- **Title:** Distributed Digital Twins as Proxies-Unlocking Composability and Flexibility for Purpose-Oriented Digital Twins

Author: Abdullah Aziz; Shailesh Singh Chouhan; Olov Schelén; Ulf Bodin
Link: https://ieeexplore.ieee.org/abstract/document/10345582
Abstract:
In the realm of the Industrial Internet of Things (IoT) and Industrial Cyber-Physical Systems (ICPS), Digital Twins (DTs) have revolutionized the management of physical entities. However, existing implementations often face constraints due to hardware-centric approaches and limited flexibility. This article introduces a transformative paradigm that harnesses the potential of distributed digital twins as proxies, enabling software-centricity and unlocking composability and flexibility for purpose-oriented digital twin development and deployment.

The proposed microservices-based architecture, rooted in service-oriented architecture (SOA) and microservices principles, emphasizes reusability, modularity, and scalability. Leveraging the Lean Digital Twin Methodology and packaged business capabilities expedites digital twin creation and deployment, facilitating dynamic responses to evolving industrial demands. This architecture segments the industrial realm into physical and virtual spaces, where core components are responsible for digital twin management, deployment, and secure interactions. By abstracting and virtualizing physical entities into individual digital twins, this approach lays the groundwork for purpose-oriented composite digital twin creation. Our key contributions involve a comprehensive exposition of the architecture, a practical proof-of-concept (PoC) implementation, and the application of the architecture in a use-case scenario. Additionally, we provide an analysis, including a quantitative evaluation of the proxy aspect and a qualitative comparison with traditional approaches. This assessment emphasizes key properties such as reusability, modularity, abstraction, discoverability, and security, transcending the limitations of contemporary industrial systems and enabling agile, adaptable digital proxies to meet modern industrial demands.

- **Title:** Visualization Approach for RAMI 4.0 Value Chain Analysis

Author: Salman Javed; Jan van Deventer; Cristina Paniagua; Jerker Delsing
Link: https://ieeexplore.ieee.org/abstract/document/10807841
Abstract:
Industry 4.0 has revolutionized industrial automation, with models, such as Industry 4.0 Reference Architectural Model (RAMI 4.0), providing a structured framework for optimizing value chains and processes. However, the complexity and abstract nature of RAMI 4.0 have limited its practical application, especially due to the lack of clear visualization methods to understand industrial ecosystems. Effective visualization is essential to translate this framework into actionable insights, enabling stakeholders to grasp system interactions, dependencies, and value-creation processes. This article proposes a multidimensional visualization approach, illustrated through a smart heat pump example, to map information and operational technologies, their interactions, and value chains. Combining 3-D visualizations for integrated system overviews with 2-D visualizations for task-specific analysis, the approach provides a comprehensive understanding of RAMI 4.0 value chains, enabling stakeholders to address their analytical needs with clarity. It facilitates run-time value chain analysis, offering real-time insights for decision-making during operations. The approach maps industrial systems across RAMI 4.0 axes and aligns them with engineering processes and lifecycle phases, enabling the exploration of system interactions, dependencies, and stakeholder contributions. This supports the analysis of engineering and business processes, optimizes infrastructure, and facilitates smooth technological transitions. It enhances RAMI 4.0’s utility for real-time decision-making and operational efficiency, boosting competitiveness in industrial ecosystems.

- **Title:** Dynamically Sharded Ledgers on a Distributed Hash Table

Author: Christoffer Fink, Olov Schelén, Ulf Bodin
Link: https://arxiv.org/abs/2405.14991
Abstract:
Distributed ledger technology such as blockchain is considered essential for supporting large numbers of micro-transactions in the Machine Economy, which is envisioned to involve billions of connected heterogeneous and decentralized cyber-physical systems. This stresses

the need for performance and scalability of distributed ledger technologies. Sharding divides the blockchain network into multiple committees and is a common approach to improve scalability. However, with current sharding approaches, costly cross-shard verification is needed to prevent double-spending. This paper proposes a novel and more scalable distributed ledger method named ScaleGraph that implements dynamic sharding by using routing and logical proximity concepts from distributed hash tables. ScaleGraph addresses cyber security in terms of integrity, availability, and trust, to support frequent micro-transactions between autonomous devices. Benefits of ScaleGraph include a total storage space complexity of O(t), where t is the global number of transactions (assuming a constant replication degree). This space is sharded over n nodes so that each node needs O(t/n) storage, which provides a high level of concurrency and data localization as compared to other delegated consensus proposals. ScaleGraph allows for a dynamic grouping of validators which are selected based on a distance metric. We analyze the consensus requirements in such a dynamic setting and show that a synchronous consensus protocol allows shards to be smaller than an asynchronous one, and likely yields better performance. Moreover, we provide an experimental analysis of security aspects regarding the required size of the consensus groups with ScaleGraph. Our analysis shows that dynamic sharding based on proximity concepts brings attractive scalability properties in general, especially when the fraction of corrupt nodes is small.

