Technologies for Manufacturing as a Service Ecosystems

Deliverable 2.3

Governance Framework v1

WP2: Reference framework, specifications and core enablers

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Executive Summary

This deliverable introduces the initial version of the **Governance Framework** for Tec4MaaSEs project, developed to support sustainable and circular value networks.

The framework is built on top of four main pillars:

- The business agreements performed in the context of a Manufacturing as a Service (MaaS) model (realized through reference negotiation flows).
- The data governance aspects (in line with the data spaces) for the information shared among consumer and providers.
- AI models governance about explainability of the models and services performed through the marketplace.
- A reference sustainability model with a set of Key Performance Indicators (KPIs), their identification process and correlations to support the sustainability assessment. The KPIs are categorized into four areas: **Environmental**, **Social**, **Governance**, and **Economic & Growth**, providing a structured tool for performance evaluation.

The document also presents how this framework has been deployed in the three pilot value networks.

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Acronyms and Abbreviations

Acronym	Description
AI	Artificial Intelligence
DGA	Data Governance Act
DGF	Data Governance Framework
DoA	Description of Action
DoC	Depends on the Case
DT	Digital Twin
DUC	Data Usage Control
ESG	Environmental Social Governance
FAIR	Findable, Accessible, Interoperable, Re-usable
GDPR	General Data Protection Regulation
IDSA	International Data Spaces Association
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
MaaS	Manufacturing as a Service
RAM	Reference Architecture Model
RFQ	Request for Quotation
SBSC	Sustainability Balanced Scorecard
SCOR	Supply Chain Operations Reference
T4M	Tec4MaaSEs
VN	Value Network
WEEE	Waste Electrical and Electronic Equipment
WP	Work Package

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1 Introduction

1.1 Purpose and Scope

This report provides an overview of the Tec4MaaSEs governance framework and its integration to support sustainable and circular value networks (VNs).

The deliverable explains the framework's objectives, its alignment with pilot use cases, and its approach to business, data, and AI governance, including compliance with FAIR (Findable, Accessible, Interoperable, Re-usable) principles and human-in-the-loop AI processes. It also details the development of Key Performance Indicators (KPIs) using cause-and-effect analysis to link performance, quality, and circular strategies. This first version provides a foundation for further refinement and use in the project pilots.

1.2 Relation with other deliverables

The document will be updated and further expanded in D2.4 Governance framework v2, due in Month 24. The report is a result of the requirements collection process from WP2. More particularly, it has obtained critical information from D2.1 Reference cases and actionable models for reconfigurable value networks and service decomposition v1 regarding the process flows within the value networks of Tec4MaaSEs use cases.

Also, this deliverable (and the refined version) will be used for the development of the governance services in WP3 and sustainability scorecard in WP4.

1.3 Structure of the document

The document is structured as follows:

- **Section 2** introduces the governance framework.
- **Section 3** describes the structure of the sustainability framework and its role in achieving the project's goals.
- **Section 4** provides a detailed overview of the identified KPIs, the anticipated models for this framework, and its potential scalability.
- **Section 5** introduces the the pilot deployments, covering negotiation flows, data governance, AI model governance, and the sustainability framework for value network.

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2 Tec4MaaSEs Governance Framework

2.1 Overall

The Tec4MaaSEs governance framework consist of the following main pillars [10]:

