NARRATE

Regenerative Resilient Smart Manufacturing Networks

D8.4 TECHNICAL PROGRESS REPORT M1 - M9

2024/09/30

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D8.4 TECHNICAL PROGRESS REPORT M1 – M9

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Abstract	The document covers NARRATE'S first nine months and underscores noteworthy advancements across key areas, including project requirements analysis to align with user needs and expectations, the development of a variety of pilot user stories and KPIs, comprehensive IIoT platform analysis, and addressing critical architectural concerns. Foundational technologies for the Intelligent Manufacturing Custodian were also established, creating a solid groundwork for future innovations. The project not only met all its specific objectives and demanding deliverables within this period but also surpassed expectations, demonstrating significant progress and setting the stage for continued success.
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STATEMENT ON MAINSTREAMING GENDER

The NARRATE consortium is committed to including gender and intersectionality as a transversal aspect in the project's activities. In line with EU guidelines and objectives, all partners – including the authors of this deliverable – recognise the importance of advancing gender analysis and sex-disaggregated data collection in the development of scientific research. Therefore, we commit to paying particular attention to including, monitoring, and periodically evaluating the participation of different genders in all activities developed within the project, including workshops, webinars and events but also surveys, interviews and research, in general. While applying a non-binary approach to data collection and promoting the participation of all genders in the activities, the partners will periodically reflect and inform about the limitations of their approach. Through an iterative learning process, they commit to plan and implement strategies that maximise the inclusion of more intersectional perspectives in their activities.

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The NARRATE Consortium is the following:

Participant number	Participant organisation name	Short name	Country
1	INSTITUTO TECNOLOGICO METALMECANICO, MUEBLE, MADERA, EMBALAJE Y AFINES-AIDIMME (coord)	AID	ES
2	SCIENTIFIC ACADEMY FOR SERVICE TECHNOLOGY EV	SERV	DE
3	FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV	FhG	DE
4	INSTITUT NATIONAL DES SCIENCES APPLIQUEES DE LYON	INSA	FR
5	INSAVALOR SA	INSA-V	FR
6	SOFTWARE AG	SAG	DE
7	F6S NETWORK IRELAND LIMITED	F6S	IE
8	SYNESIS-SOCIETA CONSORTILE A RESPONSABILITA LIMITATA	SYN	IT
9	MEDITERRANEAN WOOD FACTORY S.L. - MEDWOOD	MED	ES
10	DHL EXEL SUPPLY CHAIN SPAIN SL	DHL	ES
11	NUNSYS SA	NUN	ES
12	BUDATEC GMBH	BUD	DE
13	BRUNEL UNIVERSITY LONDON	BUL	UK

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ABBREVIATIONS

AI	Artificial Intelligence
BOM	Bill of Materials
CA	Consortium Agreement
CEP	Complex Event Processing
CFX	Connected Factory Exchange
DL	Deliverable leader
DM	Data Manager
DT	Digital Twin
DoA	Document of Activities. It corresponds with the Annex I to the GA
EC	European Commission
ERP	Enterprise Resource Planning
GA	Grant Agreement
GAs	General Assembly
HADEA	Health and Digital Executive Agency
IMC	Intelligent Manufacturing Custodian

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IM	Innovation Manager
IoT	Internet of Things
IIoT	Industrial Internet of Things
KPI	Key Performance Indicator
MaaS	Manufacturing as a Service
MBOM	Manufacturing Bill of Materials
MED	New acronym for partner MIC
MQTT	Message Queing Telemetry Transport
MSx	Milestone x
MTO	Make-to-Order
Mx	Month x
PCo	Project Coordinator
QM	Quality Manager
SMN	Smart Manufacturing Network
STM	Scientific and Technical Manager
TL	Task Leader
Tx.x	Task x.x
WP	Work Package
WPL	Work Package Leader

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EXECUTIVE SUMMARY

Manufacturing and logistics firms increasingly grapple with unexpected events that disrupt supply chains, leading to production delays, reduced output, increased costs, and ultimately jeopardizing their ability to meet customer demands. These disruptions underscore the critical need for manufacturers to build resilience across their entire value chains. Recognizing this imperative, NARRATE is developing advanced tools that offer manufacturers global visibility and control over their supply chain operations. These tools empower companies to monitor, predict, and respond to potential disruptions in real time, thereby enhancing supply chain resilience and ensuring continuity of operations.

At the heart of this initiative is the NARRATE Intelligent Manufacturing Custodian (IMC), a cutting-edge framework designed to integrate data from a wide array of production sources. The IMC not only supports proactive decision-making but also acts as the central nerve centre for supply chain networks. It provides real-time oversight and coordination of intelligent production and logistics activities, ensuring that manufacturers can swiftly adapt to changing conditions and maintain operational efficiency. By leveraging the IMC, manufacturers can anticipate challenges before they escalate, optimize production schedules, and maintain seamless logistics operations, all of which are crucial for staying competitive in today's dynamic market landscape.

The NARRATE project has made significant strides in its first nine months, firmly positioning itself to deliver impactful outcomes across various fields. The project's accomplishments in partnership collaboration, technology development, and pilot analysis have established a robust foundation for future advancements. As NARRATE continues to refine its reference architecture, enhance digital twin representations, improve AI-driven tasks that are critical for the IMC, and rigorously evaluate Industrial Internet of Things (IIoT) platforms—while continuously fine-tuning its pilots based on project insights—it is well on track to achieving its vision of a resilient and intelligent manufacturing ecosystem.

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1. PROJECT SUMMARY

1.1 PROJECT SUMMARY (FOR PUBLICATION)

Manufacturing and logistics companies frequently encounter unexpected events that can severely disrupt the supply and production chain, such as natural disasters, geopolitical tensions, pandemics, and sudden shifts in market demand. These disruptions often result in production slowdowns, reduced output, and increased costs, making it challenging to meet customer demands. To effectively combat these challenges, manufacturers must build resilience throughout their entire value chains, ensuring they can adapt and respond swiftly to any unforeseen events.

NARRATE aims to develop an innovative solution that harnesses the power of Artificial Intelligence, Digital Twin, and Internet of Things technologies. The centrepiece of NARRATE's vision is the Intelligent Manufacturing Custodian (IMC) that will gather data from various production sources to provide comprehensive visibility and control over supply chain operations. The IMC aims to allow manufacturing companies to monitor and predict potential disruptions and achieve greater resilience by enabling proactive decision-making. Acting as a nerve centre for the supply chain network, the IMC will offer real-time monitoring and coordination of production processes and logistics. Integrating an IMC into a supply and production chain transforms it into a Smart Manufacturing Network (SMN). This network becomes a connected, self-orchestrated ecosystem with programmable Manufacturing-as-a-Service (MaaS) capabilities, designed to withstand disruptions. The IMC enhances production and logistics agility by:

- Reducing the risk of disruptions and improving business continuity through proactive anticipation of disruptions and continuous learning and self-calibration.
- Reinventing the SMN ecosystem in response to unexpected events and disruptions.

A Digital Twin will model and source the production and operational data of the SMN, unlocking deeper intelligence within the IMC. Machine learning models trained on this data will predict disruptions like malfunctioning machinery, underperforming suppliers, or delayed shipments. AI algorithms will analyse the data and provide real-time reports and visualizations on a dashboard. The synergy between Integrated Manufacturing Custodian and Digital Twins, which represent and provide real-time data across the entire manufacturing ecosystem, will unlock powerful insights and enable advanced self-adapting capabilities. This dynamic integration enhances operational efficiency and drives innovation by seamlessly aligning virtual models with physical processes. This will ultimately support the Smart Manufacturing Network in evolving under human supervision, allowing it to switch services between multiple external partners in response to risks and disruptions. This approach improves energy efficiency, product circularity, and environmental sustainability across the entire production process.

Fig. 1 depicts the formation of an SMN. This figure shows that the SMN is a virtual centralised hub system with the central node that runs the IMC (operated by a lead manufacturer) coordinating production by connecting and interacting with a number of direct suppliers or logistics providers after receiving an order from a customer. The downstream and upstream linkages in the production process facilitate information flows between firms and the transformation of raw materials into finished products. To analyse the category and type of disruption, its impact, geographical scope and the duration of its effects, the IMC is facilitated by creating a Digital Twin of a lead manufacturer's supply chain and for each direct supplier. Supply chain DTs can interact with each other as shown in Figure 1 to help companies create visibility of their end-to-end supply chain, source manufacturing data and enable the modelling and evaluation of scenarios to identify hidden risks, failure points and the supply chain nodes (suppliers) that are sensitive to disruptions.

NARRATE's innovative approach ensures that the interaction between the IMC and the Digital Twin generates powerful insights and self-adapting capabilities. This enables the Smart Manufacturing Network to evolve under human supervision, switching services between external partners as needed to mitigate

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risks, improve energy efficiency, and enhance product circularity and environmental sustainability.

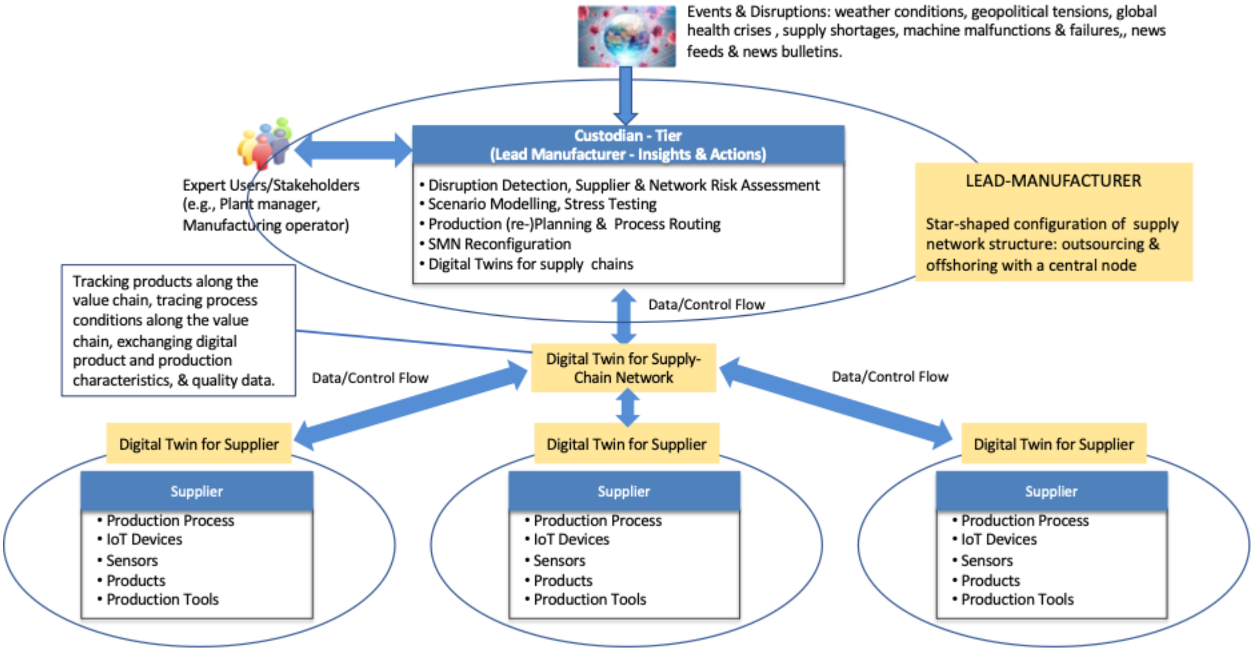

Figure 1 structure of a smart manufacturing network and its tiers.

The project's impact will be evaluated through rigorous testing of the IMC in diverse real-world production environments. By building SMN ecosystems grounded in a digital-first model, NARRATE will empower human experts with enhanced decision-making capabilities. This will increase supply chain visibility and coordination, improve productivity across partners, and provide manufacturers with the flexibility to adapt operations in response to real-world disruptions.

1.2 CONTEXT AND OVERALL OBJECTIVES

In today's fast-paced and interconnected world, manufacturing and logistics companies are frequently challenged by unforeseen events that disrupt their supply chains. These disruptions can lead to production slowdowns, reduced output, and increased costs, ultimately making it difficult for companies to meet customer demands. The COVID-19 pandemic, natural disasters, and geopolitical tensions have highlighted the vulnerabilities within global supply chains, underscoring the urgent need for more resilient and adaptive systems.

NARRATE is a visionary project designed to address these pressing challenges. By harnessing the power of cutting-edge technologies such as Artificial Intelligence, Digital Twin, and Internet of Things technologies, NARRATE aims to create a robust solution that ensures continuous and efficient supply chain operations, even in the face of disruptions.

The motivation behind NARRATE stems from the recognition that traditional supply chain management practices are no longer sufficient in an era characterized by rapid changes and unpredictability. To mitigate the risks associated with supply chain disruptions, there is a critical need for advanced tools that provide comprehensive visibility, predictive capabilities, and real-time decision-making support.

The development of the IMC will serve as the nerve centre of supply chain networks, gathering and analysing data from various production sources to enable proactive and informed decision-making. The IMC will provide real-time monitoring and coordination of production processes and logistics, transforming supply chains into Smart Manufacturing Networks. These networks will manifest into self-orchestrated manufacturing ecosystems that can dynamically respond to disruptions and maintain continuous operation.

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A key component of this transformation is the Digital Twin, which will create a virtual model of the SMN's production and operational data just like having a virtual mirror of the entire manufacturing network, where one can see everything from the products being made to how they're produced, how well they perform, what sensors are stating, and how materials and products are being moved through the logistics chain. This digital model will unlock deeper intelligence within the IMC, allowing machine learning models to predict potential disruptions, such as natural disasters or delayed shipments. AI algorithms will then analyse this data and provide real-time reporting and visualization through an intuitive dashboard.

The synergy between the IMC and the Digital Twin will generate powerful insights and self-adapting capabilities. This will enable the SMN to evolve under human supervision, switching services between multiple external partners as needed to respond to risks and disruptions. This approach not only enhances supply chain resilience but also improves energy efficiency, product circularity, and environmental sustainability across the entire production process.

NARRATE's impact will be assessed through rigorous testing in diverse real-world production environments, namely the furniture industry, 3D printing network, and semiconductor industry. By building SMN ecosystems grounded in a digital-first model, NARRATE will empower human experts with enhanced decision-making capabilities. This will increase supply chain visibility and coordination, improve productivity across partners, and provide manufacturers with the flexibility to adapt operations in response to real-world disruptions.