- **Title:** Confidentiality Preserving Data Sharing for Life Cycle Assessment in Process Industries

Authors: Hansani Wanni Arachchige Dona, Udayanto Dwi Atmojo, Valeriy Vyatkin
Link: https://research.aalto.fi/en/publications/confidentiality-preserving-data-sharing-for-life-cycle-assessment
Abstract:

The pulp and paper industry faces significant environmental challenges, such as air pollution, greenhouse gas emissions, and wastewater discharge, requiring smarter and more sustainable operations. Regulatory bodies are imposing stringent measures to mitigate these impacts, prompting the industry to adopt sustainable practices and technologies. Life Cycle Assessment (LCA) models are crucial in this effort, providing a comprehensive evaluation of environmental impacts and aiding decision making for sustainable manufacturing. However, organisations prioritise the confidentiality of their sensitive data, which can hinder collaborative efforts and LCA calculations. This paper addresses organisational requirements for improving confidentiality, tamper-proof data transfer, and ensuring data sovereignty. The ongoing proof-of-concept introduces a novel approach in LCA, employing Secure Multiparty Computation (SMPC) and data spaces to enable confidentiality-preserving LCA. Our solution ensures data sovereignty and accurate LCA calculations, promoting sustainable practices across the value chain. This paper lays the foundation for a collaborative data platform that meets the critical needs of confidentiality, security, and sustainability in the process manufacturing industry.

3.2.3. Whitepaper

Title: Bridging Domains in Large-scale Complex and Critical Systems, 2025 Edition
Authors: Spyros Lalis, Danh Le-Phuoc, Alois Zoitl, Octavian Fratu
Link: https://zenodo.org/records/14920027
Description:

The whitepaper *Bridging Domains in Large-scale Complex and Critical Systems – 2025 Edition*, presented at HiPEAC 2025, explores the integration of diverse technological and non-technological domains in the engineering of complex, large-scale, and critical systems. As part of the TechNexus Programme, it highlights the necessity of cross-domain collaboration—combining AI, IoT, and cyber-physical systems (CPS) with market, regulatory, and societal considerations—to address challenges in sectors like manufacturing, transport, and healthcare. The paper synthesizes insights from two key workshops, FORECAST and STEADINESS, which examined early validation of system requirements, secure deployment across the edge-cloud continuum, and dependable systems of systems (SoS). It proposes strategic directions, such as leveraging Europe’s regulatory frameworks for AI trust, embedding CPS/AI topics in education, and developing scalable platforms. Practical case studies, including the integration of NVIDIA AI microservices with the Eclipse Arrowhead framework, illustrate the benefits of modular, interoperable architectures. Overall, the whitepaper provides a roadmap for advancing European digital infrastructure through multidisciplinary innovation, system-level standardization, and coordinated research efforts.

3.3. Liaison with other projects, initiatives & communities

Apart of the usual collaborations with other European projects, such as following each other in social networks, in the second year of the project we have established a close collaboration with the project AIMS5.0 and DISC. We continue this collaboartion organising the following events:

- ***Advancing Semantic Alignment: Arrowhead fPVN, DISC, and CFIHOS Semantics Continue Technical Cooperation in Oslo 08/05/2025***

The ongoing collaboration between Arrowhead fPVN, DISC, and CFIHOS Semantics exemplifies a strong, cross-organizational effort to advance semantic standardization and interoperability in industrial systems. Building on productive meetings in Stockholm, Oslo, and beyond, these initiatives are aligning key international standards—such as ISO 10303, DEXPI, and CFIHOS—with the Industrial Data Ontology (IDO). By establishing dedicated working groups and an expert coordination team, the collaboration is fostering a unified approach to reference data, modelling guidelines, and ontology-driven integration. This partnership not only bridges technical frameworks across disciplines but also supports broader initiatives like Digitala Stambanan and future gatherings such as the upcoming CFIHOS meeting at ExxonMobil, emphasizing the shared commitment to digital transformation and smarter data infrastructure.

- ***The Joint AIMS5.0 – Arrowhead fPVN Deep Tech Workshop – Budapest, Hungary – 12-13/11/2024***

A two-day workshop focused on cutting-edge developments in AI-enabled engineering, system interoperability, and Industry 5.0 innovation, organized under the AIMS5.0 and Arrowhead fPVN projects. The event aims to align technological advances with use case needs through demonstrations, discussions, and collaborative exploration.

The program was the following:

- AI Toolbox and AI-Gym, Data model translation, Technology governance, Eclipse Arrowhead 5.0
- Use Case and Technology Day at BME: AI-supported engineering and Arrowhead DSL, AIMS5.0 and Arrowhead fPVN use case needs – poster sessions and technical discussions
- Also, we are planning having a closer collaboration during the whole duration of the project, by maintaining periodic calls. For the last year of the project we will organize jointly workshops and the demo days.

As a general approach, during the second year of our project the liaison with other projects was considered in several aspects:

a. Some technical connections have been highlighted during the common workshop organized together with AIMS 5.0 and the previous presented projects. It was an intense technical information exchange at researchers’ level related to different use cases presented by each project, especially related to their technical implementation.
b. Participating to TechNexus workshops (STEADINESS and FORECAST) in conjuction with HiPEAC 2025 Conference. The TechNexus Initiative powered by 7 European projects involved in the Cyber-Physical Systems (MLSysOps, ARROWHEAD fPVN, Smarty, HiPEAC, ENERGY ECS, SmartEdge & ISOLDE) is focused on the technological challenges and other relevant technical aspects in the development of Cyber-Physical Systems. Each year a white paper is published as conclusion of the TechNexus workshops (the 2025 Edition of the white paper is published at https://zenodo.org/records/14920027).
c. Based on the synergies between the research and development activities of different European or National funded research projects, teams involved in these projects, including Arrowhead fPVN decide to publish several papers presenting some common results of their research (e.g. the paper ”Architecting Scalable ICPS for the Automotive Industry: Integrating NVIDIA AI Microservices with Eclipse Arrowhead” presented as part of the IEEE ICPS25 Conference held in Emden, Germany, in 12-15 May 2025 as part of the research activity of Arrowhead fPVN and RECOMBINE projects).