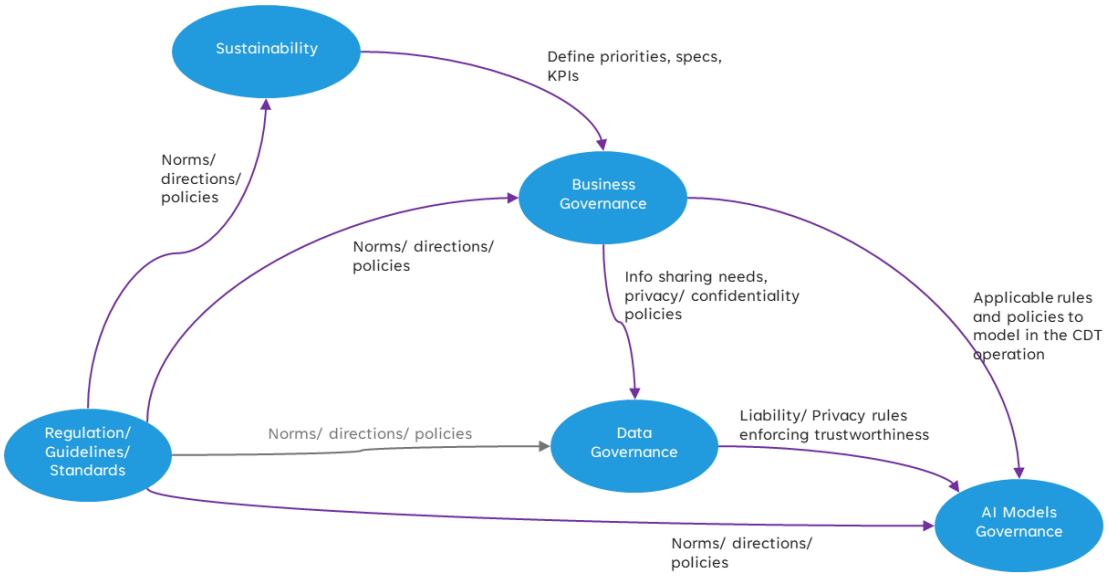

Figure 1: Basic governance framework pillars and their interactions [10]

- *Business where all negotiations and agreement activities are performed in the context of a* Manufacturing-as-a-Service (MaaS) together with agreements on the information to be shared and processed.
- *Data Governance, with regards to* (i) the definition of Data inputs/ processing and outputs per individual Digital twin (DT), enforcing data access and governance principles based on the IDSA and data spaces specifications.
- *AI models governance* addressing how AI (cognitive) models used in T4M ensure trustworthiness and in line with ethics principles.
- *A holistic sustainability framework with KPIs and inter-relations to assist organizations monitoring their MaaS operations.*
- *Applicable regulations and standards to be considered in all the above.*

2.2 Business Governance

Business governance has to do with the necessary actions to achieve an agreement between two or more organizations for a particular value network (VN). This is mainly related to a reference process from posting a resource into the marketplace, how this is communicated to the involved organizations and how the negotiation/ agreement process is operating. During the negotiation both consumers and providers can agree on different aspects such as:

- More detailed specifications of the resource to be servitized (e.g. in the case of AIBEL detailed specifications can be exchanged and modified until an agreement is reached).
- Other supporting document (e.g. RFQ, Order documents, etc.)
- Agreement on the terms of collaboration including also NDAs and other relevant clauses.

- Agreement on the information to be shared (which will be then realized in the data governance)

Tec4MaaSES – based on the pilot needs – elaborated on the particularities of such framework and create generalized and replicable flows which can be used or adapted in any Manufacturing as a Service (MaaS) process. Section 5.1 presents the generic flows and how those are adapted per pilot case in the project.

2.3 Data Governance

Data governance refers to the overall management and control of an organization's data assets, ensuring that data is accurate, accessible, secure, and used responsibly throughout its lifecycle, while a **data governance framework (DGF)** provides the structural foundation for defining how data governance should be carried out.

2.3.1 Data governance in data spaces

Data spaces are collaborative ecosystems where multiple organizations share and exchange data while retaining control over their own data assets. In these environments, data governance becomes particularly challenging due to the decentralized nature of data, the involvement of diverse stakeholders, and the wide range of legal, technical, and organizational requirements.