The significance of NARRATE's expected impacts cannot be overstated. By creating more resilient, efficient, and sustainable supply chains, the project will help manufacturers better navigate the complexities of the modern world. This, in turn, will lead to increased customer satisfaction, reduced operational costs, and a stronger, more competitive industry.

NARRATE stands as a testament to the power of collaboration and innovation, poised to drive significant advancements in manufacturing and logistics. Through the concerted efforts of its multidisciplinary European team, NARRATE is set to create a more resilient, efficient, and sustainable future for the European industry.

1.3 WORK PERFORMED AND MAIN ACHIEVEMENTS

To address the challenges faced by manufacturing and logistics companies, NARRATE has embarked on a comprehensive and innovative approach. In its first nine months, the consortium has successfully met all the planned milestones, demonstrating effective collaboration and strong project management. The project has made significant progress in several critical areas, including partnership collaboration, technology development, and the comparative analysis of key components. The technology analysis has been particularly comprehensive, covering several pivotal aspects. The project has identified essential areas requiring focused attention and development to establish a solid foundation for future work. These areas include identifying potential manufacturing and logistics data sources, developing integration strategies, enhancing the fidelity of Digital Twin representations, and ensuring the chosen Internet of Things platform can support future advancements and scalability needs. By addressing these key areas, the project has created a robust foundation as highlighted below that paves the way for continued innovation and success in the domain of resilient SMNs.

1. **Pilot Testing and User Feedback Collection:**

NARRATE has launched pilot testing in real-world manufacturing settings to gather practical insights and validate the project's effectiveness. Meticulous collection and analysis of pilot and user feedback have been conducted to refine and enhance the IMC system components, ensuring they meet real-world demands and user needs. Pilot requirements have been established, incorporating the needs and perspectives of the pilots and their potential users. Priorities have been identified, and the specific pilot environment for each pilot has been specified, accompanied by an initial deployment plan. An initial set of KPIs has been defined to guide the development of future pilot execution plans, ensuring the

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continuous improvement and success of all pilot projects.

2. **Identification and Prioritization of Manufacturing Data Sources:**

Accurate and timely data enables manufacturers to anticipate disruptions, optimize operations, and enhance overall productivity. In SMNs, data sources play a crucial role in creating a resilient and intelligent manufacturing ecosystem. With a focus on pilot projects, NARRATE has identified and prioritized the most relevant and impactful manufacturing data sources. These data sources encompass a wide range of information, including MTO orders, BOMs and MBOMs, product details and production plans and capacity, sensor data from machinery, production metrics, supply chain logistics, and real-time environmental and circularity conditions. Prioritizing these data sources is essential because they provide the foundational insights necessary for predictive analytics, real-time monitoring, and decision-making processes.

3. **Data Integration Complexity and Interoperability:**

The consortium has begun addressing the complex challenges of integrating data from diverse manufacturing sites by adopting a hybrid federated data mesh approach. In this model, data is treated as a product and managed through a domain-oriented, self-serve design. Instead of relying on a centralized data platform managed by a single team, ownership of data is distributed across various business domains. Each domain is responsible for the data it produces and consumes, promoting accountability and ensuring proper management and curation. This approach lays a sound foundation for resolving compatibility issues and enabling seamless data sharing and exchange, fostering a cohesive and efficient manufacturing ecosystem.

4. **Digital Twin Representation and Data Sourcing:**

NARRATE has explored the potential of representing critical data elements in abstract programmable form as digital twins. These precise digital replicas of physical products and production processes, continuously source significant data, enhance monitoring, simulation and optimization capabilities, providing a robust foundation for predictive and adaptive operations. The project has initially identified the following inter-related precise virtual representations of manufacturing aspects with a focus on identified data sources in item-2 and pilot projects:

- *Supplier Facet:* focuses on assembling information regarding the essential characteristics of suppliers in an SMN, including their production capacities, lead times, reliability, quality control measures, geographic locations, and sustainability practices. This facet ensures a comprehensive understanding of each supplier's capabilities and performance, facilitating better decision-making and optimizing the supply chain.
- *Product Facet:* focuses on creating virtual replicas of physical products, encompassing their design, components, materials, and specifications. By encompassing every aspect of a product's structure and behaviour, this facet enables precise monitoring, simulation, and optimization of manufacturing processes. It also facilitates enhanced quality control, streamlined product development, and more efficient maintenance and repair strategies.
- *Production Facet:* focuses on simulating and optimizing manufacturing processes and workflows, resource utilization, and master production scheduling. This facet aims to provide a comprehensive view of production dynamics, including the sequencing of operations, allocation of resources, and identification of bottlenecks. By leveraging advanced simulation techniques and real-time data analytics, it enables manufacturers to enhance efficiency, reduce downtime, and improve overall productivity. Additionally, it supports predictive maintenance, capacity planning, and strategic decision-making, ensuring that production schedules are aligned with market demands and operational goals.
- *Performance Facet:* facilitates quality control by monitoring product specifications and production performance, providing real-time insights into productivity, quality, and efficiency, detecting defects, and ensuring compliance with quality standards.
- *Sensor Facet*: represents and fuses data from a wide range of sensors embedded within manufacturing equipment and processes to provide a comprehensive view of manufacturing

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operations and equipment health, diagnose equipment faults or abnormalities facilitating timely maintenance and repairs.

- *Logistics Facet:* provides visibility into supply chain operations, including inventory levels, order status, and logistics movements, optimize logistics routes, minimizing transportation costs, lead times, and environmental impact, help analyse historical data and market trends to forecast demand accurately, optimizing inventory management and production planning.

5. Design of Preliminary Reference Architecture:

The project has embarked on the design of a comprehensive system architecture featuring a centralized decision-making hub, real-time data analytics integration, and machine learning models for predictive analysis. Standard APIs using real-time protocols like WebSockets or MQTT is being considered to ensure real-time data push, low-latency, immediate updates from digital twins. This approach is well-suited for a smart manufacturing network MaaS principles, where data exchanges are limited, controlled by digital twins, involve push real-time data access, and do not require extensive integration. The next steps involve refining this architecture based on feedback from pilot testing to meet the highest standards of functionality and user satisfaction.

6. Evaluation of Industrial IoT Platforms:

Continuous assessment of potential IIoT platforms is a priority. NARRATE aims to identify a robust foundation for the Intelligent Manufacturing Custodian by scrutinizing various platforms for their connectivity and Integration, data management, AI and Analytics, scalability, security, user experience and ability to support advanced manufacturing applications. The project has focused on open-source IIoT platforms as they provide a viable alternative to proprietary solutions, offering flexibility, customization, and cost-effectiveness.

Table 1 comparative study of open-source IIoT platforms.

Criteria	FIWARE	Eclipse IoT (Kura, Kapua, etc.)	ThingsBoard	OpenRemote
Connectivity and Integration	Supports various IoT protocols (MQTT, HTTP, CoAP); extensive device integration via IoT Agents	Supports diverse devices and protocols; MQTT, CoAP, OPC UA	Supports various devices; MQTT, CoAP, HTTP	Supports a variety of devices; MQTT, HTTP, CoAP
Data Management	Strong data management via Orion Context Broker; scalable data storage and processing	Flexible data management; modular architecture; scalable	Scalable data storage; real-time and batch processing; flexible	Flexible data management; scalable storage; real-time processing
AI and Analytics	Integrates well with external AI tools and platforms; supports advanced analytics and ML	Integrates with external AI tools; supports custom analytics	Basic analytics; supports integration with external AI/ML tools	Basic analytics; supports integration with external AI/ML tools
Security	Strong security features including identity management, access control, and policy enforcement	Good security features; community-driven updates; flexible configuration	Strong security features; flexible; community support	Good security measures; customizable; community support
Scalability and Performance	Highly scalable architecture; supports large-scale deployments	Highly scalable; designed for diverse environments; modular	Good scalability; designed for high performance; community support	Scalable; good performance; flexible and adaptable

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User Experience	User-friendly interface; strong documentation; active community support	Flexible UI; good documentation; active community support	Intuitive UI; good documentation; strong community support	User-friendly; good documentation; strong community support

Table-1 presents a comparative analysis of leading open-source IIoT Platforms that the project has identified. The analysis has revealed that FIWARE is a strong candidate for AI-based applications in smart manufacturing networks due to its modularity, strong data management capabilities, and support for AI integration. Compared to other open-source platforms like Eclipse IoT, ThingsBoard, and OpenRemote, FIWARE offers a more robust and flexible solution for real-time data management and AI applications. This comprehensive pilot analysis will continue within the context of the project's pilots to gather practical insights and evaluate the chosen platform's potential and effectiveness. The goal is to ensure that the chosen infrastructure meets the operational pilot requirements and user acceptance. By leveraging real-world scenarios and feedback, we aim to establish a practical platform baseline that ensures building a robust framework that guarantees continuous and efficient supply chain operations, even in the face of disruptions.

Through the initiatives identified above, NARRATE is poised to create a transformative impact on the manufacturing and logistics sectors. By developing an innovative solution that leverages Artificial Intelligence, Digital Twin, and IoT technologies, the project aims to build a resilient, efficient, and adaptive supply chain capable of responding to disruptions and meeting customer demands effectively. The project's expected impacts include increased operational efficiency, reduced costs, enhanced energy efficiency, and improved environmental sustainability, setting the stage for a more robust and competitive industry.

1.4 RESULTS BEYOND THE STATE OF THE ART

FhG IPK and AID published a paper entitled *“The challenge of integrating multi-sectorial requirements in dissimilar industrial pilots“* in I-ESA 12th International Conference on Interoperability for Enterprise Systems and Applications (**https://mklab.iti.gr/iesa2024/**) held in Crete 10th -12th April 2024. María José Núñez Ariño from AID presented how NARRATE addresses end users' requirements using existing methodologies for systematic engineering requirements, based on findings from WP1. In NARRATE, FhG spearheads the methodology for gathering user requirements, while AID oversees the piloting and evaluation of the NARRATE's solutions.

This paper introduces an approach to address the complexities of integrating system elements across diverse pilot activities and formalized requirements modelling. It incorporates temporal logics and other formalisms and emphasizes the need for adaptable, data-driven requirements engineering. The paper also evaluates the broader challenges and development needs in requirements engineering, particularly in managing distributed requirements within collaborative research endeavours that span multiple sectors.

SERVTECH and AIDIMME published a paper called “*Technology Roadmap for Resilient Smart Manufacturing Ecosystems*” in 30th IEEE/ITMC International Conference on Engineering, Technology and Innovation (ICE 2024) (https://mdtweek.digit-madeira.pt/ice/) held in Funchal - Madeira 24-28 June 2024. María José Núñez Ariño from AID presented the NARRATE technology roadmap, designed to boost supply chain resilience and support circularity in smart manufacturing ecosystems, while navigating technological integration and operational optimization complexities. In NARRATE, SERV provides the scientific and technical leadership, while AID manages the piloting and evaluation of the NARRATE solutions.

This paper presents a strategic technology roadmap for achieving resilient Smart Manufacturing Ecosystems. It outlines key steps and milestones for integrating digital technologies into manufacturing processes and identifies critical gaps between current capabilities and requirements for growth and sustainability. A major focus is the selection and implementation of an AI platform to support design and

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enhance supply chain resilience. Additionally, the roadmap includes a digital maturity model to guide ambitious Smart Manufacturing projects, assessing current digital capabilities and defining a path for advancing maturity over time.

These results are preliminary in nature and require further research and demonstration to achieve impact and ensure uptake.

1.5 POLICY RELEVANCE OF NARRATE

N/A given that the project has barely started.

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2. LIST OF DELIVERABLES IN THE PERIOD

Del No.	Del. Name	WP No.	Lead Ben.	Type	Diss. level	Due date	Delivery date	Status
D8.2	NARRATE Technology roadmap	8	SERV	R	PU	29/02/2024	01/03/2024	Submitted
D8.1	Project handbook, ethics, quality and management plan	8	AID	R	SEN	29/02/2024	04/04/2024	Submitted
D1.2	Pilot Analysis	1	AID	R	PU	31/05/2024	30/05/2024	Submitted
D1.1	Project Requirements	1	FhG	R	PU	31/05/2024	31/05/2024	Submitted
D7.1	Stakeholders' engagement, Dissemination, communication and training plan	7	F6S	R	PU	31/05/2024	03/06/2024	Submitted
D8.3	Data Management plan	8	SYN	DMP	SEN	31/05/2024	03/06/2024	Submitted
D7.2	Web-presence and online channels / portal	7	F6S	DEC	PU	31/05/2024	04/06/2024	Submitted
D8.4	Technical Progress Report	8	SERV	R	PU	31/08/2024	30/09/2024	Submitted
D1.3	Energy efficiency and circularity	1	AID	R	PU	31/08/2024	02/09/2024	Submitted

3. LIST OF MILESTONES IN THE PERIOD

Mil. No.	Milestone Name	WP No.	Lead Ben.	Means of verification	Due date	Delivery date	Achieved	Comments
1	Pilot requirements	1 / 5	FhG	D1.1, D1.2, D7.1, D7.2	31/05/2024	31/05/2024	YES	M1 is initially measured by deliverables D1.1 and D1.2. While D1.1 defines the project requirements, including users and technology, D1.2 covers the planning and setup of pilots and scenarios, along with validation criteria and KPIs. In later project stages, D7.1 and D7.2 will be used to further solidify the results.

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2	Architectural and energy efficient model	1, 2, 3, 4, 5, 6	AID	D1.3, D1.4	31/08/2024	31/08/2024	YES	M2 is initially measured by deliverable D1.3 addresses the requirements of assessing process circularity, energy efficiency, carbon footprint, and other sustainability aspects of the supply chain and develops environmental and circularity KPIs.