3.4. ARROWHEAD FPVN Dissemination and Communication Channels/Tools

3.4.1. Visual and identity branding (ARROWHEAD fPVN brand book)

Information about the approach can be found in D11.1 [1].

3.4.1.1. Logo

Information about the approach can be found in D11.1 [1].

3.4.1.2. Colors & typography

Information about the approach can be found in D11.1 [1].

3.4.2. Website

The Arrowhead fPVN website has been in service since June 2023 and can be accessed at https://fpvn.arrowhead.eu/fpvn-arrowhead/. It is operated by LTU, UPB, and BEIA. The website provides a thorough summary of the project and its several work packages. An essential element of the website is the dissemination section, which organizes project outputs and partner contributions, allowing for convenient access to references for efficient citation. There is a strong dedication to ensuring that all partner distributions are made available to the public to the fullest extent feasible. The objective of the website is to provide the easy accessibility to all open access materials on the internet.

3.4.3. Social networks

In this section, we will review the tasks done in dissemination in communication in the social networks, not only in the ARROWHEAD fPVN social networks, but also in own website/social networks accounts of the ARROWHEAD fPVN consortium partners.

However, LinkedIn has focused to a more specialized audience including related projects, cybersecurity companies, academic world. Information and language in this channel (scheduled on a weekly basis) will be more technical and will be focused on scientific publications, blog posts, objectives of the project, information about the use cases, technical achievements, etc. in Twitter we also disseminate other daily information such re-tweeting interesting post from other projects; and in average we tweet twice per week, whereas in LinkedIn we usually publish once per week. Currently the data of both accounts are:

- **X**: ARROWHEAD fPVN’s X channel was the first communication channel of the project. A screenshot of the X account can be seen in Figure 11. At the time (OCTOBER 2023) ARROWHEAD fPVN X account has 213 followers and follows 193 accounts.
  - Link: https://twitter.com/ARROWHEADTools
  - Followers: 207

- **LinkedIn:** ARROWHEAD fPVN’s LinkedIn account, as shown in Figure 12 is a LinkedIn Page at the beginning. In the coming months we will try to increase the number of followers and make the project appreciated.
  - Link: https://www.linkedin.com/company/101027122/admin/feed/posts/
  - Number of connections: 232

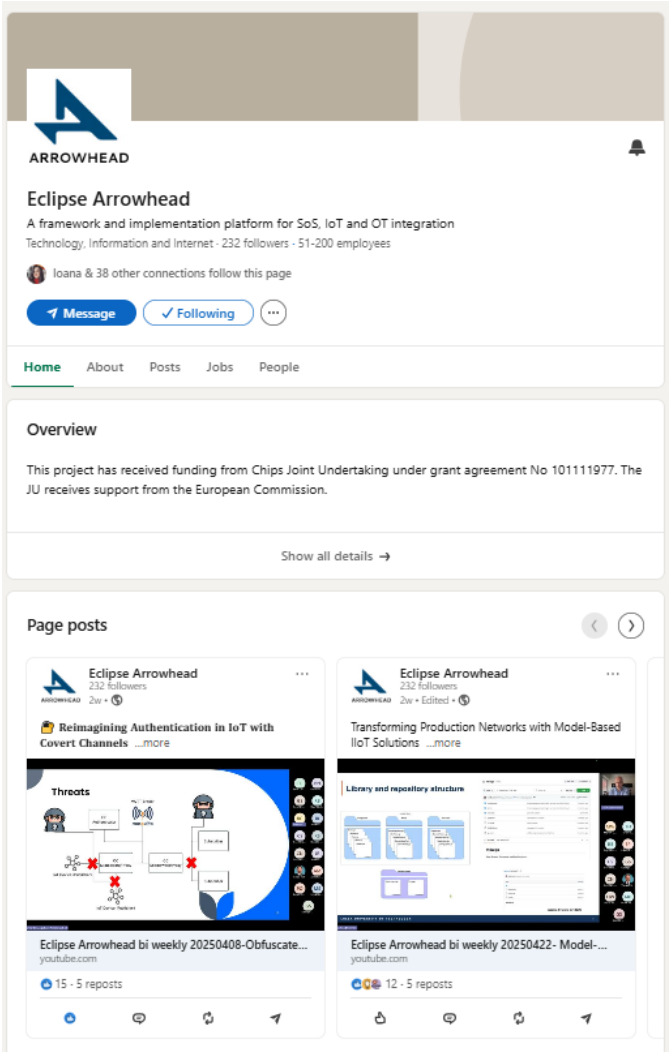

Fig. 11. Number of followers of Arrowhead fPVN LinkedIn account

- **YouTube**:
  - Link: https://www.youtube.com/@ArrowheadProject
  - Number of subscribers: 141
  - Number of videos: 55

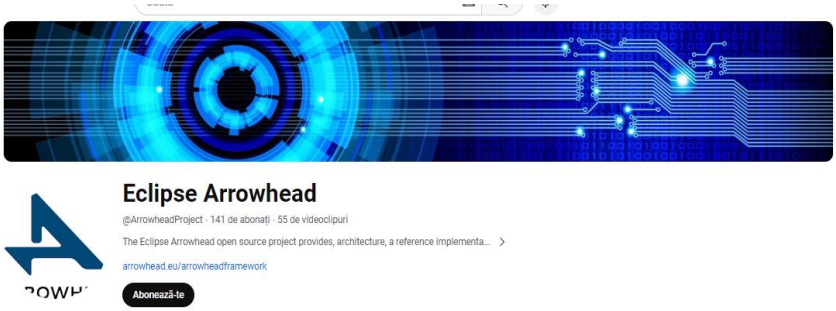

Fig. 12. Arrowhead fPVN Youtube account

Figure 13 shows one of the most appreciated LinkedIn posts during the second year of ARROWHEAD FPVN.