Data governance principles in data spaces are designed to build trust, encourage collaboration, and maintain control, while addressing the challenges of decentralized ecosystems. They ensure secure and seamless data sharing among stakeholders, supporting transparency, interoperability, and fairness. These principles help participants collaborate and create value from data while protecting their interests. They can be summarized as follows:

- **Decentralized Governance**: Governance in data spaces is shared among participants, promoting collaboration and inclusivity. This decentralized structure balances collective rules with individual autonomy, empowering stakeholders and fostering ownership.
- **Data Sovereignty**: Data sovereignty is central to data spaces, ensuring participants maintain full control over their data. They decide how, when, and who can use it, preserving their autonomy. Clear usage policies and agreements define rights, responsibilities, and protect sensitive information while aligning data sharing with everyone’s interests.
- **Transparency and Accountability**: Data spaces rely on transparency to build trust. Each data transaction is tracked, showing what data was shared, who accessed it, and why. Accountability mechanisms ensure compliance with policies and help resolve disputes.
- **Data Security and Privacy**: Data spaces prioritize strong security and privacy protections. Safeguards prevent unauthorized access, while technologies like anonymization and encryption protect sensitive data. Compliance with regulations, such as GDPR, ensures responsible handling of personal data.
- **Fair Value Exchange**: A fair value exchange ensures all participants benefit equally from data sharing. Transparent mechanisms assess the value of data and its services, enabling fair monetization and compensation for all parties.
- **Interoperability** in data spaces ensures seamless integration by using standardized data models, protocols, and technologies. It connects diverse systems across domains and regions, aligning legal and technical frameworks for a unified, collaborative ecosystem.

Data has become an asset that can be used and reused in various scenarios, generating different levels of business value based on factors like context, availability, and accuracy. The governance framework aims to help stakeholders understand potential relationships and the underlying business models by providing clear rules and policies for data sharing and usage. A robust **DGF in dataspaces** must ensure that data is handled properly by all

participants in the data space, addressing challenges such as data sovereignty, transparency, accountability, and fair value exchange.

Data spaces involve multiple stakeholders, each with distinct roles and responsibilities. The key roles are:

- **Data Owner**: The data owner has authority over how their data is used by others. When data is shared with third parties, it includes terms and conditions and **data usage policies**, specifying rights and obligations. data owners can share data for free (e.g., open data for innovation) or for a fee, depending on their business model.
- **Data Acquirer or Provider**: A data provider collects, preprocesses, and supplies data to others on behalf of a data owner. Data providers enable trustworthy data services by offering technical means for **data exchange**.
- **Data Processor or Consumer**: A data processor utilizes specific data to develop new services for the market, which can range from domain-specific solutions to cross-domain applications.
- **Data Marketplace Operator**: A data marketplace operator facilitates data exchange by providing infrastructure and governance. They govern the marketplace by setting terms and conditions and enforce compliance with data usage policies, such as limitations on usage time, frequency, or application fields.

Figure 2 highlights the flow of data among data space stakeholders, ensuring seamless and governed data exchange.

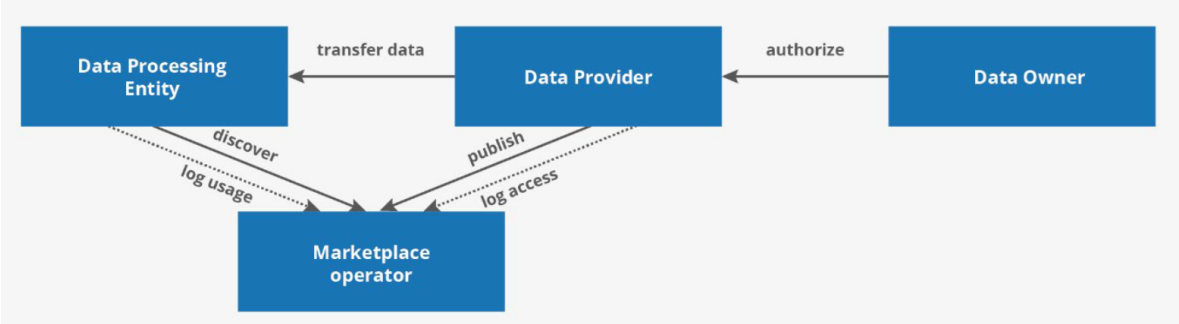

Figure 2: Flows among data space stakeholders

2.3.2 Data Governance in a MaaS ecosystem

Data governance is crucial in a MaaS data space because it ensures trust, efficiency, and value creation in an ecosystem where participants share sensitive and valuable industrial data. It ensures secure, compliant, and efficient data exchange, empowering collaborative manufacturing while protecting stakeholders' interests.