4. LIST OF CRITICAL RISKS IN THE PERIOD

4.1 FORESEEN RISKS

Risk No.	Description	WP No.	Proposed mitigation measures
1	Lack of trust in automated AI interventions, which results in a negative public perception and hesitancy to adopt technologies developed in the project	4	Clear descriptions of the AI intervention are reported in the pilots (T5.1), including instructions and skills required for use, the setting in which the AI intervention for the IMC is integrated, the handling of inputs and outputs of the AI intervention, and the human-AI interaction. This acts as a catalyst for collaboration between technical and pilot stakeholders and will improve trust.
2	Learning support needed to assist the introduction of new technology, particularly in pilots to ensure it is applied effectively and implemented in the most efficient way.	1, 2, 3, 4, 5, 7, 8	T7.1 embeds "learnability" in the workforce through a systematic process of continuous learning as personnel skills must evolve to comprehend the fluid, new roles they must fulfil.
3	Security, confidentiality, and privacy issues.	1, 2, 3, 4, 5, 7, 8	Security and confidentiality of sensitive information that is communicated through the IMC is ensured and it is only accessed by authorised individuals after obtaining consent. Mechanisms will be provided to prevent data leaking in T3.4
4	Reluctance of participants in pilot trials to reveal and share their data.	1, 2, 3, 4, 5, 7, 8	The project will help pilot partners regard data as a business asset and understand its value and the value they receive. It will inform them: (a) how it manages their data assets, how it categorizes them with respect to what is and what is not shareable, and carefully assess the value and risks arising from each use, (b) which data will be monitored, collected and stored and who has access to it (see T1.1, T1.4 and T8.3). This process has already started and is well

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			received by pilot partners.
5	Concerns about possible legal implications on data protection, (aggregated) data ownership, outsourcing and protection of trade secrets	1, 2, 3, 4, 5, 7, 8	These issues are fully covered by T8.3 which deals with ethics and broad area of legal issues and data management guaranteeing complete data and trade secret protection.
6	Slow adoption of digital platform and digital custodian by stakeholders	4	The project will follow a participatory approach with industry professionals and agencies to maximise the benefits and mitigate risks and obstacles of platform adoption and will raise awareness among stakeholders.
7	Lack or poor quality of data to validate the results	1, 2	Pilot sites have already been carefully selected to ensure the data they will provide are suitable for the pilots. T1.2 will analyse pilot sites and existing infrastructure to ensure data adequacy from an early stage.
8	Not enough stakeholders to exploit results and ensure commercialisation.	7	A specific task 7.3 has been allocated to ensure stakeholders' engagement; all project partners have existing communication channels to ensure project commercialisation.

4.2 UNFORESEEN RISKS

Risk No.	Description	WP No.	Proposed mitigation measures
9	The coordinator main contact has been on sick leave for several months	1	Skilled senior staff from the coordinator partner has been supported the project team.

4.3 STATE OF PLAY

Risk No.	Reporting period	Dis you apply risk mitigation measures	Proposed mitigation measures
9	1	YES	A person from AIDIMME's PMO was allocated to cover the sick leave of the main contact.

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5. EXPLANATION OF THE WORK CARRIED OUT AND OVERVIEW OF THE PROGRESS

5.1 OBJECTIVES

The specific objectives for the project described in section 1.1 of the DoA, which achieve the expected 01-07 call outcomes, are listed below together a short summary of progress towards the groundwork for achievement of each of the project objectives. All objectives are fully achieved and on schedule regarding the period from M1 to M9.

STO-1: Data Visibility and AI Solutions to Improve Resilience and Production Efficiency
Scope: NARRATE will design, implement, and validate a Big Data infrastructure in support of supply-chain resilience with a focus on data visibility and transparency that boost production efficiency by enabling manufacturers determine how products are produced and how actors operate in a supply-chain. Supplementing data visibility and transparency with AI predictive and prescriptive capabilities will improve operation-wide efficiency, identify disruptions and inefficiencies, predict and reduce failures, and improve automation. **Deliverables:** D1.1, D1.2, D8.2, D8.4 **Milestones:** M1, M2

Results, discoveries and theories: From months 6 to 9, work has targeted data visibility and transparency to enhance production efficiency by enabling manufacturers to understand how products are produced and how actors operate within the supply chain. This undertaking is attributed primarily to two key factors mainly pursued in work package 3 and has already made significant strides:

Data Integration Complexity and Interoperability:

This foundational approach in NARRATE leverages data categorization and metadata tagging, represented in a reusable format grounded in open standards like the IPC-2591 Connected Factory Exchange (CFX). By creating a digital communication framework, it enables seamless real-time data exchange between different machines and production lines within a factory or across multiple factories. When combined with a hybrid federated data mesh approach, this strategy supports a cohesive and efficient manufacturing ecosystem. It facilitates better coordination and streamlines operations across various systems and actors within the supply chain, ensuring optimal performance and integration.

Digital Twins Representation:

Building on the robust foundation of data integration complexity and interoperability, digital twins offer a powerful tool for representing critical data elements in an abstract, programmable form. These precise digital replicas of physical products and manufacturing processes further enhance monitoring, simulation, and optimization capabilities. The seamless real-time data exchange enabled by the integrated framework provides digital twins with accurate and up-to-date information, enhancing their ability to enhance data visibility and transparency and eventually provide predictive insights and facilitate swift adaptations. Consequently, manufacturers can optimize operations, predict potential issues, and improve overall production efficiency and effectiveness, leveraging the integrated and interoperable data ecosystem.

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STO-2: Contextualization of SMNs using Advanced Digital Twin Technologies
Scope: NARRATE will provide a Digital Twin (DT) foundation acting as a 'one-stop-shop' to support a holistic and precise view of production and enhance decision-making. A DT will range from a product configurator to a precise representation of an entire SMN, with each of its interweaved elements (product, quality, service, production process representations) dynamically linked to SMN operational data to unlock deeper operational intelligence, supporting proactive resilience management. A DT will provide a reliable model to help reproduce an entire SMN's performance, simulate complex SMNs and processes to analyze challenges, such as physical flow complexity, disruptions, supplier concentrations, supply bottlenecks by assessing various disruption scenarios. **Deliverables:** D1.1, D1.2, D8.2, D8.4 **Milestones:** M1, M2

Results, discoveries and theories: From months 6 to 9, NARRATE has delved into the fundamentals of digital twin representation. This initial work aims to enhance visibility, monitoring, simulation, and optimization, providing a robust foundation for predictive and adaptive operations. To date, we have identified and detailed the contents of the following digital twin facets.

- *Supplier Facet*: Gathers data on suppliers' capabilities, capacities, reliability, and sustainability practices, optimizing supply chain management.
- *Product Facet:* Creates virtual replicas of products, detailing design, materials, and specifications, enabling precise process monitoring and optimization.
- *Production Facet:* Simulates manufacturing processes and resource use, improving efficiency and productivity with real-time analytics.
- *Performance Facet:* Monitors product and production quality, offering real-time insights into productivity and compliance.
- *Sensor Facet:* Integrates sensor data from equipment, diagnosing faults and facilitating timely maintenance.
- *Logistics Facet:* Provides visibility into inventory and logistics, optimizing routes, reducing costs, and improving demand forecasting.

Significance of Facets and their Inter-relationship: The above DT facets are crucial for a comprehensive view of manufacturing operations. They are interconnected, allowing seamless data flow and integration. For instance, sensor data (Sensor Facet) informs production optimization (Production Facet), while supplier data (Supplier Facet) impacts logistics planning (Logistics Facet). This interrelated approach ensures a cohesive and efficient manufacturing ecosystem, enhancing overall production efficiency and adaptability.

STO-3: Advanced Analytics Tools for more Accurate Predictions and Mitigation of Risks and Disruptions
Scope: Advanced analytics facilities working synergistically with DTs will form the foundation of the IMC. Their mission is to provide human (e.g., SC managers) with more intuitive, easy to operate technologies and deeper, more actionable insights to enable them to enact tailor-made resilience management for unforeseen situations. Advanced analytics will help SC managers achieve resilience by taking proactive measures to prevent disruptions and managing risks. They will also help an SMN self-adapt to swiftly adapt logistics and production to varying external conditions, improving the resilience of the industrial systems and value chains, learn and make targeted improvements to their operations to prevent similar disruptions from occurring in the future. **Deliverables:** D1.1, D1.2, D1.3, D8.2, D8.4 **Milestones:** M1, M2

The objective of developing Advanced Analytics Tools for more Accurate Predictions and Mitigation of Risks and Disruptions is currently in its early stage of investigation. This objective is based on the results

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of the digital twin facets identified and specified earlier. These facets - Supplier, Product, Production, Performance, Sensor, and Logistics - facilitate predictive analytics and risk mitigation by providing comprehensive, real-time data and insights. For example:

- *Supplier Facet*: Enables risk assessment by analysing supplier reliability and capacity, helping predict supply chain disruptions.
- *Product Facet*: Allows for precise monitoring and simulation of product performance, aiding in the early detection of potential defects or failures.
- *Production Facet*: Provides insights into manufacturing processes and resource utilization, identifying bottlenecks and optimizing workflows to prevent downtime.
- *Performance Facet*: Monitors quality control metrics, ensuring compliance and reducing the risk of quality-related issues.
- *Sensor Facet*: Integrates real-time data from equipment, enabling predictive maintenance and reducing the risk of unexpected breakdowns.
- *Logistics Facet*: Offers visibility into supply chain operations, improving demand forecasting and inventory management, and mitigating risks related to logistics.

Together, these interconnected facets create a cohesive and efficient manufacturing ecosystem, laying the groundwork for advanced analytics and proactive risk management.

STO-4: Building and Validating Smart Manufacturing Networks and Intelligent Manufacturing Custodian
Scope: NARRATE will build easy-to-access SMNs that are resilient and capable of self-adaptation in response to external threats. SMNs will be controlled by an IMC, which will streamline and automate production processes and bring smart, data-driven intelligence to swiftly adapt logistics and production to varying external conditions, improving the resilience of the industrial system and value chains, sustainability, and circularity of the entire production process. STO-4 will perform continuous validation via prototyping, proof of concept experimentation and demonstrators to test and evaluate the findings of the project using real-life demanding pilots in WP-5. **Deliverables:** D1.1, D1.2, D1.3, D8.2, D8.4. **Milestones:** M1, M2

The above objective is primarily pursued through Work package 6, set to begin in month 13.

SO-1: Societal Impact
Scope: To reduce the environmental impact and achieve efficiency savings, NARRATE will adopt a smart manufacturing approach that achieves sustainability by implementing an advanced energy management process that monitors the energy sources required for carrying out production activities, providing useful information related to power distribution parameters, identifying patterns and trends minimizing wasted material used to make a product. Circularity will be supported by creating a closed-loop system in which waste and by-products are reused or recycled rather than discarded in accordance with the EC’s Circular economy action plan.
BO-1: Innovation Management, Economic Objectives: Commercialization and Exploitation
Scope: NARRATE will engage with stakeholders, conduct market analysis, develop a business plan, and exploit outcomes and tools, including the IMC, DTs, AI models, algorithms and tools. New business models will emerge around an SMN eco-system and IMC, which leverage exponential technologies including AI, Big Data, and Digital Twins, and are digitally connected from the outside-in and fully cognitively enabled from the inside-out.

The project is now in its early stages, so SO-1 objectives that target societal impact and BO-1 objectives like innovation management, economic objectives, commercialization and exploitation are not fully

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pursued yet. However, initial findings indicate substantial potential, laying a solid foundation for future achievements in these areas. The groundwork established promises successful pursuit of these objectives as the project matures.

5.2 EXPLANATION OF THE WORK CARRIED OUT PER WP

Table 2 work performed per work package.

WP No	Work Package Title	Task	Obj.	Verifi-cation	Status
1	Project Requirements Management, Reference Architecture and Pilot Analysis [M1-M18]	T1.1 Project and User Requirements Management [M1 – M6]	STO1, 2, 3 & 4	D1.1	Completed
		T1.2 Pilot Analysis, Set Up and Validation Criteria [M1 – M6]	STO1, 2, 3 & 4	D1.2	Completed
		T1.3 Energy Efficiency, Circularity and Environmental Sustainability [M1-M9]	STO1, 2, 3 & 4	D1.3	Completed
		T1.4 Architectural Requirements [M1 – M18]	STO1, 2, 3 & 4	D8.2	Completed
				D1.4	Due M18
2	Supply Chain Disruption Risk Detection and Diagnostic Framework [M7-M30]	T2.1 Disruption and Resilience Strategies [M7 – M24]	STO1, 2, 3, 4 & SO-1	D2.1	Due M15
3	Data Contextualization, Interoperability, and SMN Knowledge Model [M7-M33]	T3.1 Production Contextualization and Interoperability [M7 – M24]	STO1, 2, 3, 4 & SO1	D3.1	In progress Due M15
		T3.2 SMN Knowledge Model using Digital Twin Technology [M7 – M30]	STO1, 2, 3, 4 & SO1	D3.2	In progress Due M15
4	The Intelligent Manufacturing Custodian and the Trustworthy AI-driven Platform [M7-M33]	T4.1 Resilience, Sustainability and Circularity Stress Testing Scenarios [M7 – M30]	STO1, 2, 3, 4 & SO1	D4.1	In progress Due M15
		T4.2 Use of combined SMN Knowledge Models to Achieve end-to-end AI driven visibility [M7– 30]	STO1, 2, 3, 4 & SO1	D4.2	In progress Due M15
5	Pilot Analysis, Experimentation and Validation [M7-M36]	T5.1 Planning and Early Demonstrator [M7 – M27]	STO1, 2, 3, 4, SO1, BO1	D5.1	In progress Due M18
6	Intelligent Manufacturing Custodian and AI Platform: Implementation and Assessment [M13-36]	T6.1 begins on M13			
7	Dissemination, Communication, Exploitation and Impact [M1-M36]	T7.1 Dissemination and Communication Plans and Training Activities [M1 – M36]	STO1, 2, 3, 4, SO1, BO1	D7.1	Completed
				D7.2	Completed
		T7.2 Exploitation and Business Plan [M7 – M36]	STO1, 2, 3, 4, SO1, BO1	D7.3	In progress Due M18
		T7.3 Innovation Potential and Impact [M7 – M36]	STO1, 2, 3, 4, SO1, BO1	D7.4	Due M18
8	Project Coordination and Quality Assurance [M13-36]	T8.1 Project Coordination and Management [M1 – M36]	STO1, 2, 3, 4, SO1, BO1	D8.1	Completed
		T8.2 Scientific and Technical Coordination [M1 – M36]	STO1, 2, 3, 4, SO1, BO1	D8.2	Completed
				D8.4	Completed
		T8.3 Quality Assurance, Risks, Ethics and Data Management [M1 – M36]	STO1, 2, 3, 4, SO1, BO1	D8.1, D8.3	Completed

Table-2 demonstrates the progress made towards achieving the project objectives for the period from M1 to M9. It aligns specific tasks with the overarching project objectives, identifies the means of verification through corresponding deliverables, and indicates the current status of these deliverables.