3.4.4. Newsletters

In January 2025, the Arrowhead fPVN project launched its inaugural LinkedIn Newsletter series, aiming to enhance communication and engagement with stakeholders across the manufacturing and industrial automation sectors. This initiative reflects the project's commitment to disseminating knowledge, fostering collaboration, and promoting advancements in interoperability within production value networks (PVNs).

Arrowhead fPVN Newsletter #1

The first edition of the newsletter provided a comprehensive overview of the project's mission, objectives, and key developments from its initial year. It introduced Arrowhead fPVN as a European catalyst focused on enhancing industrial resilience and flexibility through advanced interoperability solutions. The newsletter highlighted the project's ambition to double European industrial productivity by enabling transformative, autonomous, and evolvable information interoperability within PVNs. This goal is pursued through the creation of machine-interpretable content that enhances resilience and adaptability in manufacturing processes.

Key events from the first year were featured, including the Kick-off Meeting in Helsinki in June 2023, which brought together over 60 participants to establish connections and outline objectives. The newsletter also reported on Arrowhead fPVN's active participation in international standardization efforts, such as the ISO 23726 Working Group 26, and collaborations with other European projects like AIMS5.0. Joint events, including the Deep Tech Workshop at the University of Applied Sciences in St. Pölten, were highlighted as platforms for knowledge exchange and collaboration.

The newsletter series serves as a vital tool for disseminating the project's progress, fostering a community of practice, and engaging with a broader audience interested in the advancements of the Arrowhead fPVN project. Future editions are anticipated to continue this trajectory, providing regular updates on developments, events, and collaborative efforts within the project's ecosystem.