- **Decentralized Governance**: Decentralized governance in a MaaS data space is essential to foster negotiation and collaboration among diverse stakeholders while maintaining autonomy and trust.
- **Data Sovereignty**: Manufacturers and service providers must retain control over their proprietary data, including production specifications, designs, and operational information. A robust data governance framework ensures participants decide how, when, and by whom their data can be accessed or used.
- **Transparency and Accountability:** Trust is the backbone of MaaS data spaces. Data Governance provides clear policies and accountability mechanisms that assure participants their data will be used responsibly and according to agreed terms, encouraging broader participation.
- **Data Security and Privacy:** In MaaS ecosystems, multiple stakeholders exchange data to optimize manufacturing processes. Industrial data often involves sensitive information subject to legal and regulatory constraints, such as intellectual property protection and trade compliance. Governance

ensures adherence to regional and international standards like GDPR, ISO/IEC norms, or industry-specific regulations, as well as secure data sharing, protecting participants from unauthorized access or misuse while fostering collaboration.

- **Fair Value Exchange:** Data in MaaS ecosystems have significant economic value, whether shared for operational efficiency or monetized through services. Governance ensures transparency and fairness in usage agreements fostering trust and equity among participants.
- **Interoperability** MaaS data spaces involve diverse systems, platforms, and devices. Governance provides a framework for interoperability, enabling smooth data integration and exchange while ensuring compatibility across stakeholders' technical infrastructures.

In a MaaS Data Space, diverse stakeholders collaborate to enable efficient and scalable manufacturing processes. The key stakeholders are the MaaS Consumer, MaaS Provider, and Platform Provider (Tec4MaaSEs):

1. **MaaS Consumer**: A MaaS Consumer is an organization that needs manufacturing services to produce goods or parts. They define requirements like product specifications, production volumes, timelines, and quality standards, and may provide design files and forecasts. Consumers rely on MaaS Providers to fulfil their manufacturing needs.
2. **MaaS Provider**: A MaaS Provider offers manufacturing services and resources to consumers. They provide production capabilities, expertise, and on-demand services, including access to machinery, specialized labor, production facilities, and technology solutions. Providers offer flexible and scalable manufacturing services to meet consumer demands.
3. **Platform Provider**: A Platform Provider operates the digital platform (marketplace) and supporting tools that connects MaaS Consumers and MaaS Providers. The platform facilitates service exchanges and data sharing by providing the necessary infrastructure, tools, and services. The platform provider establishes a governance framework and enforces governance rules, ensuring data protection, security, and compliance with legal standards, and ensuring that all participants adhere to agreements and terms of service.

MaaS Consumers, MaaS Providers, and Platform Providers interact with data in various ways, acting as both data consumers and data providers depending on the situation as summarized in the table below.

Table 1: Data exchange in MaaS data spaces

Stakeholder	Data Provider	Data Consumer
MaaS Consumer	Provides product feedback, operational data, and design specifications, etc.	Consumes data for decision-making.
MaaS Provider	Provides technical and operational data, such as capabilities, production status updates, and resource availability.	Consumes data to offer manufacturing services and optimize production processes.
Platform Provider	Provides service metrics, transaction data, and platform analytics.	Consumes data to provide and improve services (e.g. decomposition, optimization, composition and matchmaking), and ensure compliance.

2.3.3 Tec4MaaSEs Data Governance Framework

The Data Governance Act (DGA) [5], which is a key pillar of the European strategy for data [4], seeks to increase trust in data sharing, strengthen mechanisms to increase data availability and overcome technical obstacles to the reuse of data. The DGA has been applicable since September 2023 and recommends having a domain governance authority for each data space.