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Activities on Work Packages 2, 3, 4, and 5 began in M7. Despite being in the early stages of development, these work packages have already shown promising results and are making steady progress, and the initial outcomes are encouraging, indicating potential for significant breakthroughs as the project progresses. At this stage of the project, it is too early to define and include Key Performance Indicators associated with the project objectives. These KPIs are being established in WPs 1 and 5 and included at the appropriate time as the project evolves. The inclusion of KPIs will be timed to align with the project's advancement to ensure they accurately reflect the project's impact and success.

5.2.1 Work Package 1

WP1 will develop the requirements analysis of the project to define what the project must do to meet the users' needs and expectations will also come up with a detailed definition of the project pilots and the architectural development needs. Work carried out during the first nine months of the project is described below.

T1.1 Project and User Requirements Management [M1 – M6] – Lead: FHG

NARRATE leads ground-breaking research and development efforts across three distinct, real-world pilots:

1. Pilot #1: Enhancing Automation and Supply Chain Resilience in the Furniture Industry,
2. Pilot #2: Creating a Printing Network-as-a-Service to Boost Resilience and Mitigate Unexpected Disruptions,
3. Pilot #3: Building a New, Resilient Supply Chain for Semiconductor Manufacturing.

These pilots are intentionally diverse, encompassing a broad spectrum of challenges and requirements that span various vertical industries, ensuring comprehensive coverage of industry-specific needs for SMNs.

The first task constructed the basis of the requirements for each pilot and the result in generic requirements that may apply to more than one pilot.

With the support of AID, the requirements from the pilot partners MED, AID and BUD were identified and included as User stories in natural language reflecting different roles in the pilot companies.

Subsequently, they were translated into formal, operational, informational and performance requirements.

The specific requirements were then converted into a set of generic requirements, reflecting the collective needs that were identified across all pilot partners. We identified between 65 and 85 specific requirements per pilot.

Lastly, pilot requirements were integrated into a web-based application to make the management simpler.

All these activities concluded in M6 and have been reported in D1.1 “Project Requirements" (M6).

T1.2 Pilot Analysis, Set Up and Validation Criteria [M1 – M6] – Lead: AID

The second task details the requirements through prioritization, validation criteria and pilot based KPIs.

The prioritization process for user requirements was performed using the MoSCoW methodology, categorizing them into Must, Should, Could, and Won't have.

The requirements have been revisited, identifying the most critical aspects, so the pilot partners could prioritize them based on their main expectations, considering a later review by the technical partners.

To advance the impact evaluation, a comprehensive set of KPIs has been established for each industrial case, with careful consideration given to indicators that are shared across multiple pilots.

Validation criteria for pilot assessments and result evaluations were also meticulously defined for each pilot, ensuring accurate measurement of impact and alignment with project goals. This was achieved through a structured elicitation process, tailored to address the specific needs and expectations of each pilot.

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The validation criteria, including the Requirement Traceability Matrix (RTM) and User Acceptance Testing (UAT) will ensure that the implementations meet the pilots' needs and expectations. The validation methodology involves a detailed plan to evaluate the effectiveness of the proposed solutions in real industrial scenarios preparing a preliminary workplan for the pilots' implementation to be conducted in WP5.

All these activities concluded in M6 and have been reported in D1.2 "Pilot Analysis" (M6).

T1.3 Energy efficiency, Process Circularity and environmental sustainability [M1 – M9] – Lead: AID

Task 1.3 analyzes the requirements for assessing processes circularity, energy efficiency and carbon footprint of the supply chain. Initially the sustainability context is analyzed from the perspective of regulations and market trends, establishing a future scenario with higher environmental requirements for companies, over and above the current demands that companies can identify.

Current requirements and their priority for companies are stablished on the basis of a sustainability diagnosis performed on pilot companies. First, the diagnosis methodology has been developed. It consists of two parts:

- A questionnaire covering current and/or potential improvement actions to be carried out by companies, according to eco-design strategies, since they represent the life cycle thinking that should be implemented by companies. They are identified, prioritized and connected with requirements to their implementation. This was mostly completed by direct interviews with responsible staff from each company.
- A production process mass balance, to identify main environmental aspects, potential industrial symbiosis actions and the effort or capability to collect needed quantitative data.

General conclusions regarding sustainability requirements are extrapolated and highlighted from pilot´s diagnosis. Then sustainability related risk and disruption scenarios are drafted and the related decision process and resilience actions are identified. From all those results, IMC requirements related to sustainability are defined.

Finally, to cover the three major needs from companies to support supply chain sustainability improvement, data needed to be managed and related KPIs are detailed explained and related to:

- Industrial symbiosis functionalities for the supply chain for tracking, tracing and mapping of secondary resources over the supply.
- Corporative carbon footprint calculation: direct emissions, indirect from energy demand and good´s delivery transport.
- Energy efficiency and circularity..

All these activities are reported in D1.3 "Energy efficiency, Process Circularity and environmental sustainability", released in M9.

T1.4 Architectural Requirements [M1 – M18] - Lead: SERV

Task 1.4 has included the collaboration of NUN, and AID, alongside face-to-face and frequent online meetings over multiple rounds with technical and pilot partners, focused on evaluating prominent Industrial IoT (IIoT) platforms. The goal was to identify the essential functionalities needed to support the IMC. This analysis that was conducted by SERV assessed the capabilities of existing IIoT platforms, their integration with the IMC, and functionalities to enhance IMC's role in SMNs. Key areas assessed included:

- **Data Integration and Management**: Seamless integration of data from diverse sources for real-time decision-making.
- **Scalability and Flexibility**: Ability to scale and adapt without significant reconfiguration or downtime.
- **Interoperability**: Easy interfacing with various systems and technologies for smooth data exchange.
- **Security and Compliance**: Robust security measures and industry regulation compliance.
- **Predictive Analytics and AI Integration**: Support for advanced analytics and AI tools to optimize production and efficiency.

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- **User Interface and Experience**: User-friendly and intuitive platforms for efficient process management.
- **Customization and Extensibility**: Ability to customize and extend platforms for different manufacturing environments.

The results of this exhaustive IIoT platform analysis appear in Table-1. According to these results, FIWARE emerged as a strong candidate due to its modularity, strong data management, and AI integration, outperforming other open-source platforms like Eclipse IoT, ThingsBoard, and OpenRemote.

Work in T1.4 performed by SERV with input from NUN also concentrated on integration of manufacturing eco-systems where the number of systems is low and they are loosely coupled, with the requirement for real-time integration and employing an event-driven architecture to process critical events in real-time. Several decisions were made that include:

- **Edge Computing**: Deploying edge computing to process data close to the source, reducing latency and enabling real-time decision-making. Edge supplier sites can communicate with the lead manufacturing through a logically centralized system, viz. the IMC.
- **Hybrid Federated/Data Mesh Approach**: A hybrid federated/data mesh approach can significantly enhance the integration of manufacturing eco-systems when dealing with a low number of loosely coupled supplier systems that require real-time data exchange. This is due to the fact that it treats data as products, facilitates real-time data access through data products that are designed to be interoperable and can be used to access data across different systems in real-time without the need to move data to a central repository.

RESTful APIs: RESTful APIs offer a straightforward solution for real-time data exchange in loosely coupled SMNs. They support:

- *Real-Time Communication*: RESTful APIs enable systems to communicate in real-time over HTTP/HTTPS, facilitating easy implementation and maintenance.
- *Real-Time Integration*: Ideal for targeted, real-time integrations between production and PLM systems, providing flexibility and direct control for immediate data exchange.
- *Narrow Integration Scope*: Best suited for scenarios with a loose and narrow integration scope, unlike Data Spaces, which are designed for large, complex, and interconnected networks, creating a unified, scalable, and interoperable data ecosystem.

Future work: will concentrate on further valuating the FIWARE platform and simplifying the NARRATE architecture based on the findings in technical WPs 2, 3 and 4 as well as the piloting WP6. T1.4 will continue engaging with both pilot, technical stakeholders and potential users to validate findings and gather new perspectives.

5.2.2 Work Package 2

WP2 will deliver a disruption and resilience strategy for SMNs, providing a framework to detect, classify, and assess supply chain disruptions, evaluate suppliers, and identify disruption patterns within the manufacturing network. Work carried out during the first nine months of the project is described below.

T2.1 Disruption and Resilience Strategies [M7- M24] – Lead: BUL

During Mo 7 to Mo 9, efforts in Task T2.1 have been centred on a comprehensive examination of the risks and disruptions facing SMNs, as well as the resilience strategies and tools necessary to ensure continuity of SMNs against Risks and Disruptions.

BUL has conducted a thorough review of relevant literature, guidelines, and standards, (for example, ISO 22301 and BS 25999:2), to extract a list of potential risks and disruptions.

Additionally, pilot partners presented their major risks and disruptions based on historical data during the Berlin General Assembly.

We have analysed and merged the risks and disruptions identified from both the literature review and pilot contributions into a preliminary common list.

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To validate this list, we organized several face-to-face and online meetings over multiple rounds, involving technical and pilot partners such as SERV, INSA, AID, SAG, BUD, and MED. This collaborative effort led to the categorization of risks and disruptions into internal and external categories (including 12 internal and 13 external risk and disruption).

Furthermore, BUL is developing a Resilience Framework for SMNs within the context of Manufacturing as a Service (MaaS). This framework consists of five circular steps designed to enhance the performance of SMNs, addressing resilience at both system and operational levels.

We have established resilience strategies for strategic and tactical decision-making at the system level, as well as operational strategies for enhancing operational resilience. Key Performance Indicators (KPIs) have also been defined to measure the resilience performance of the companies involved. The results have been circulated among technical partners and pilots to gather feedback.

Future work: In the upcoming three months, we will focus on measuring the KPIs related to SMNs, emphasizing the requirements and needs of our pilot partners. This analysis will allow us to assess the performance of SMNs in terms of resilience. Also, feedback from partners will be considered in refining our common list of risks and disruptions, developing effective resilience strategies at both system and operational levels, identifying appropriate KPIs for measuring resilience, and proposing a comprehensive framework for embedding resilience in SMNs within the MaaS context.

Task T2.2 Risk Identification and Processing that will start in M13 will focus on the detection of disruptions which is a work for a Complex Event Processing (CEP) engine. Activities here will focus on choosing a suitable CEP engine, formulating what manifests a disruption in a language understandable by this engine and defining both sensible reactions on the disruptions and appropriate storing of the disruption data (when, where, how, ...). Apart from looking at events occurring inside the SMN, external information (news, weather, traffic) will also be considered.

5.2.3 Work Package 3

In WP-3 production, supply, and logistics data are to be enriched with supplementary information and metadata, interlinked to enhance its usefulness and clarity for WP4's analysis and decision-making. Digital Twin technology will support this process by generating a reliable production knowledge model representing the entire SMN and its elements. Work carried out during the first nine months of the project is described below.

T3.1 Production Contextualization and Interoperability [M7 – M24] – Lead: SERV

Our current work in T3.1 - from M7 to M9 - focuses on investigating key elements for homogenizing and integrating data within SMNs. Face to face and several online meetings have been organized between technical and pilot partners that included SERV, INSA, AID, FHG and MED to decide on the necessary manufacturing data, its sharing mechanisms, and examples of related manufacturing processes and workflows. We conducted a comprehensive review of existing literature and current practices in the field. The typical data considered includes historical data, make-to-order (MTO) data, product, production and product capacity data, primary, backup, alternative, and supplementary supplier data, master scheduling data, device, IoT and machine-related data, logistics and warehousing data, environmental and circularity data.

The ongoing scientific and technical work led by SERV is organized under several key categories, each encompassing critical preliminary results and strategic decisions, as outlined below.

Standardized Metadata Definitions: Establish common schemas and definitions for data elements across data sources including:

- BOM data from PLM systems that list all the components, parts, and materials required to manufacture a product,
- MBOM data from ERP systems that include all the components listed in the BOM, along with additional details related to the manufacturing process, such as machine settings, labour requirements, and assembly instructions and make-to-order data to leverage the detailed component

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list from BOM and the process details from MBOM to customize the manufacturing process.
- IoT real-time data from sensors and devices so that can be integrated into the Digital Twin model using standardized metadata providing real-time insights into manufacturing processes and enabling predictive maintenance and optimization.

We currently, consider the use industry standards like ISO 11179 for defining, managing, and standardizing data elements and their metadata for all critical data elements across ERP, PLM, MES, and IoT systems. ISO 11179 aims to ensure data consistency, quality, and interoperability across various systems by establishing common definitions and standards for data elements to ensure consistency and interoperability.

Semantic Integration: Current activities focus on annotating data from the standardized metadata definitions in item-1 with semantic tags and classifications to ensure consistent understanding of product information across different stages and enable interoperability and reasoning. Industry-specific classification schemes are essential for standardizing, organizing, and integrating data across different systems in smart manufacturing networks. Objective is to provide a common language and framework for categorizing data, ensuring consistency, interoperability, and efficient data exchange. These schemes often include ontologies that define relationships and hierarchies between data elements, enabling semantic integration.

We shall also investigate the use of GAIA-X and Manufacturing-X for classifying and managing manufacturing data through a standardized and interoperable data framework. The federated architecture of GAIA-X is particularly advantageous as it allows manufacturing companies to maintain their data infrastructure while participating in a larger data ecosystem. This approach supports the classification and integration of data from diverse sources without centralizing data storage.

Data Cataloguing and Discovery: Current activities focus on:

- Building metadata catalogues to index and make metadata from diverse sources searchable and discoverable.
- Using attributes like keywords and descriptions to facilitate data discovery and reuse.

Future work: will concentrate on extending and improving the findings outlined above as well as determining the standards that can be used in contextualization, data sharing and exchange and on:

- Data Mapping and Transformation: Use the classification schemes to map and transform data between different systems. Define transformation rules and mappings that align with the standard classifications.
- Data Access and Security: Ensure secure and governed access to data, protecting sensitive information while enabling authorized use across the network.
- Continue engaging with stakeholders to validate findings and gather new perspectives.