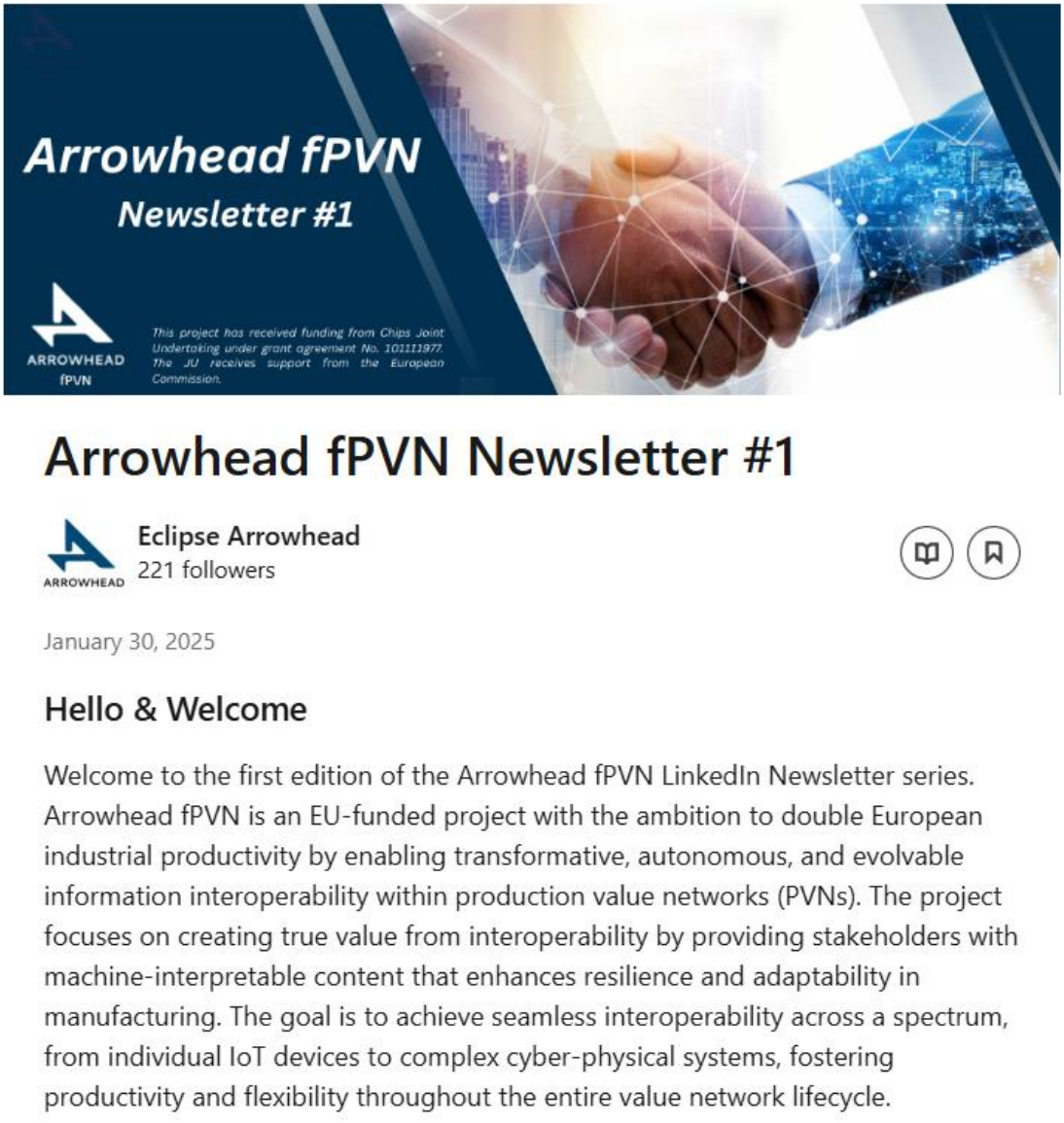

Fig. 13. ARROWHEAD fPVN Project Newsletter

3.4.5. Press releases

Press release is the media used to inform about the real benefits that ARROWHEAD fPVN can offer to the stakeholders’ groups identified in D11.1 [1]: General public and civil society organisations, Industry, Government and Scientific community.

We plan to produce two press releases during the whole project, one at the beginning and another at the end of the project. The second of these press releases, will be produced in November 2025, and it is available in both, the website and the repository. This press release has been also published in LinkedIn as an article. The idea is that the different partners can adapt this press release, for instance, translating it to their different languages or putting more the focus on the contribution of that partner; and then it may be used to be published in their internal websites or to be communicated to their own.

3.4.6. Dissemination & Communication toolkit

The following section describes the printed/published online dissemination material to be prepared in order to spread the message of ARROWHEAD fPVN. The initial idea was to print part of this material, such as brochure, posters and infographics to be used in face-to-face meetings or in different online events.

3.4.6.1. Factsheet

This current Section presents the ARROWHEAD fPVN Project Factsheet. The factsheet has been created as a one-page presentation of the project’s major data, where project’s key points are emphasised concisely.

A brief summary of the project is given, as well as some basic information about the project, such as the topic of the project, the start date and duration, the budget, the consortium composition and the name of the coordinating organisation.

Furthermore, the strategic objectives of the project are presented, while an overview of the Project’s Use Cases is provided. Moreover, the logos of all Partners participating in the project are presented (in the form of clickable images that redirect to each specific partner’s website address), along with acknowledgement of the EU Funding. Finally, on the upper right corner of the project, there are three clickable images that respectively redirect to the project website, the ARROWHEAD fPVN Twitter profile and the project’s LinkedIn profile. The project Factsheet is uploaded on the Project’s Repository and shared with all project Partners and is presented below.

Fig. 14. ARROWHEAD fPVN Project Factsheet

3.4.6.2. LinkedIn campaign

The ongoing LinkedIn campaign "Meet Our Team – Arrowhead fPVN" serves as a strategic communication initiative designed to showcase the interdisciplinary expertise and collaborative strength of the Arrowhead fPVN consortium. By featuring key contributors, such as the partner, a leader in industrial standardization, the campaign elevates awareness of the critical roles each organization plays in enabling semantic interoperability and digital integration across industrial systems. This campaign not only disseminates technical insights to a broader audience but also fosters transparency, stakeholder engagement, and knowledge exchange within the digital transformation community. In spotlighting the partner’s contributions to the development of flexible Productive Value Networks (fPVNs), the campaign underscores the consortium’s unified effort to accelerate the adoption of standardized, sustainable industrial practices.

3.4.6.3. Videos

ARROWHEAD fPVN YouTube channel has been created to offer ARROWHEAD fPVN followers’ visual material about the project results (demos, presentations, videoblogs, etc). During last consortium meeting, the consortium prepared some videos that depict some demonstrations. In the next months, the consortium will prepare some videos: one of them where the project coordinators introduce ARROWHEAD fPVN to a general audience, and another one where the use cases present the benefits of using ARROWHEAD fPVN. These

videos will be uploaded to YouTube in the next months. The consortium plans to publish at least the next videos during the whole duration of the project.

3.5. Evaluation

This section presents the success indicators of the aforementioned dissemination and communication activities of the project through measurable targets that will be evaluated and measured throughout the lifetime of ARROWHEAD fPVN, as shown in Table 7.

Table 2. ARROWHEAD FPVN D&C Metrics, Success Indicators & Target Values

Communication/ Dissemination Means	Success Indicators	Target Values	Timeline
Project Website	Search Engine Optimization metrics	Online by month 1; Unique visitors from M12: 1000; from M36: 2000	Ready by M1; M1-M36
Social media	#of users/ followers	LinkedIn >200 followers; Twitter > 200 followers;	M1-M36
Newsletters	# of publications	Newsletters: >3	M1-M36; 1 Newsletter per year
Video Clips	# of video clips and views	Number of online video clips: >3; Number of video views: > 500	By M36
Factsheets/ Brochures	# of factsheets and hardcopies	Technical factsheets: 3; Non-technical factsheets: 3; Hardcopies: > 1000	M1-M36
Flyers/ Posters & roll-ups	# of flyers and banners	Project flyers: >3; Posters & roll-up banners: >3	M1-M36
Industrial exhibitions	# of exhibitions	Participation in industrial exhibitions, trade fairs: >10	M7-M36

Scientific publications	#of publications	Journals/magazines >10; Conferences >20; Conference demonstrations: >6	M7-M36
Training	# of trainings over the course of the project	Online training tutorials: 3 Number of PhD schools: 2; Webinars: 2	M7-M36
Online Repository	Deliverables accepted by the European Commission	Number of publicly available deliverables: > 19	M1-M36
Networking	Envolve in European and international networks for Interoperability	Participate in workshops and seminars > 15	M6-M36

3.6. Monitoring and reporting rules

In order to achieve the C&D success indicators set out in the previous chapter 2.4.5 Evaluation, partners shall take BEIA, as responsible for Communication & Dissemination, and the coordinator LULEA TEKNISKA UNIVERSITET informed about any project-relevant communication activities and initiatives undertaken. Both are available to discuss the content and/or the visual presentation of communication and dissemination materials.