This section explains the method for creating the DGF for the Tec4MaaSEs data space aiming to be a trustworthy, collaborative, decentralized, open, standardized and secure data ecosystem supporting MaaS.

The method is based in four main layers, where each higher layer flows into the ones below, and the lower layers align with those above (see Figure 3).

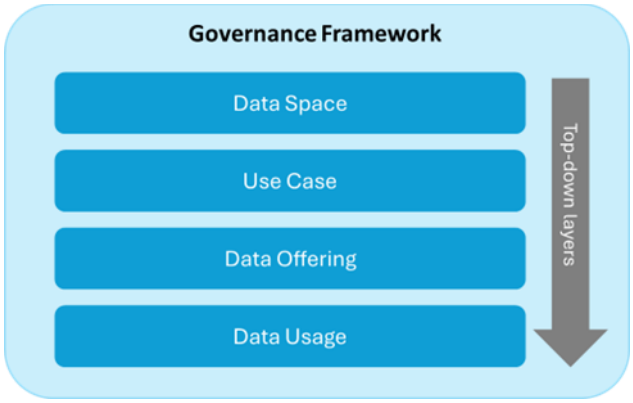

Figure 3: Main layers underpinning T4M Data Governance Framework

Data Space Layer

At this level, the governance framework is defined by outlining basic principles of the data ecosystem. Compliance is mandatory for all participants in the Tec4MaaSEs Data Space. The foundations for operation and participation in the data space are established through the identification of fundamental principles and the operating model.

Fundamental principles

The fundamental principles define the core values of the data ecosystem, providing clear guidelines for developing lower-level specifications and setting the scope and boundaries of technical standards. Below is a preliminary list, which will be refined and updated as necessary during the final version of this document (i.e., D2.4).

- **Compliance with IDSA and Gaia-X:** The principles and values of the International Data Spaces Association (IDSA) and Gaia-X serve as the foundation for implementing the Tec4MaaSEs Data Space and facilitating decentralized data exchange transactions within it.
- **Data Sovereignty:** The Tec4MaaSEs Data Space is designed to support a MaaS ecosystem, connecting manufacturing service providers and consumers while enabling cooperation across enterprise boundaries. All participants shall have equal access and sovereign control over their data, ensuring that the services they offer, or use remain open, fair, and free from discrimination.
- **Freedom of Contract:** Participants shall have the freedom to enter contracts within the Tec4MaaSEs Data Space, in accordance with the Governance Framework.

- **Registration and Certification**: Each participant commits to the Governance Framework by registering with the Tec4MaaSEs Data Space. Certified credentials will be required for accessing Tec4MaaSEs services (i.e., T4M credentials).

The agreement between Tec4MaaSEs and participants (e.g., data providers and data consumers) is established during onboarding.

Operating model.

The operating model outlines the governance framework to facilitate decentralized data exchange transactions and is based on the concepts and values of the International Data Space Association (IDSA) and Gaia-X. The operating model describes the onboarding. It provides an overview of the onboarding process to the Tec4MaaSEs Data Space (i.e., what to do to be granted access as a Data Provider or Data Consumer).

Access and usage policies are central to data spaces and rely on accurately identifying and verifying participants in the data space. As a result, identity and attestation management is crucial for ensuring the authenticity of individuals and enforcing policies based on verified identities, often aligned with each participant's role. A strong identity management system ensures that only authorized individuals can access the data space, supporting consistent policy enforcement.

The onboarding process for an organization to become a Data Provider or Data Consumer in the Tec4MaaSEs Data Space follows a structured approach to ensure compliance with the principles and standards set by key frameworks, including IDSA, GAIA-X, and T4M data space-specific guidelines. This process is being developed as part of the task and will be documented in the next iteration of the deliverable (i.e., D2.4).