T3.2 SMN Knowledge Model using Digital Twin Technology [M7 – M30] – Lead: SERV

The ongoing work in T3.2 from Mo. 7 to Mo. 9 is dedicated to building a robust and actionable model of SMNs using digital twins by establishing the necessary structure and functionality. We analysed recent advancements and innovations to identify gaps, opportunities for improvement, and identified key trends and emerging technologies relevant to the project's objectives. The project focuses on improving decision-making, enhance supply chain resilience, and optimize operational performance by using digital twins that exhibit the following features and functionality

Representing Digital Twin Views:

- **Abstract Programmable Views**: Pulling and representing critical data elements such as supplier performance metrics, materials, products, machine status, production processes, logistics data, and IoT sensor data. These elements are represented in abstract, programmable digital twin (DT) views, or frames, which contextualize products and real-time production conditions.
- **Conversion of Raw Data to Structured Knowledge**: Converting raw data into structured knowledge readily available for users. This knowledge seamlessly integrates into the holistic model of a DT for the entire SMN.

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Expanding and Combining Multiple Digital Twin Views:

- **Integrated Data Elements**: Combining views of suppliers, materials, products, machine status, production processes, and logistics flows to provide a comprehensive model of the entire SMN.
- **Enhanced Transparency**: **Integrating** diverse DT views enhances transparency across the manufacturing network, making it easier to identify inefficiencies and potential issues.

This work is performed mainly by SERV with input from AID and NUN. It also involves frequent interactions with pilot and technical partners.

Future Work: Building on the achievements from M7 to M9, the next steps for T3.2 will focus on expanding and refining the current activities to achieve more detailed and actionable results and continue engaging with stakeholders to validate findings and gather new perspectives. It will target the following:

- Solidifying Representation Schemes and Algebra for DT Frames:
    - Developing robust representation schemes and algebra to ensure consistency and accuracy in contextualizing real-time production conditions.
    - Contextualizing Real-Time Production Conditions:
    - Improving the contextualization of real-time production conditions within DT frames.
    - Providing enhanced visibility into all aspects of the SMN to enable proactive identification and mitigation of risks.
- Proactive Risk Management:
    - Ensuring that the digital twin model remains an up-to-date and reliable tool for risk management.

5.2.4 Work Package 4

WP4 will focus on developing the disruptive technologies for the IMC and AI Platform, including augmented intelligence through machine learning, deep learning, and a neuro-symbolic reasoner-based Decision Support System that will ensure efficient SMN management, minimize disruptions and maximize performance. Work carried out during the first nine months of the project is described below.

T4.1 Resilience, Sustainability and Circularity Stress Testing Scenarios [M7 – M30] - Lead: SAG

The work in Task T4.1, initiated by Software AG with contributions from INSA, BUL, and NUN currently focuses on:

- Conducting an in-depth analysis of the outcomes from WP1, where application partners meticulously listed and prioritized their requirements for the upcoming pilot implementations.
- Coupling this analysis with insights from Task T2.2, which outlined potential disruption scenarios alongside recommended remedies. These remedies include, among other strategies, the potential reconfiguration of nodes within the Smart Manufacturing Network.
- Planning stress-testing activities that take into account dynamic simulation scenarios that deliberately disrupt the SMN to ensure that the proposed remedies are effectively considered. This simulation will integrate all key components of the SMN, including suppliers, logistics, warehouses, transportation networks, and analyse the complex interactions and dependencies between these components. Various scenarios will be considered, such as fluctuations in demand, shipping delays, and supply chain disruptions, to evaluate how the SMN responds under different conditions.

Future work: Dynamic simulation will encompass a comprehensive virtual representation of the entire SMN, utilizing the SMN digital twins developed in Task T3.2. If a reconfiguration is triggered during this process, it is essential to ensure that the adjustments not only effectively address the disruption but also either maintain or enhance overall supply chain performance, ensuring that the reconfiguration delivers measurable improvements. This approach provides a deep understanding of the network's resilience and adaptability, allowing for the proactive identification of potential vulnerabilities and the implementation of robust mitigation strategies.

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T4.2 Use of combined SMN Knowledge Models to Achieve end-to-end AI driven visibility [M7– 30] - Lead: NUN

In the context of Task T4.2, progress has been made in the digital representation of a generic supply chain model and how to expand it based on specific cases. A graph model has been used for this representation, allowing us to represent the main entities of the SMN, such as customers, suppliers, materials, and their relationships.

Work Performed:

- Analysis of WP1 Deliverables:
  - A detailed analysis of the WP1 deliverables was conducted, which allowed for the identification and prioritization of specific requirements for the different use cases. This analysis has been essential in guiding the development of the knowledge models in T4.2.
- Consideration of Disruption Scenarios from T2.1:
  - The initial disruption scenarios identified in T2.1, along with the initial proposed remedies, have been incorporated into the model development, to ensure that these models will be able to effectively address and manage disruption situations in the SMN.
- Development of a Physical Model:
  - A physical model has been developed using graph databases, representing the structure of entities and their relationships within a generic supply chain. Based on the results of the WP1 analysis, this model has been adapted to meet the specific requirements of the use cases, ensuring an accurate and useful representation of the SMN. This physical model will be aligned with T3.2 & T3.3.

Future Work:

- Incorporation of Information Flow:
  - The next step will be integrating the information flow model, which will allow mapping and analysing how critical information, such as order data, inventories, and performance metrics, flows between different SMN entities. This task will gather inputs from T3.2 and T3.4.
- Determination of Decision Processes:
  - Collaborative work with project participants will be conducted to identify and model key decision-making processes in SMN operations, such as forecasting, planning, and risk management. This will ensure that the developed models reflect not only the physical structure and information flow but also the essential decision dynamics for efficient and resilient supply chain management. This task will consider inputs from T3.4.
- Research on the Interrelation with Risk Models:
  - Investigate how the supply chain graph model can relate to and integrate with other risk models. This integration will allow exploiting the information through advanced techniques such as generative AI or data-driven AI models. The goal is to improve predictive capacity and decision-making in the SMN by fully leveraging the capabilities of these combined models. This task will also consider inputs from T3.4.
- Incorporation of Knowledge Graphs:
  - Investigate the integration of knowledge graphs into the existing SMN model. This will allow the incorporation of an additional level of structured knowledge, enriching the model with semantic information that can improve analysis and decision-making capabilities. This research will explore how knowledge graphs can interact with existing models to offer a more comprehensive and intelligent view of the supply chain. This approach will further strengthen the SMN's ability to handle complex situations, improving both forecasting and resilience in dynamic and challenging environments. This task will collect inputs from T3.4.

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5.2.5 Work Package 5

WP-5 will assess the real-world performance of the NARRATE project outcomes from WPs 2, 3, 4, and 6 through three pilots in diverse sectors (furniture construction, multi-sector 3D printing as-a-service, and semiconductors). These pilots will determine the success factors for the innovation, ensuring the NARRATE solution meets specific end-user needs in the tested sectors while also being applicable to other industries. Work carried out during the first nine months of the project is described below.

T5.1 Planning and Early Demonstrator [M7 – M27] – Lead: AID

WP5 "Pilot Analysis, Experimentation and Validation" started on M07 (June-24) with the task T5.1 that will end in M27 and its output will be documented in two deliverables, D5.1 "Pilot planning report - early pilot demonstrator (a) in M18 and D5.3 "Pilot planning report - early pilot demonstrator. Choice of one pilot to demonstrate modules (b)" in M27.

The work done since M07 has been to:

- revise all pilots' requirements based in the defined user stories and the associated KPIs described in D1.1 "Project requirements" and the analysis of the pilots,
- prioritise the project and pilot requirements,
- validate criteria and a tentative workplan to guide the implementation of the pilots described in D1.2 "Pilot Analysis" taking into account the environmental sustainability requirements in order to start planning demonstrators for the different pilots.

The digital technology roadmap included in D8.2 "NARRATE technology roadmap" has been analysed to be aligned with the architectural requirements.

Future work: The focus will be on meticulously planning activities for each pilot through dedicated meetings with pilot partners. These meetings will address detected risks and disruptions, assess data-gathering possibilities, and review supply chain information, machine data, production interruptions, and potential suppliers. Collaboration with technical partners will ensure alignment in the design phase of the AI platform and IMC, creating a cohesive approach to tackling the identified challenges.

5.2.6 Work Package 6

Tasks in Work Package 6 (T6.1, T6.2 and T6.3) do not start until M13 based on project schedule. However, early preparatory work identified during our online meetings and discussions led to important decisions that will significantly influence the tasks in this work package. These are described below.

Following the analysis conducted in Task T1.4 on architectural requirements and recognizing that SAG's Cumulocity platform will not be available for the project, NUN who leads this work package has proposed the adoption of NUN's *MLPredictive* platform, which is built on the FIWARE framework. This alternative platform is recommended to leverage its already integrated functionalities, offering significant advantages and aligning with NARRATE's objectives for enhanced project outcomes.

MLPredictive is a cutting-edge, FIWARE-based predictive maintenance platform that empowers users to manage and visualize data captured within a plant through IoT devices and other technologies. The platform supports data acquisition from IoT devices via multiple protocols, including API, MQTT, ULTRALIGHT, and OPC UA, with additional data uploads facilitated through periodic ETLs.

Once captured, the data is processed by the platform's robust big data capabilities, allowing for the creation and deployment of advanced AI services. Among these are AI-driven anomaly detection services that are already in place, enabling early identification of potential issues in devices.

The platform's data model is structured around machines, each composing various IoT devices. This hierarchical organization allows users to group and process data at the machine level, streamlining analysis and enhancing decision-making.

A key feature of *MLPredictive* is its Complex Event Processing (CEP) engine, which enables users to define both simple and complex rules, including those based on time windows. For example, users can set up

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alerts for conditions like "trigger an alert when the temperature of device 1 exceeds 55°C" or "trigger an alert if the average temperature over the last 5 minutes surpasses the 7-day average by 5%." The CEP engine is highly efficient, capable of processing up to 400 simple rules per minute, making it a powerful tool for real-time monitoring and response.

Future work: will focus on conducting knowledge transfer sessions, particularly with SYN – who are heavily involved in this this WP- to ensure a comprehensive understanding of the platform and minimize the learning curve. Additionally, we will actively engage with WP2, WP3, and WP4 teams to coordinate and finalize the communication protocols between the platform and the various tools slated for integration.

5.2.7 Work Package 7

WP-7 will develop the dissemination and communication strategy as well as exploitation and impact plans of the project. Work carried out during the first nine months of the project is described below.

T7.1 Dissemination and Communication Plans and Training Activities [M1-M36] - Lead: F6S

Since the project's launch in M1 (December 2023), F6S has been instrumental in driving Task 7.1, which centres on the development and execution of dissemination, communication, and training plans. This ongoing task, spanning until M36 (November 2026), is crucial to achieving WP7 objectives. Key efforts include crafting a comprehensive dissemination and communication strategy, enhancing awareness of project milestones, and establishing an interactive portal for stakeholders and the public.

FS6 has submitted key deliverables: D7.1, which outlines the communication strategy, targets, and KPIs; and D7.2, which defines the overall strategy for web presence and online channels, including the project's branding and the use of platforms such as LinkedIn, YouTube, and the project website.

In line with establishing a significant online presence, F6S has also made considerable progress by launching social media channels and creating the project’s main webpage, achieving this milestone a month ahead of schedule.

- The creation of the project webpage in M6, https://project-narrate.eu/, serves as a central hub for engaging with the project's ecosystem. Initially launched as a simple landing page, it was expanded a month later into a fully-featured platform. It provides comprehensive information about the project, its partners, and the work being carried out, including pilots, news, and events. Additionally, it offers access to public deliverables and a means to contact the project team. This digital presence is crucial for maintaining engagement, offering transparency, and facilitating interactions with all interested parties.
- On LinkedIn, our communication efforts have been active and targeted. We regularly use the platform to share updates on project activities, on a weekly basis, including major milestones like the completion of the project site, and two different press releases. Posts feature news related to the project's themes, consortium activities, and meetings, keeping our network informed and engaged. Highlights of achievements and upcoming events are also shared to maintain visibility and foster connections within the industry. These LinkedIn updates help build visibility, foster connections within the industry, and enhance the project's overall impact.

NARRATE participated in and contributed to three different events, aligned with the dissemination activities.

- FHG and AIDIMME attended the International Conference on Interoperability for Enterprise Systems and Applications (I-ESA24) held in Crete from April 10th-12th, 2024. Their paper, titled “The challenge of integrating multi-sectorial requirements in dissimilar industrial pilots,” was accepted and presented at the conference. Maria José Nuñez from AIDIMME stepped in to present the paper last Friday, discussing how the NARRATE project is addressing end users' requirements through systematic engineering methodologies. The paper highlights Fraunhofer IPK's role in leading the user requirements gathering methodology, with AIDIMME focusing on piloting and assessing the NARRATE project’s solutions. This presentation not only shared valuable insights but also furthered the project's

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visibility within the international research community.

- At FIMMA + MADERALIA on M6 (14th - 17th May 2024), F6S representatives from AIDIMME and MEDWOOD worked to promote the NARRATE project by showcasing its objectives and solutions at both the AIDIMME booth and the MEDWOOD stand. Through continuous presentations, a dedicated TV display, and a project video, they highlighted how NARRATE addresses production and logistics disruptions in the furniture manufacturing sector. The discussions held at the fair are expected to contribute to broader recognition of the project's potential to address industry disruptions through advanced manufacturing solutions. This event served as an important opportunity to raise awareness about the project on an international level and helped to set the stage for future collaborations and the adoption of NARRATE's solutions.
- SERV and AIDIMME published a paper called "Technology Roadmap for Resilient Smart Manufacturing Ecosystems" in 30th IEEE/ITMC International Conference on Engineering, Technology and Innovation (ICE 2024) (https://mdtweek.digit-madeira.pt/ice/) held in Funchal - Madeira 24 th - 28 th June 2024. The paper underscores SERV's groundbreaking approach to the Technology Roadmap for Resilient Smart Manufacturing Networks and AID's support with piloting activities, which has the potential to significantly reshape how smart manufacturing systems are envisioned, designed, and developed in the future. By introducing innovative strategies and methodologies, this Technology Roadmap could set new standards for the industry, driving the evolution of smarter, more adaptable manufacturing systems that are better equipped to meet the challenges of a rapidly changing technological landscape. This approach not only promises to influence future system architectures but also to catalyse a transformative shift in the way manufacturing networks are structured and optimized for resilience.