All C&D activities should be reported periodically (at the beginning of each semester – M6, M12, M18, M24, M30, and before the final reporting period).

The dissemination of project results included in different reports/deliverables is permitted only after the report/deliverable was fully approved to go public by the project coordinator. To this aim, each partner shall keep BEIA and LULEA TEKNISKA UNIVERSITET informed about their dissemination activities. The key of the optimal implementation of this master plan will be the active involvement and constant reporting of each project partner.

The whole ARROWHEAD fPVN consortium is expected to contribute to the project communication and dissemination activities. Therefore, the consortium will be kept up to date of the key actions metrics and will provide their input. Project partners are also expected to bring in their local knowledge and connections for promoting the project results and organizing local workshops. Moreover, they are all expected to contribute to raise their visibility in the appropriate stakeholders’ groups.

A continuous reporting process will be implemented; thus, each partner will periodically, according to the above mentioned, fill-in the Table below: Reporting summary of the communication, dissemination and networking activities.

Table 3. Reporting summary of the communication, dissemination and clustering activities

Responsible partner	Date	Location	Type of activity Name of person	Title	Audience outreach	Proof
Partners' accronym	dd.mm.yyyy	Online / offline and where	Press-releases; Online articles, Publication in journals, Poster or powerpoint presentation; Social media; Videos; Events.	Topic of the contribution, Title of the article, Name of the event / video	Indicate approx. number of audience	Link, pictures

3.7. Dissemination and communication plan for Y3

During the third year of ARROWHEAD fPVN the consortium will plan at least the next dissemination and communication activities:

- 3 use case videos
- 6 blog entries
- 1 workshop in collaboration with another project
- 1 infographic in collaboration with another project
- 2 Newsletters

Apart of these planned activities, ARROWHEAD fPVN will be continuously updating the website as well as posting in LinkedIn and Twitter. On the other hand, after one year of work, the maturity of the project will be enough to get benefits in terms of scientific publications (conference and journals) both individually and in collaboration with different partners.

The individual plans for dissemination and communication of the different partners are detailed in the next subsections.

3.8. Standardization Activities

3.8.1. Standardization Landscape update

During the Arrowhead project the standards ISO 15926 and ISO 23726 have been more available on the Pocs Caesar Library Service https://posccaesar.org/pages/about-pca-library-services The outcome of the Arrowhead project and cooperation with DISC project in Norway https://wix.posccaesar.org/pages/disc and Digitala Stambanan Phase 2 in Sweden https://digitalastambanan.se/en/digitala-stambanan-indtech/ are better knowledge and usage of this standards. In WP9 the goal is to contribute with added reference and classes to the ISO 15926-4 and CFIHOS Reference Data Library (RDL).

Pocs Caesar have a unique agreement with ISO to be a maintenance agency and the same process are now proposed for the ISO 23726 OBI / Ontology Based Interoperability.

To reach the library Service you could see on the picture below how the start page looks like.