Use Case layer

At this level, the basic requirements for data usage at use case level are outlined. Each Participant must agree to these basic principles to effect data exchanges through a registered Data Space Connector complaint with the latest Data Space Protocol Specification [3] (i.e.,2024-1).

A Data Usage Control (DUC) policy defines which actions a data consumer can or cannot perform on a data asset. This includes granting or prohibiting various operations, such as displaying, printing, or calculating data. A policy may allow a general action, like reading the data, but restrict specific actions, such as printing it.

In the IDSA context, DUC technologies use a "whitelisting" approach, where access to non-public data is restricted by default. Based on requirements from specific use cases, various restrictions may apply, such as limiting data use to a specific time or location. These restrictions are categorized into 21 atomic templates called policy classes [7], detailed in Appendix A: IDSA Usage Control Policy Templates. A DUC policy combines one or more of these policy classes to govern access to a specific data asset. Additionally, these policy classes may evolve over time to meet the needs of stakeholders and adapt to changing rules and regulations.

Participants are required to confirm compliance with the policies to participate in a specific use case.

Data Offering layer

At this level, participants configure specific data offerings, which are datasets (e.g., specifications, capability or capacity data) made available for sharing or use within the Tec4MaaSEs ecosystem. A data offering represents a package of data provided by an organization to other participants, under clearly defined terms and conditions, including usage rights. Data offerings are essential for fostering collaboration, allowing participants to securely share valuable information under controlled conditions.

Interoperability is crucial to ensure data offerings can be seamlessly integrated and utilized across the broader ecosystem. To achieve this, data offerings should adhere to established domain vocabularies.

Data Usage layer

At this level, negotiations of data usage contracts between participants for specific data offerings occur through the Data Space Connector, as results of this negotiation phase agreement policies are defined. This occurs during the data space operation.

Data space and use case layers are common to all the participants, while the data offering depending on the needs and interest of each participant.

The DGF will be implemented as part of Task 3.5 (Data spaces and data governance services). This implementation will be based on the IDSA Reference Architecture Model (IDSA-RAM) [8], which provides a structured foundation to establish and execute data governance within data spaces and will comply with the latest version of the Data Space Protocol Specification (i.e., 2024-1).

In summary, the data governance framework establishes the rules and policies necessary for managing, securing, and protecting data within a data space. Meanwhile, the IDSA-RAM and data space protocol provides the technical infrastructure to enforce these policies, facilitating secure, seamless, and compliant data exchange across decentralized systems. Together, they form the foundation for a trust-based, collaborative, and efficient data ecosystem.

2.4 AI Model Governance

In the **Tec4MaaSEs project**, AI model governance focuses on ensuring the ethical, transparent, and user-centric operation of AI models embedded in services supporting value networks. This framework emphasizes **explainability**, with clear descriptions of how AI decisions are made, alongside **human-in-the-loop processes** that allow users to provide feedback during or after model execution. This feedback mechanism supports continuous training and adaptation of AI models to evolving requirements, ensuring they remain trustworthy and aligned with ethical standards.

To enhance transparency, an **AI Model Passport** will be implemented, enabling users to access detailed information about AI services. This includes how models operate, the conditions under which they function, evaluation criteria, and compliance with applicable regulations, such as the EU AI Act. For example, users of a matching service will be able to review the criteria and processes that influenced recommendations or decisions. These features promote trust by ensuring that AI systems are explainable, and that data privacy and security are upheld throughout their use. The main information included in an AI passport could be (see Figure 4):

- **Maintenance and history**: versioning, information about changes, etc.
- **Data structure**: which data has been used to develop, train and update the AI model?
- **Model structure**: information related on how the model works: inputs, process used, and outputs generated alongside with basic assumptions.
- **Evaluation info**: how the AI model has been evaluated against robustness, performance, etc.
- **Compliance declarations**: for e.g. compliance with EU AI Act.
- **Usage requirements**: how can this model be used? What is the user journey?