The efforts listed above contribute directly to the dissemination targets outlined in the grant agreement, including raising awareness, facilitating knowledge transfer, building networks, influencing stakeholders, and ensuring the publication of research results. These foundational achievements are critical to fulfilling the project's long-term objectives and ensuring its success as a central reference point at the European level.

T7.2 Exploitation, and Business Plan [M7 – M36] - Lead: F6S

F6S has started Task 7.2 on Exploitation and Business Planning. At this stage, work has primarily involved initial steps such as gathering market insights and conducting foundational research. Although these activities have set the groundwork, significant progress on the comprehensive business strategy is still pending.

The upcoming business plan will be pivotal in identifying market opportunities, assessing competitive positioning, and outlining financial projections. Key aspects will include defining pilot deployment scenarios, formulating an exploitation and sustainability plan, and exploring potential partnerships.

T7.3 Innovation Potential and Impact [M7 – M36] - Lead: SAG

Task 7.3 "Innovation Potential and Impact" started in M7 by Software AG and tries to coordinate and manage work done with respect to innovation. Within the NARRATE project, innovation mostly means ideas of new products or combinations thereof, new services, new processes or an improvement of already existing products, services, or processes.

Managing innovation is, firstly, identifying and collecting innovative project outcomes that partly already took place as described above, and secondly trying to identify novel areas of innovation. This process of course includes obtaining a precise view of the state-of-the-art in the area covered by NARRATE, which is resilient supply-chain-management as well as flexible production management, for both utilizing existing technologies wherever possible and extending the realm of knowledge and practicability where applicable.

Task 7.4 is scheduled to begin in M13, so no work has been undertaken yet.

Future work: As the project progresses, F6S will focus on keeping dissemination efforts ongoing and dynamic under Task 7.1. We will leverage social media and the project website to attract and engage a broader audience by organizing webinars that showcase key developments and project progress.

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Additionally, strategic participation in conferences and events, especially after major milestones like the creation of the platform and tools, will promote the project through in-person engagement, complementing our online activities and enhancing network-building.

To diversify our outreach, we plan to launch a podcast series featuring discussions with project experts, stakeholders, and industry leaders, providing an accessible platform for sharing knowledge and insights. We will also develop specialized training programs focused on the project's technical aspects and results, ensuring stakeholders are well-prepared to effectively utilize the platform and tools. Furthermore, a LinkedIn forum will be created to foster ongoing discussion and engagement, enabling partners and stakeholders to share updates and contribute to the project's evolution. These initiatives will be crucial for maintaining momentum, increasing visibility, and ensuring the continued success of our dissemination and communication strategy.

To ensure effective advancement of Task 7.2, F6S will hold monthly meetings with all contributors starting immediately. These meetings will be crucial for tracking progress, addressing challenges, and refining the business strategy. Regular discussions will facilitate coordination, integration of findings, and progression from initial activities to a detailed plan for commercializing the project's innovations. This approach will help transition from foundational work to a robust exploitation strategy.

Software AG's next steps in Task 7.3 will focus on fostering innovation throughout the project by more precisely identifying and detailing key areas of innovation, along with a thorough understanding of the current state-of-the-art. Given the collaborative nature of this effort, input from all partners is essential. To facilitate this, an Innovation Questionnaire will be developed and distributed among the partners. The insights gathered from this questionnaire will play a pivotal role in shaping Deliverable D7.4, "Innovation Strategy and Impact Report," due in M18.

5.2.8 Work Package 8

WP-8 is about project coordination and quality assurance, managing resources, monitoring the overall project performance and managing risks and contingencies. Work carried out during the first nine months of the project is described below.

MEETINGS

The SCM hold several meetings with the different WP leaders previously to the project kick-off meeting in order to better prepare the event. These meetings included at least one participant from all partners.

- Kick-off Meeting

The official kick-off meeting took place in AIDIMME's facilities on December 11th - 13th. All partners attended in person, only the STM was unable to travel but was present at the meeting online. A welcome pack was prepared by AID and distributed to everyone including information on the meeting place, agenda and others.

The agenda was prepared to cover all the different activities and objectives of the project. Special care and attention were given to those WPs and tasks with an early commencement date, while an overview was given to those with a later start date. It should be noted that the various technical meetings beforehand greatly facilitated the work of the KoM. The agenda was the following:

Monday 11/12/2023

Slot	Start	Lead	Topic
Welcome and overview	13:00	AID	Meeting kick-off and welcome
	13:15	All	Who is who? And Main role in NARRATE
	13:30	SERV	NARRATE Project overview. Outcomes and KPIs.
WP8	14:00	AID, SYN	Project Coordination. Data Management
	14:30	AID	PM tools (CA, Lists, repositories, telcos, reporting…)
	15:00	Coffee break	

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WP1		FHG	Project Requirements Management, Reference Architecture and Pilot Analysis
	15:30	FHG	Overall WP1 Requirements Management
	16:00	AID	Pilots Setup. Methodology for validation criteria
	16:30	AID	Requirements for circularity and environmental sustainability
	17:00	SERV	Architectural requirements
	17:30	ALL	Team building

Tuesday 12/12/2023

Slot	Start	Lead	Topic
WP2		SAG	SC Disruption Risk Detection and Diagnostic Framework
	08:30	SAG	Overall WP2 Risks Identification and Processing
	09:15	BUL	Disruptions and Resilience Strategies Supplier and SMN Risk Assessment
	10:00	Coffee break	
WP3		SERV	Data Contextualization, Interoperability, and SMN Knowledge Model
	10:30	SERV	Overall WP3 Contextualization SMN Knowledge Model using Digital Twin Technology
	11:15	NUN	SMN Knowledge Model using a Neuro Symbolic Approach
	12:00	FHG	Automated Workflows and Production Process Orchestration
	12:30	INSA	Security and Privacy
	13:00	Lunch break	
WP4		INSA	The Intelligent Manufacturing Custodian and the Trustworthy AI-driven Platform
	14:00	INSA	Overall WP4 AI-driven Production Planning and Process Routing Reconfiguration of Production and the SMN
	14:30	SAG	Resilience, Sustainability and Circularity Stress Testing Scenarios
	15:00	NUN	Combined SMN Knowledge Models to Achieve end-to-end AI driven visibility
	15:30	DHL	Intelligent Logistics and Warehousing
WP5		AID	Pilot Analysis, Experimentation and Validation
	16:00	AID MIC AID BUD DHL	Overall WP5 Planning and Early Demonstrator Pilot Execution and Progress Monitoring **Pilot#1**: Improving Automation and Supply-Chain Resilience in the Furniture Industry **Pilot#2**: 3D Printing Network as-a-service to Improve Resilience and Mitigate Unexpected Disruptions **Pilot#3**: Achieving Supply-Chain Resilience in the Semiconductor Industry Overall Pilot Assessment, Evaluation and Improvement
	17:30	ALL	Visit to AIDIMME facilities pilot#2

Wednesday 13/12/2023

Slot	Start	Lead	Topic

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WP6		NUN	Intelligent Manufacturing Custodian and AI Platform: Implementation and Assessment
	08:30	NUN	Overall WP6 IMC and AI Platform: Implementation, Deployment and Testing
	09:00	SYN	IMC and AI Platform: Early Integration
WP7		F6S	Dissemination, Communication, Exploitation and Impact
	9:30	F6S All	D&C&E Plans and Training Partners engagement
	10:00	F6S	Exploitation and Business Plan
	10:30	SAG	Innovation Potential and Impact
	11:00	FHG	Standardisation in SMNs
WP8	11:30	Project Officer	NARRATE – EC expectations

The NARRATE kick-off meeting served as a crucial initial step to ensure the project's success. This ambitious endeavour involves collaboration among academia, industry, and partners from various European countries, each bringing complementary expertise. The meeting targeted a comprehensive and cohesive approach to tackling the complexities of modern supply chains by uniting these diverse participants. Leveraging their expertise, the project aims to develop robust and adaptable smart manufacturing networks capable of withstanding disruptions.

- Purpose and Achievements of the NARRATE Kick-Off Meeting

The purpose of this meeting was multifaceted, focusing on establishing a clear vision and roadmap, aligning expectations, fostering collaboration, and setting the foundation for effective communication and coordination throughout the project's lifecycle. A key objective was to facilitate the building of strong collaborative relationships among participants from different countries and sectors. The NARRATE kick-off meeting was marked by fruitful discussions and informative presentations that delved into the content and nature of work packages and their interconnections. Participants demonstrated a shared commitment to realizing NARRATE's objectives, creating a unified front to address the challenges and opportunities in developing resilient smart manufacturing networks. The meeting set clear targets that included:

1. Project Alignment and Vision Setting

- Clearly defined the project's objectives, scope, and expected outcomes.
- Established a shared vision and common goals, ensuring everyone understands the broader context and their roles, minimizing ambiguities.
- Stimulated a collaborative environment where diverse perspectives can converge, encouraging knowledge sharing and cross-disciplinary learning.

2. Roles and Responsibilities

- Identified and assigned specific roles and responsibilities to team members from academia, industry, and other partners.
- Clarified the contributions and expectations from each participant, leveraging their unique expertise.

3. Communication and Coordination

- Set up communication channels to facilitate seamless interaction among dispersed teams.
- Agreed on regular meeting schedules to ensure continuous engagement and accountability.

4. Technical Framework

- Outlined the technical architecture and methodologies for developing resilient smart manufacturing networks.
- Helped prioritize tasks and reduce complexity.

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- Encouraged the adoption of best practices and cutting-edge technologies, spanning AI, Big Data, IoT and Digital Twins, to ensure the SMNs are resilient and future-proof.

5. Risk Mitigation

- Identified and discussed potential risks and challenges and mitigation strategies. The necessity of an Industrial IoT Platform to replace *Cumulocity*, which despite the fact that it was mentioned in the DoA it be not available due to the internal business rearrangements in SAG.

In summary, the NARRATE kick-off meeting laid a strong foundation for a collaborative and innovative approach to building resilient smart manufacturing networks, ensuring the project is well-positioned for success.

- First General Assembly

The first project General Assembly took place in Berlin on 14th - 16th May 2024, at FhG facilities. The agenda was the following:

Tuesday 14/05/2024

Start	Lead	Topic
13:00	FhG	Welcome
13:10	SERV	Brief project overview
13:30	AID	Project coordination
	FHG	Pilots Session (1h per pilot including questions) Outline of pilots' user stories and list of requirements
13:50	MIC	**Pilot#1**: Improving Automation and supply chain resilience in the furniture industry
14:50	Coffee break	
15:15	AID	**Pilot#2** 3D printing network as-a-service to improve resilience and mitigate unexpected disruptions.
16:15	BUD	**Pilot#3** Achieving supply chain resilience in the semiconductor industry
17:15	AID	Circular economy pilot requirements to ALL pilots
18:00	End of meeting	

Wednesday 15/05/2024

Start	Lead	Topic
	SERV	Technical insights and interrelationship analysis of WPs 2, 3, 4 & 6
09:00	SERV	Introduction and brief presentation of technology roadmap
09:20	SAG/BUL	Risk detection and diagnostic framework Disruption and reliance strategy for SMNs Supplier and SMN risk assessment
10:20	Coffee break	
10:50	SERV / INSA	Types of data and contextualisation
12:00	Lunch break	
13:00	SERV	Digital twin functionality and capabilities
14:00	INSA / NUN	Intelligent manufacturing custodian functionality and features
15:00	Coffee break	
15:30	NUN	AI platform functionality and features and types of AI
16:30	DHL	Intelligent logistics and warehousing
17:30	BUL	Resilience metrics and KPIs

Thursday 16/05/2024

Start	Lead	Topic

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09:00	AID / MIC / BUD	Pilots and user stories revisited Improvement/extension of user stories. Requirements refinement Planning for testing (early demonstrator)
10:20	Coffee break	
11:15	F6S	Dissemination/Communication/Website
11:45	FHG	Standardisation in SMNs
12:00	AID	Next deliverables
12:15	SERV	Wrap up. Actions. Next meetings.
12:30	Lunch	End of meeting
13:30	Visit	Visit to FHG IPK laboratories

The NARRATE General Assembly adopted a comprehensive, three-pronged approach to drive the project forward, with a particular emphasis on pilot projects and the technical foundations underpinning the entire initiative. The approach meticulously focused on the inner workings of WPs 2, 3, and 4, ensuring their alignment with the envisioned future functionality of the pilot projects in WP-5 in light of the findings in WP-1.

1. Pilots: Current and Future Functionality

Detailed Outline and Analysis

- **Current Functionality:** A thorough assessment of the existing capabilities of the pilot projects, documenting operational conditions, user stories, and requirements.
- **Future (To-Be) Functionality:** Defining the roadmap for future enhancements, including advanced functionalities and improvements to meet emerging needs.

User Stories and Requirements

- **Diverse User Base:** Inclusion of various user types, ensuring the pilot projects address the needs from the simplest to the most sophisticated user stories.
- **Risk Identification:** Identifying potential risk factors that could impact the implementation and operation of the pilots.
- **KPI Development:** Proposing a comprehensive list of potential Key Performance Indicators (KPIs) for each pilot, enabling effective performance monitoring and evaluation.

Work Evaluation and Prioritization

- **Exhaustive Study:** Conducting an in-depth study encompassing different user scenarios and requirements.
- **Prioritization**: Evaluating, prioritizing, and refining the list of requirements to ensure they are realistic and beneficial for the project's success.

2. Technical Underpinnings of the Project

Technical Roadmap and Requirements

- **Technical Project Roadmap:** A detailed analysis of the technical development plan, identifying milestones and critical path activities.
- **Data Requirements:** Outlining the types of data required, their nature, and utilization for effective project execution.
- **Contextualization Approaches:** Exploring potential methods for contextualizing data to enhance its relevance and usability.

Digital Twins and Intelligent Manufacturing Custodian (IMC)

- **Digital Twin Capabilities:** Defining the necessary features and functionalities of Digital Twins to support the IMC.
- **AI and Generative AI:** Exploring the types of AI, including generative AI, required to support the IMC's operations and decision-making processes.
- **Intelligent Logistics and Warehousing:** Examining the role of intelligent logistics and

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warehousing in the context of Smart Manufacturing Networks (SMNs) and their integration with the IMC.

3. Interaction Between Pilots and Technological Support

Key Decisions and Implementation

- **Alignment and Integration:** Ensuring seamless integration between pilot projects and the supporting technological infrastructure.
- **Coordination Mechanisms:** Establishing mechanisms for continuous coordination and communication between pilot project teams and technical workpackages.
- **Feedback Loops:** Implementing robust feedback loops to facilitate iterative improvements and adaptive planning.