Link to the service https://posccaesar.org/libraries/pcardl

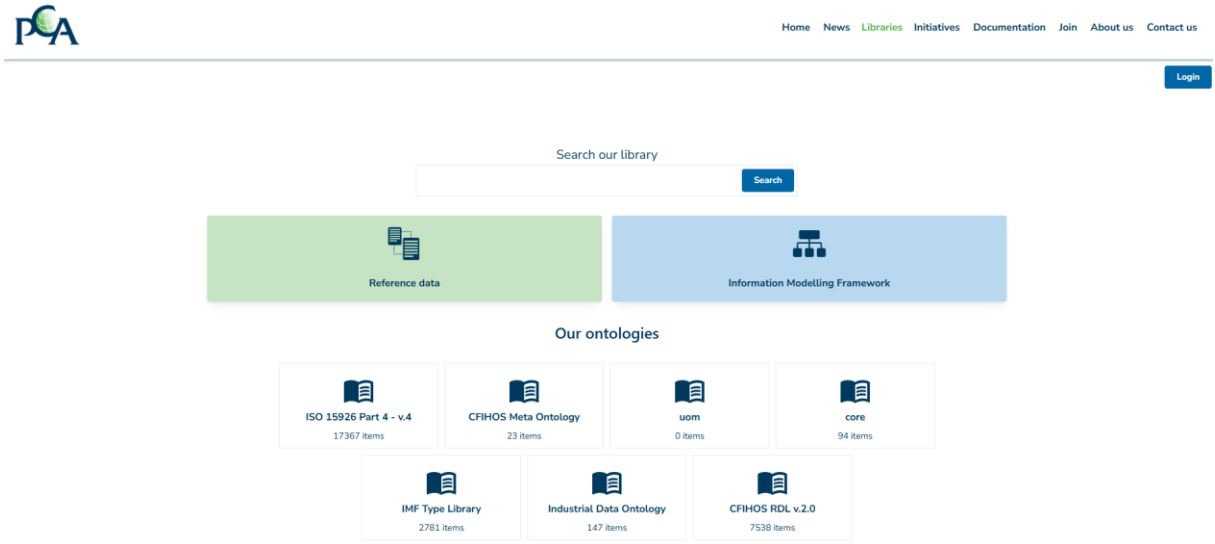

Fig. 15. ARROWHEAD fPVN Project Factsheet

3.8.1.1. Applied standards in each use case category

- Automotive (WP6):
  - ASAM-ODS, ISO-IEC 25012
- Aerospace (WP7):
  - **ISO 10303-239 and 242**, **S5000F**, S2000M, S3000L, **IPC 2581**
- Process industry (WP9):
  - **DEXPI, DEXPI+, CFIHOS, ISO 15926**-2 and **4**, ISO 18101, **IEC 61987**, IEC 61131-3, ISO 81346-1, ISO **10303-239 and 242**, ISO 12006, ISO 19650, ISO 61499, OPAF, **OPC UA, Peppol**

The Deliverable D3.1 Major industrial data models. Document title: Arrowhead fPVN Deliverable D3.1 is a good report of the standardisation landscape. The main topics from the report is listed below. For more detailed information read the report.

Data model foundations

ISO 15926
ISO 15926-2: Data model
ISO/TS 15926-4: Core reference data
DEXPI
DEXPI+
ISO/IEC 81346-1

CFIHOS
IEC 61131-3
S5000F
S3000L
S2000M International Specification for Material Management
ISO 10303-239 Product Life Cycle Support
ISO 18101
OPAF
ISO 10303-242
IFC – Industry Foundation Classes
IEC 61499
ISO 12006 – Building construction
IEC 61987
ISO/TS 4398:2022
ISO 19650 Common Data Environment CDE
ASAM-ODS
ISO-IEC 25012
IEEE 1451
IEC 61850
IEC 62351

- ISO 23726-3 Industrial Data Ontology (IDO)

Data representation formats
Communication protocols

- CoAP
- MQTT
- Diameter
- HTTP
- HTTP2
- Conclusion on communication protocols
- Modeling and knowledge representation languages
- SysML
- OWL

Commonalities
Comparison analysis

- ISO 10628 vs. DEXPI
- ISO 15926 vs. ISO 10303
- ISO 15926 vs. ISO 81346

Conclusion

The document (Arrowhead fPVN Deliverable D3.1) provides a report about the major standardised data models, describing the key properties of the predominantly applied, uses case related standards.

The deliverable includes a survey result, key properties, scope and limitations of the collected standards, a summary about communication protocols, and comparisons.

It provides an overview of the currently applied data model standards. As an additional benefit of this document, the use-case participants can identify common issues and solutions based on the comparison results.

The document answers the following objectives of WP3:

- Select major standardised data models relevant to the use cases.
- Identify the foundational properties of the selected data models.
- Identify similarities and dissimilarities between the standardised data models.

This standardisation activity has already made an impact in the steel industry. The PRIMSA project was granted by the RFCS EU unit and started April 2025. Here Europes four largest steel plant builders, Tenova, Danieli, SMS and Primetal cooperate with Estelle makers like Tata steel, Orimartin, Salsa and ADS with the ambition to create the Unified Environmental Data Model, UEDM. The UEDM will be based on the IDO and using results from WP2, WP3 and WP4 of Arrowhead fPVN. Further more it worth mentioning that LTU on request from the steel industry coordinate the PRIMSA project.

3.8.2. Digital Product Passport - DPP

Since start of 2024 the European Commission have given the European standardisation organisation CEN the mission to develop standards for the new regulation ESPR - Ecodesign for Sustainable Products Regulation and the new tool for fulfilment is that all products except medicine and food that’s are sold in Europe need a digital product passport that shows the product source.

Setting harmonised ecodesign requirements applicable throughout the single market helps boost the uptake of sustainable products, production and consumption. Ecodesign requirements are effective in reducing the environmental, energy and climate impacts of products and energy consumption and in improving circularity.

The ongoing standardisation work is divided into eight (8) modules under CEN JTC24 and the modules are represented in four working groups.

1. European standards on unique identifiers
2. European standards on data carriers and links between physical product and digital representation.
3. European standards on access rights management, information systems security and business confidentiality
4. European standards on interoperability (technical, semantic and organisation)
5. European standards on data processing, data exchange protocols and data formats
6. European standards on data storage, archiving and data persistence
7. European standards on data authentication, reality and integrity
8. European standards on Application Program Interface (APIs) for the product passports lifecycle management searchability

One important task in the standardisation is that the result not only will be useful and efficient for consumer products (B2C). The need and benefits of Business needs (B2B) and how it will affect industry in the future is important. It has been a risk in the work that source standards that could lead to some sort of vendor inlock could be mandatory. The involvement from industry in the standardisation has from start been low and that have created a risk that the final

standards could be difficult to use and give extra cost for industry. That risk has been considered, and we hope that the late involvement from industry have minimised that risk.
The final standards from the eight modules will end up in a unique standard in early beginning of 2026, first quarter. Drafts for the standards are now done and the work on finalised them are ongoing during the rest of 2025.

3.9. Innovations Catalogue

The Innovation Catalogue, a key outcome of the Arrowhead project, acts as a central online hub for showcasing Internet of Things (IoT) innovations, technologies, and real-world applications built upon the Eclipse Arrowhead framework. Its main purpose is to highlight where and how the Arrowhead framework is being used, detailing the specific contexts, industries, and individuals involved. This not only makes these projects visible but also helps users discover and analyze existing use cases that might be relevant to their own initiatives.