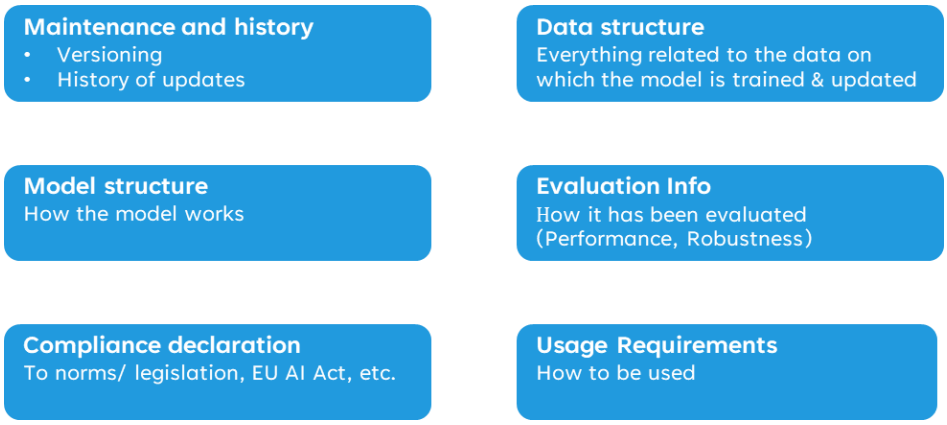

Figure 4: AI models passport – basic elements

The basic usage scenario of an AI passport is:

- The AI service provider will have the necessary functionality to create an AI passport and assign it to the particular service available to the end user.
- The User has any time information about how a particular AI service works.
- The user can also **give feedback** on the use and this AI model by either filling in a questionnaire and/or answering specific questions. This feedback form will be structured by the model provider and will be available to the end users any time in the Tec4MaaSEs UI. The results of the AI passport will be aggregated and available to the model's provider for further use and improvements.

3 Tec4MaaSEs Sustainability Framework

The Tec4MaaSEs Sustainability Framework integrates key concepts and KPIs from established frameworks to create a comprehensive and up-to-date system. While the ESG framework primarily focuses on environmental, social, and governance aspects, it excludes financial and growth perspectives. However, the Tec4MaaSEs project aims to achieve measurable improvements in circularity, sustainability, and resilience across value networks. To meet these objectives, the framework expands on ESG by incorporating financial and growth dimensions, forming an integrated system built on two pillars: a) the Sustainability Framework, encompassing ESG plus financial and growth perspectives, and b) the Governance KPIs.

The framework allows for continuous refinement, with pilot partners actively contributing to its development by suggesting additional KPIs relevant to their specific processes and industrial domains. This collaborative approach enhances the framework's adaptability, ensuring it can address a wide range of product and process requirements effectively. The structure of the Tec4MaaSEs Sustainability Framework is represented as follows:

Figure 5: Tec4MaaSEs Sustainability Framework Structure [13]

The framework retains the clarity and structure of the ESG model, dividing KPIs into Environmental, Social, and Governance categories. Additionally, the Economy & Growth layer provides a broader business perspective, encompassing financial considerations and the entire value network. Opportunity-driven KPIs have also been integrated within each vertical domain to reflect potential advancements.

To maintain clarity, the framework organizes KPIs into clusters such as "Product Assessment" and "Growth Perspective". This clustering approach ensures ease of navigation, even as the number of indicators grows. Pilot partners are encouraged to further expand the list by adding KPIs tailored to their specific industrial domains, ensuring flexibility for end users. This design allows stakeholders to select and analyse the most relevant indicators for their unique needs while preserving clarity through the structured clustering system.

The different KPIs included in the Tec4MaaSEs Sustainability Framework are detailed further in the following section of this document.

4 Key Performance Indicators

Key Performance Indicators (KPIs) play a vital role in Tec4MaaSEs, especially in developing the Sustainability Balanced Scorecards (SBSC) and linking different categories of indicators. The project uses a clear approach to define KPIs, based on the Governance Framework and Sustainability Framework, to create a unified performance assessment system.