Detailed Steps and Actions

1. Pilot Projects Implementation
   - **Step 1:** Conduct workshops with stakeholders to gather detailed user stories and requirements.
   - **Step 2:** Develop a comprehensive risk assessment matrix for each pilot.
   - **Step 3:** Define specific KPIs and establish baseline measurements for current functionality.
2. Technical Underpinnings Execution
   - **Step 1:** Follow the detailed technical roadmap in D8.2 that outlines key development milestones.
   - **Step 2:** Specify data types and sources, and develop data integration **protocols**.
   - **Step 3:** Design the Digital Twin functionalities, ensuring alignment with the IMC requirements.
   - **Step 4:** Follow a master scheduling approach for Smart Manufacturing Networks for the coordination and optimization of production activities as the central hub for aligning supply chain operations, production processes, and demand forecasts to ensure that the right products are produced in the right quantities at the right times. Master scheduling in smart manufacturing networks represents a significant advancement over traditional manufacturing scheduling. By leveraging the power of real-time data, AI, and IoT, it enables manufacturers to achieve higher efficiency, responsiveness, and overall performance.
   - **Step 5:** Critically evaluate well-known open Industrial IoT (IIoT) platforms and identify the essential functionalities needed to support the Intelligent Manufacturing Custodian (IMC) and its basic operations. This involves a comprehensive analysis of the capabilities of existing IIoT platforms, assessing their ability to integrate with the IMC, and determining the specific functionalities required to enhance the IMC's effectiveness in managing and optimizing smart manufacturing networks.
3. Pilot-Technology Interaction
   - **Step 1:** Establish regular review meetings between pilot project leads and technical teams.
   - **Step 2:** Select a shared digital platform for real-time data sharing and collaboration.
   - **Step 3:** Implement a continuous improvement process based on feedback from pilot project outcomes.
4. Standardisation Efforts
   - The recurrent idea of standardisation was seriously considered and was agreed to include a session on training and discussion in the next General Assembly that shall also take into account eventual links with ethics and potential risks. The main agreements were on issues such as: Despite different programming languages,

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standard APIs will be used; Standards to be considered: GAIA-X or Manufacturing-X; Interoperability: Enterprise Interoperability Framework; IOF Industrial Ontology Foundry - ISA-95; UML better not to be used. No ISO 19440 artefacts needed for Enterprise Modelling RDF; Semantic Integration NIST OAGI; DTs already 23247-1 in SC4 and others.

We can conclude that the NARRATE General Assembly's approach, with its detailed emphasis on pilot projects and robust technical underpinnings, provides a clear and actionable roadmap for the project's success. By focusing on comprehensive analysis, thorough evaluation, and continuous integration, the project is well-positioned to achieve its goals and deliver significant value to resilient Smart Manufacturing Networks.

The next General Assembly meeting will take place in Como on 26th - 28th November 2024 at SYN facilities.

NARRATE Technology Roadmap

SERV with the help of AID developed a technology roadmap that identifies the most effective technology development path to achieve resilient Smart Manufacturing Networks. This technology roadmap is a strategic guide that outlines the steps and milestones involved in integrating digital technologies into various aspects of the manufacturing ecosystem process in NARRATE. It identifies the critical gaps between technology capabilities and technology requirements to achieve the growth and sustainability required by SMNs. A critical component of this roadmap involves the selection and implementation of an AI platform tailored to support the design and enhance supply chain resilience. In addition, the roadmap incorporates a digital maturity model to guide the implementation of SMNs. The maturity model assesses the current state of digital capabilities across various aspects of the manufacturing process and defines a path for advancing digital maturity over time under the guidance of the technology roadmap.

All these activities concluded in M6 and have been reported in D8.2 "NARRATE Technology Roadmap" (M6).

DELIVERABLES

A list of reviewers has been stablished from WP8 and each deliverable to be submitted has, at least a double internal review for quality purposes.

WP8 has already submitted three deliverables, being this the fourth one. These are:

- D8.1 Project handbook, ethics, quality and management plan. Authors: AIDIMME and SYNESIS. Internal reviewers INSA and NUN.
- D8.2 NARRATE technology roadmap. Author SERV. Internal reviewers: AID, NUN, SERV.
- D8.3 Data management plan. Author: SYN. Internal reviewers: SERV, F6S
- D8.4 Technical progress report. Authors: SERV, with contributions from AID, F6S, SYN, SAG and NUN. Internal reviewers: AID, NUN.

HOP-ON INSTRUMENT

The inclusion of the widening partner, Policy Lab (PL), through the HOP-ON Facility, will greatly enhance the project's objectives, elevate PL's visibility, and improve knowledge circulation. PL will bring substantial added value by taking on a critical, complementary role: evaluating systemic risks related to import dependence on geopolitically competitive economies, providing detailed mapping of global supply and demand at the product group level, and guiding firms toward high-potential markets to boost sales, exports, and market share. Additionally, the HOP-ON proposal expands media monitoring to incorporate near-real-time tracking of global socio-economic, environmental, and climate events. This enhancement will enable predictive market analysis and early warning systems, alerting businesses to significant developments that could disrupt established market trends on both the supply and demand sides.

AMENDMENT

Initial woks on an amendment were initiated in the funding and tender's portal in order to include one affiliated entity to NUN. However, the company finally reorganised the personnel and the amendment was finally withdrawn.

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Contacts were hold with the PO to check if an amendment was needed for different issues referred to changes of person/month and budget between partners. Instead, it was agreed that these changes did not need to be amended and that the changes would be detailed in the "deviations" section of the progress report.

RISKS MATRIX

A matrix covering the different risks already foreseen at proposal stage has been designed and new possible risks can be included in the matrix by the partners, if needed. The matrix is available at TEAMS project folder.

6. IMPACT

6.1 PROGRESSS IN THE FIRST NINE MONTHS TOWARD DELIVERING IMPACT

Overview: In its first nine months, the NARRATE project has made considerable progress toward achieving its objectives, laying a solid foundation for delivering impact across scientific, economic, societal, and industrial domains. The project's efforts have focused on key areas such as partnership, collaboration, technology development, pilot testing, and the early design of digital twins, all of which are integral to advancing the project's goals in resilient SMNs.

6.1.1 Scientific Impact:

NARRATE has made significant strides in advancing scientific knowledge in the domain of resilience. Through comprehensive technology analysis, Industrial IoT (IIoT) platform evaluation and the exploration of DT representations, the project has contributed to the development of innovative methodologies that enhance the monitoring, simulation, and optimization of manufacturing processes. The project's adoption of a hybrid federated data mesh approach for data integration is a groundbreaking step toward overcoming the challenges of data interoperability in SMNs. This approach, combined with the exploration of digital twin representations across various facets—such as supplier, product, production, performance, sensor, and logistics—provides a robust framework for optimizing production operations. These advancements have not only expanded the scientific understanding of SMNs but have also provided valuable insights into the complexities of data integration and interoperability within these networks.

6.1.2 Economic Impact:

The project's progress in identifying and prioritizing relevant manufacturing data sources is paving the way for economic benefits. By focusing on critical data such as MTO orders, production metrics, and supply chain logistics, NARRATE is enabling manufacturers to optimize operations, reduce downtime, and enhance productivity. The project's emphasis on predictive analytics, the development of a comprehensive system architecture and pilot testing in real-world manufacturing settings to gather practical insights and validate the project's effectiveness is expected to lead to cost savings and increased efficiency for manufacturers.

6.1.3 Societal Impact:

NARRATE's focus on open science and data accessibility has societal implications, as it promotes transparency, collaboration, and inclusivity in research and development. The project's efforts in pilot testing and user feedback collection have ensured that the IMC system components are aligned with real-world demands and user needs, making the benefits of resilient, smart manufacturing more accessible to a broader range of stakeholders. By prioritizing user-centred design and continuous improvement based

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on stakeholder feedback, NARRATE is fostering a culture of innovation and adaptability, which is crucial for societal resilience in the face of technological advancements.

6.1.4 Industrial Impact:

In the industrial domain, NARRATE's advancements are already playing a crucial role in boosting the resilience and efficiency of manufacturing processes. The continuous pilot testing, ongoing evaluation of IIoT platforms with an emphasis on open-source solutions, and the development of a comprehensive reference architecture—featuring a centralized decision-making hub, real-time data analytics integration, and machine learning models for predictive analysis—further underscore NARRATE's commitment to fostering a flexible and scalable manufacturing environment, while laying a solid foundation for future progress. Additionally, by reducing barriers to knowledge access, NARRATE is helping smaller companies and startups to leverage cutting-edge research without the need for significant upfront investment. These efforts are expected to drive significant improvements in industrial production processes, ultimately leading to more sustainable and competitive manufacturing practices.

NARRATE project also has made significant strides in delivering impact through a coordinated dissemination strategy, involving a collective effort from all partners to ensure that the project's innovations and research findings reach key stakeholders across various domains.

6.1.5 Channels/Means That Facilitated Impact:

- **Website:** The NARRATE project website, developed as a collaborative effort, serves as the central hub for project information. With 490 unique visitors, it has been crucial in disseminating key updates, objectives, and resources to stakeholders, facilitating easy access to the project's progress and outcomes.
- **LinkedIn Group:** The LinkedIn group for NARRATE, with 151 members, has been a joint initiative to foster engagement among industry professionals, researchers, and other stakeholders. Regular updates and discussions have kept the community informed about the project's milestones, events, and technical achievements, helping to maintain a high level of interest and participation.
- **Social Media Presence:** The project's social media channels have been collectively managed to maximize outreach. With 712 reactions to posts, these platforms have been instrumental in engaging a broader audience, ensuring that NARRATE's messages and findings are widely shared and discussed within the community.
- **Event Participation:** Project partners have actively participated in key industry events and conferences, presenting NARRATE's advancements to targeted audiences. These events have provided valuable opportunities to showcase the project's work, gather feedback, and build relationships with potential collaborators, thereby enhancing the overall impact of NARRATE.

This collaborative approach to dissemination has ensured that NARRATE's innovative contributions to resilient manufacturing networks are not only shared widely but are also positioned for adoption and integration within relevant industrial sectors.

6.2 UPDATE OF THE PLAN FOR EXPLOITATION AND DISSEMINATION OF RESULTS

As previously mentioned, Task 7.2, focused on Exploitation and Business Planning, is currently in its early stages, with initial efforts directed at gathering market insights and conducting foundational research. To ensure steady progress, F6S will begin holding monthly meetings with all contributors, aiming to refine the business strategy and transition from preliminary work to a detailed plan. This plan will be essential for identifying market opportunities, defining pilot deployment scenarios, and exploring potential partnerships as we move forward in commercializing the project's innovations.

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7. OPEN SCIENCE

In NARRATE, open science promotes making research publications and prototype development freely accessible, fostering the expansion of informed and collaborative knowledge co-creation and co-experimentation. Open data serves as the cornerstone of open science within NARRATE. Open data in resilient SMNs refers to the practice of making manufacturing-related data and prototypes freely accessible, shareable, and reusable across the industry and research community. This data can include information from various stages of the manufacturing process, such as production data, equipment performance, quality control metrics, and supply chain logistics.

The goal of open data in smart manufacturing as espoused by NARRATE is to facilitate innovation, collaboration, and efficiency by enabling researchers, engineers, and companies to access and use shared datasets. This can lead to better decision-making, improved process optimization, and the development of new technologies and strategies within the manufacturing sector. Open data can be particularly valuable in the context of SMNs, where interconnected systems, automation, and real-time data analytics play a crucial role. By sharing data openly, manufacturers can help to create a more transparent, competitive, and innovative environment that benefits the entire industry.

Focusing on open science and open data management and handling within the project, several measures can be implemented to ensure the reproducibility of results, credibility, equity and trustworthiness. These properties are crucial for enabling other organizations to benefit from the project's outcomes. The following are specific procedures that will be applied to achieve this goal.

- **Standardized Open Data Formats:** Establish data sharing agreements that outline the format, structure, and handling procedures for shared data. Convert all incoming data to a standardized format upon entry into the centralized data layer.
- **Implement role-based access control (RBAC)** to manage who can view, edit, or export data.
- **Open Data Quality and Validation:** Generate reports that detail the quality of data before and after preprocessing. These reports should be stored alongside the data to provide context and justification for the preprocessing steps taken. Establish protocols for validating data before it enters the analysis phase. These protocols should include checks for consistency, accuracy, and completeness, with detailed records of each validation step.
- **Documented Preprocessing Steps**: Record every step of the data cleaning and transformation process, including scripts or algorithms used, parameters set, and any assumptions made.
- **Classification of Open Data:** Use a data catalogue to index and describe all available datasets, including metadata that describes the origin, structure, and intended use of each dataset.

  Document all assumptions, input data, and model parameters used in the simulation. This includes detailing the nature of the disruption, the scope of the impact, and any mitigating actions considered.
- **Historical Data and Archiving:** Implement version control for historical datasets so that any updates or corrections are tracked, and previous versions can be retrieved and used to replicate past analyses. Save all model parameters, configuration files, and input data snapshots used in each analysis or simulation run.
- **Automated Analysis Pipelines:** Implement automated pipelines that take data through a consistent sequence of steps to reduce human error and ensure that analyses are performed the same way every time.
- **Open collaboration and systematic sharing of knowledge and tools:** NARRATE aims to create cumulative efficiencies between project - and external - partners wherein research tools (e.g., the Platform, AI tools, Digital Twin, AI algorithms) and R&I output of are combined to accelerate the delivery of new knowledge generated by encouraging multiple examinations and interpretations of data leading to improvement and a more accurate verification of scientific results and contributing to replication, refinement, and its eventual (re)use. Such initiatives are described below:
  - **Open Access to Research and Case Studies:** Research on resilient SMNs and their application includes evolving case studies and findings. Making research publications and case studies

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freely accessible ensures that the latest advancements in SMNs are widely disseminated and can be built upon by others.