A core function of the Innovation Catalogue is to identify both current and future projects that leverage the Arrowhead Framework. Once identified, these projects are first featured on IoT-Catalogue.com and then transitioned to the dedicated Arrowhead Innovation Catalogue website. This staged approach takes advantage of IoT-Catalogue.com's robust features, especially its ability to reveal connections between different projects. For instance, it has already established a link between the KYKLOS 4.0 project and Arrowhead, demonstrating its capacity to highlight synergies.

To address concerns about sensitive information in some original use cases, a strategic "generalization" process has been implemented. This ensures that proprietary details are protected while still allowing for wider sharing of the use cases' core value. These "Arrowhead generic cases" are expected to be published soon, which will significantly boost knowledge sharing and promote the reuse of Arrowhead-based solutions across various industries and applications.

Furthermore, the Arrowhead project website will integrate a section directly from IoT-Catalogue.com, offering a quick overview of the Arrowhead Framework's practical applications. This section will include insightful statistics on the number of use cases, geographical locations, and specific components utilizing the framework. It will also feature dedicated areas for Use Cases, Projects, and Technological Assets, all linked to Arrowhead, providing a comprehensive and easy-to-navigate resource for anyone interested in the real-world impact and potential of the Eclipse Arrowhead framework.

3.10. Dissemination and standardization KPIs

3.10.1. Content

Follow the KPI table.

Table 5. KPI table

Communication/ Dissemination Means	Success Indicators	Target Values	Results achieved	Timeline
Project Website	Search Engine Optimization metrics	Online by month 1; Unique visitors from M12: 1000; from M36: 2000		Ready by M1; M1-M36
Social media	#of users/ followers	LinkedIn >200 followers; Twitter > 200 followers;	234 207	M1-M36
Newsletters	# of publications	Newsletters: >3	1	M1-M36; 1 Newsletter per year
Video Clips	# of video clips and views	Number of online video clips: >3; Number of video views: > 500	89 >500	By M36
Factsheets/ Brochures	# of factsheets and hardcopies	Technical factsheets: 3; Non-technical factsheets: 3; Hardcopies: > 1000	0 1 >100	M1-M36
Flyers/ Posters & roll-ups	# of flyers and banners	Project flyers: >3; Posters & roll-up banners: >3	1 >3	M1-M36
Industrial exhibitions	# of exhibitions	Participation in industrial exhibitions, trade fairs: >10	>10	M7-M36
Scientific publications	#of publications	Journals/magazines >10; Conferences >20;	7 >20 4	M7-M36

		Conference demonstrations: >6		
Training	# of trainings over the course of the project	Online training tutorials: 3 Number of PhD schools: 2; Webinars: 2	>3 >2 >2	M7-M36
Online Repository	Deliverables accepted by the European Commission	Number of publicly available deliverables: > 19	6	M1-M36
Networking	Envolve in European and international networks for Interoperability	Participate in workshops and seminars > 15	>15	M6-M36

3.10.2. Summary of the achieved results

3.10.2.1. Scientific dissemination

No. of. Peer reviewed publications: **14**
No. of White Papers: **2**

3.10.2.2. Society dissemination

No. of articles distributed on LinkedIn: **20**
No. of articles distributed on X: **224**
No. of articles distributed on Youtube: **89**
No. of articles distributed on project website: **17**

3.10.2.3. Business dissemination

No. of news articles on result exploitation: **15**

3.10.2.4. Standardization

Number of news articles in standardization efforts: **1**

4. References

1. Deliverable D11.2

5. Conclusions

The dissemination, communication, and standardization activities have continued to be highly successful, building upon the robust plan initially released in D11.1 and further refined in D11.2. Evaluating the communication efforts conducted throughout Y1 and Y2, we can confidently assert that these periods have been exceptionally rewarding for the project. The brand image of Arrowhead fPVN has achieved significant scope and influence, attracting a larger user base and generating a higher-than-anticipated response across all channels. The Project has consistently engaged audiences by disseminating both technical material and strengthening its brand image, with the internet channel remaining a crucial instrument for executing the communication plan and social networks playing a vital role in driving traffic and boosting visitor numbers.

Looking ahead to the third phase of the project, Y3, the Consortium plans to maintain and intensify its proactive approach on social media and other online channels. Building on the established digital presence, Y3 will further leverage internet channels to drive engagement in offline activities, with a continued and heightened emphasis on participation in key industrial events. This comprehensive plan will be implemented in ongoing collaboration with the team, ensuring a truly successful and impactful year for Arrowhead fPVN.

6. Revision history

6.1. Contributing and reviewing partners

Contributions	Reviews	Participants	Representing partner
Table of Content	Romulus Cheveresan	Octavian Fratu, Cosmina Stalidi	UPB, Beia
Content contributions	Romulus Cheveresan	Cosmina Stalidi, Octavian Fratu, Alexandru Vulpe, Erik Molin, Bruno Almeida, George Suciu, Simona Halunga, Eduard-Cristian Popovici, Inge Gavat, Theodor Pintilie, Svetlana Segarceanu	UPB, Beia, SEIIA, UNP

6.2. Amendments

No.	Date	Version	Subject of Amendments	Author
1	2025-06-90	1.0	Follow internal review recommendations	Octavian Fratu

6.3. Quality assurance

No	Date	Version	Approved by
1	2025-06-10	1.0	Jerker Delsing