- **Collaborative Research and Open Collaboration Platforms:** NARRATE will encourage collaborative research through an open platform, where researchers, engineers, and industry experts can work together. Source code, AI algorithms and datasets used in the open-platform will be made publicly available, in a user-friendly manner, under an open license. This license grants others the right to use, access and study resources, enabling them to validate the results and build upon the work.
- **Leveraging AI-driven Outcomes and Tools:** Open Science, with its principles of transparency, collaboration, and accessibility, can play a transformative role in the context of AI and smart manufacturing. This can be applied as follows:

- **Open Data Sharing:** AI models in resilient SMNs rely heavily on large datasets for training and validation. NARRATE will promote the sharing of these datasets across the research community, industry, and academia.
- **Open-Source Tools and Algorithms:** The development and deployment of AI algorithms for resilient SMNs can benefit from open-source software and tools.
- **Open Access to Research Publications:** Making research publications in NARRATE freely accessible aligns with Open Science principles.
- **Ethical Considerations and Transparency:** NARRATE fosters transparency in the development and deployment of AI systems, ensuring that ethical considerations are addressed.
- **Open Innovation and Intellectual Property:** NARRATE's approach to Open Science can lead to open innovation models where intellectual property is shared or managed collaboratively.

- **Leveraging Digital Twin Data and Algorithms**: Open Science can play a significant role in enhancing the development, deployment, and utilization of digital twins in SMNs. Below we describe how Open Science principles can be related to digital twins in this context:

- **Open Data for Digital Twins**: Digital twins rely on vast amounts of data, including product data, real-time sensor data, historical production data, quality data and environmental data, to create accurate virtual models of physical manufacturing systems. Open Science in NARRATE promotes the sharing of such datasets, making them accessible to researchers, engineers, and manufacturers. By opening up data, digital twin models can be improved and refined with contributions from a broader community.
- **Open-Source Models and Algorithms:** Digital twins are built using complex algorithms and models that simulate real-world manufacturing processes. Sharing these algorithms and models as open source allows for collective improvement and adaptation. The global community can contribute to refining these models, making them more robust and applicable across different scenarios.

NARRATE project embraces Open Science by promoting early and open sharing of research and fostering a collaborative environment. This approach ensures that the project's findings and methodologies are accessible and reproducible, advancing the field of resilient smart manufacturing networks (SMNs).

Early and Open Sharing of Research:

NARRATE prioritizes transparency by disseminating research updates and preliminary findings through its website and social media channels. This strategy facilitates early access to research developments and encourages engagement from the broader scientific and industrial communities. Presentations at international conferences and workshops are publicly available and further support the open sharing of research outcomes, allowing for real-time feedback and collaborative improvement.

Ensuring Reproducibility:

The project is committed to reproducibility by documenting research methodologies and results comprehensively. This includes detailing the processes and parameters used in simulations and experiments. Such documentation is crucial for verifying and replicating results, ensuring that other researchers can build upon the project's work with confidence.

Channels/Means Facilitating Open Science:

- **Digital Communication Platforms:** The project's website and social media channels play a key role in

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sharing research findings and updates. These platforms offer a wide reach, allowing the project to communicate its progress and developments to a diverse audience.

- **Conference Presentations:** NARRATE regularly participates in international conferences and workshops. These events provide opportunities to present research findings, engage with experts, and foster collaboration. Such interactions help disseminate knowledge and integrate feedback from various stakeholders.
- **Upcoming Collaborative Platforms:** As part of its commitment to Open Science, the project is planning to launch a LinkedIn Forum. This forum will serve as a dedicated space for sharing specialized content and fostering discussions among stakeholders. It will feature contributions from project partners, including articles and blog posts on relevant topics. This initiative aims to enhance collaborative research and facilitate knowledge exchange across the project's network.

By leveraging these channels, NARRATE not only adheres to Open Science principles but also promotes a culture of transparency and collaboration, ultimately advancing the field of resilient SMNs.

8. DEVIATIONS FROM ANNEX 1 AND ANNEX 2

8.1 TASKS/OBJECTIVES

All tasks have been successfully completed, and critical objectives have been met. The only deviation from the original DoA stems from the unavailability of sag's *cumulocity* platform for the NARRATE project, due to internal business decisions at SAG. To mitigate this issue, a thorough evaluation of available open IIOT platforms was undertaken, leading to the identification of FIWARE as the most suitable alternative. In response, NUN proposed their FIWARE-based platform, *MLPredictive*, as a replacement for *cumulocity*. *MLPredictive* aligns well with the project's architectural requirements (see table 1) and has been selected as the foundational platform for the necessary extension with IMC functionality and further development. Since this change was implemented early in the process, there has been no impact on any tasks, and the project remains fully on track.

8.2 USE OF RESOURCES

As far as the deviations at WP level we find significant deviations in WP1 and WP5.

WP1 has used less resources than foreseen due to the lack of technical knowledge from one partner, the already work done for other business reasons for another company and the interrelation between WP4 and WP1 that has made difficult to distinguish between some tasks that belong to one or the other WP.

WP5 had to start in July, but just a few partners were really working on the matter due to the lack of initial coordination due to the summer break and staff turns.

Regarding the deviations at partner level:

- **AID** had to start WP5 activities on July, however the different summer breaks turns on the team have made it impossible to start until September. The work will be recovered and on track on the reporting at M18.
- **SERV** has made significant progress over the summer months, focusing extensively on the architecture components of the project through its work in Work Packages 1 and 8, as well as contributing to the technological progress report.

  This concentrated effort has led to substantial advancements in these critical areas. However, due to this strategic allocation of resources, SERV has experienced a slight delay in its contributions to WP4, where its role is more limited (8PMs for the duration of the project).

  Despite this minor setback, SERV is well-positioned to fully recover in the upcoming period. The team has already developed a clear plan to address this deviation and is confident that the necessary adjustments will ensure timely completion of WP4 deliverables without impacting the overall project

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timeline

- **FhG** has an experienced team in project management and there has not been necessary to invest more p/m in WP8 so far.
- **INSA-L** began working on WP4, specifically T4.3 (AI-driven Production Planning & Process Routing), earlier than scheduled due to the complexity of this work package and task. There are two distinct challenges: the first concerns internal production planning, and the second involves network configuration and the external organization of supply (supplier, manufacturer, and customer network). The necessary investigation for this task is much more extensive than originally planned in the submitted proposal. The process of WP4 and task T4.3 includes understanding the business case, identifying and analysing industrial data, developing mathematical models, studying the feasibility of applying AI in APP (which type of AI and where), developing an application, conducting experiments, and refining the APP. This task and WP is one of central aspects of the project because of its role in transforming data into actionable decisions. Many other tasks and work packages are linked to it, either by providing data and constraints or serving as inputs and outputs. Workshops in Valencia and Berlin, along with several meetings, helped to gain a deeper understanding of the issues across three use cases. Progress has also been made in problem understanding and data identification, and the meetings with partners allowed to identify the available industrial data and clarify how and when the necessary data can be received. Additionally, INSA has made advances in the mathematical modelling of internal production planning and Master Scheduling. Some of the work in WP4 can (or should) be considered as part of the investigation in WP1, giving a clearer image of the situation and covering part of the deviation in these two WPs. A few hours have been used in WP6 to better understand the issue and focus the tasks in WP4.

  Regarding WP7, INSA has internally planned to prepare a report and a paper for publication at an international conference, with the submission deadline in December and this work is mainly developed from M10 on, which is not part of this report.
- **INSAV** is an affiliated entity to INSA-LYON with a specific, skilled and senior team that is dedicated full time to project management and that no more p/m were needed at this.
- **SAG** was a bit late in starting at WP7 and that is the reason for the scarce participation in that WP so far. As far as WP8 is concerned, there is a misunderstanding on the coordination of the tasks and WP that has been included in WP8 instead of being included in the WP concerned. Besides there has been some discussions about a suitable replacement for Cumulocity. This also holds for WP1.
- **F6S** for WP1, as non-technical partners, was not able to fully contribute to task 1.2, and our contributions were limited to those interactions carried away in the consortium meeting. We were never called to action in that sense. For WP8, they are spending a bit more time coordinating and making sure partners are actually using the templates that we are creating for different purposes, as well as coordinating with partners their attendance to events, etc. These hours will be recorded in WP7 from now on.
- **DHL** WP5 started in M7 (June 2024) and only one of the 3 tasks in which DHL participates. The reason for the deviation is the combination of the summer break and that the reporting period went to 31st August, which basically means that the real workload for this task had not started yet
- **NUN** started some work before than foreseen and advanced some of the tasks. On the other side they have done some initial extra effort to trigger the project correctly and finally they have done a previous analysis on NUNSYS MLPredictive platform.
- **BUD.** Although the work needed so far was done in WP1, the time needed was not so much due to internal tasks that had been already made for company business. Regarding WP8, they are not experienced in European Projects and starting with the project has meant more time than initially foreseen.

  The tables below show the different figures referred to the human resources used per WP, per partner and WP and the deviations (if any) already explained in the paragraphs above.

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Table 3 Use of personnel resources and its deviations per WP

	Description	Start	End	GA p/m	Executed 31/08/2024	Planned 31/08/2024	Difference in %
WP1	Project Requirements Management, Reference Architecture & Pilot Analysis	1	18	**61,5**	41,2	52,4	-21,2 %
WP2	Supply Chain Disruption Risk Detection & Diagnostic Framework	7	30	**69,0**	3,0	3,0	0 %
WP3	Data Contextualization, Interoperability, and SMN Knowledge Model	7	33	**86,0**	5,2	4,7	9,4 %
WP4	The Intelligent Manufacturing Custodian & the Trustworthy AI-driven Platform	7	33	**156,5**	9,2	7,8	18,4 %
WP5	Pilot Analysis, Experimentation & Validation	7	36	**142,0**	2,1	3,2	-34,7 %
WP6	Intelligent Manufacturing Custodian & AI Platform Implementation & Assessment	13	36	**56,0**	0,1	0,0	100%
WP7	Dissemination, Communication, Exploitation & Impact	1	36	**89,5**	12,7	13,0	-2,5 %
WP8	Project Coordination & Quality Assurance	1	36	**47,5**	15,1	15,2	-0,9%
				708,0	**88,6**	99,3	-10,8 %

Table 4 % of the deviations of personnel resources per partner and WP

	P1 AID	P2 SERV	P3 FhG	P4 INSAL	AP BUL	P5 SAG	P6 F6S	P7 SYN	P8 MED	P9 DHL	P10 NUN	P11 BUD	P4.1 INSAV	total proj
WP1	3%	7%	4%	-74%	-76%	23%	-52,0%	-9%	16%	-4%	8%	-51%		**-21,2%**
WP2	-5%	-11%	8%	5%	1%				-5%					**0,5%**
WP3	0%	10%		11%					-1%		27%			**9,4%**
WP4	-4%	-60%		27%		-5%			12%	8%	13%			**18,4%**
WP5	-77%			-4%			-5%		1%	-17%	26%			**-34,7%**
WP6				100%										**100%**
WP7	-11%	-15%	2%	-53%	0%	-28%	3,5%	3%	-7%	-14%	27%	-3%		**-2,5%**
WP8	-11%	-7%	-32%		-64%	184%	104,0%	11%	12%	4%	32%	24%	-96%	**-0,9%**
TOTAL	**-8%**	**-1%**	**3%**	**-11%**	**-64%**	**14%**	**-0,3%**	**1%**	**9%**	**-4%**	**13%**	**-37%**	**-96%**	**-10,8%**

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Table 5 User of personnel resources and its deviations per partner and WP

Total	P1 AIDIMME			P2 SERVTECH			P3 FhG			P4 INSA LYON			AP BRUNEL UNIV.			P5 SAG		
	P0	PLAN	%	P0	PLAN	%	P0	PLAN	%	P0	PLAN	%	P0	PLAN	%	P0	PLAN	%
WP1	10,4	10,1	3%	5,3	5,0	7%	7,2	6,9	4%	0,8	3,0	-74%	0,7	3,0	-76%	4,6	3,7	23%
WP2	0,2	0,3	-5%	0,1	0,2	-11%	0,6	0,5	8%	0,5	0,5	5%	0,6	0,6	1%	0,5	0,5	
WP3	0,2	0,2	0%	3,3	3,0	10%				0,4	0,3	11%						
WP4	0,1	0,1	-4%	0,1	0,2	-60%				6,0	4,8	27%				0,5	0,5	-5%
WP5	0,3	1,4	-77%							0,1	0,1	-4%						
WP6										0,1		100%						
WP7	0,5	0,6	-11%	1,2	1,4	-15%	0,3	0,3	2%	0,1	0,2	-53%	0,0	0,0	0%	1,0	1,4	-28%
WP8	3,9	4,4	-11%	5,3	5,8	-7%	0,2	0,3	-32%				0,1	0,3	-64%	0,7	0,3	184%
TOTAL	**15,6**	**17,0**	**-8%**	**15,4**	**15,4**	**-1%**	**8,3**	**8,0**	**3%**	**7,9**	**8,8**	**-11%**	**1,5**	**4,0**	**-64%**	**7,2**	**6,3**	**14%**

Total	P6 F6S			P7 SYNESIS			P8 MED			P9 DHL			P10 NUNSYS			P11 BUDATEC			P4.1 INSA VALOR		
	P0	PLAN	%	P0	PLAN	%	P0	PLAN	%	P0	PLAN	%	P0	PLAN	%	P0	PLAN	%	P0	PLAN	%
WP1	0,5	1,0	-52%	2,7	3,0	-9%	4,1	3,5	16%	5,8	6,0	-4%	5,6	5,2	8%	1,0	2,0	-51%			
WP2							0,5	0,5	-5%												
WP3							0,1	0,1	-1%				1,2	0,9	27%						
WP4							0,1	0,1	12%	0,1	0,1	8%	2,4	2,1	13%						
WP5	0,2	0,2	-5%				1,1	1,1	1%	0,2	0,2	-17%	0,2	0,1	26%						
WP6																					
WP7	7,5	7,2	3%	0,2	0,2	3%	0,6	0,6	-7%	0,3	0,4	-14%	0,7	0,6	27%	0,3	0,4	-3%			
WP8	0,5	0,3	104%	3,3	3,0	11%	0,1	0,1	12%	0,3	0,3	4%	0,3	0,3	32%	0,3	0,3	24%	0,0	0,3	-96%
TOTAL	**8,7**	**8,7**	**0%**	**6,2**	**6,2**	**1%**	**6,6**	**6,0**	**9%**	**6,6**	**6,9**	**-4%**	**10,3**	**9,1**	**13%**	**1,6**	**2,6**	**-37%**	**0,0**	**0,3**	**-96%**

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