The SBSC covers four main areas: environment, society, governance, and economy & growth, with a set of indicators that can be easily adapted and expanded for different industrial value networks. These KPIs are designed using a cause-and-effect model to show how actions lead to results, allowing the Tec4MaaSEs project to be replicable and scalable across various industries, supporting continuous improvements in sustainability.

4.1 Methodology for KPIs Identification

The Tec4MaaSEs approach, combines top-down and bottom-up methods, to develop a framework for assessing sustainability and circularity in MaaS systems. A key part of this approach is the creation of a flexible Balanced Scorecard Framework that addresses both general and pilot-specific needs. To achieve this, a generic list of adaptable KPIs was designed to fit various industrial value networks. From this foundation, tailored KPI lists were created for each pilot, integrating indicators from the generic list with specific KPIs outlined in the Description of Action (DoA).

The generic list of KPIs was developed based on established frameworks like ESG (Environmental, Social, Governance) and SCOR (Supply Chain Operations Reference), aligning with the sustainability framework described in Section 3. The goal was to equip pilot organizations with the ability to measure critical aspects of sustainability, such as environmental, social, governance, economic and growth factors and enable stakeholders to make well-informed decisions.

The initial list was based on the previous work by the Plooto Sustainability Framework [13] that focuses on measuring performance across environmental, social, governance, and economic pillars in supply chains. This pool of KPIs was adopted for the context of a manufacturing as a service extending the existing work and deployed for the need of the value networks and further enhanced with pilot-specific KPIs introduced in the DoA and further investigated in Task 2.1, as detailed in deliverable D2.1. This integration ensured that the indicators were meaningful, practical, and fully aligned with the project's goals by addressing both general and specific requirements of the pilot organizations.

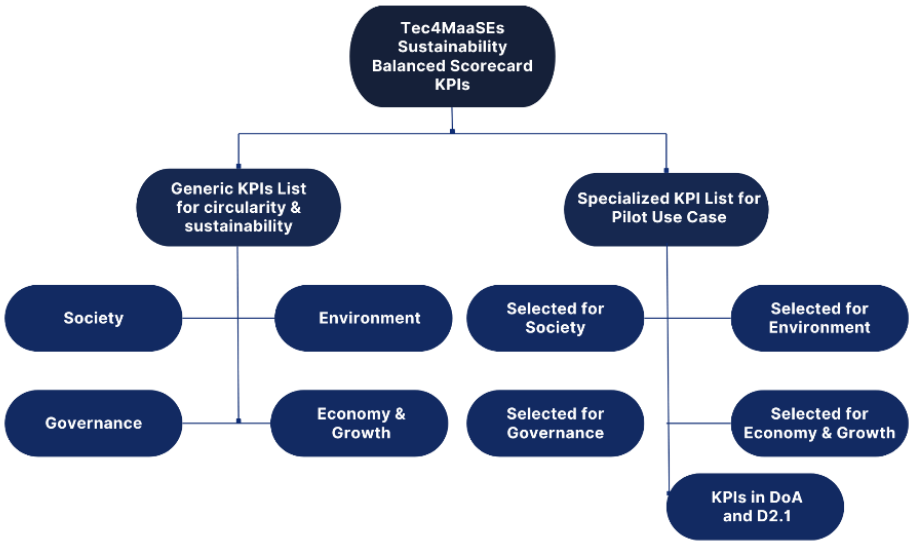

Figure 6: Tec4MaaSEs Sustainability & Governance KPIs [13]

4.2 Cause-and-effect Model and Scalability

Cause-and-effect analysis is a method used to identify the key factors that contribute to an outcome or event by understanding the relationships between causes and their effects. Specifically, it reveals how changes in one aspect of a system impact the broader network, making it possible to address challenges and enable better decision-making [15].

In the Tec4MaaSEs project, the cause-and-effect model is used to refine the KPIs that support the Sustainability and Governance Framework. By analyzing the value networks of each pilot, the model helps assess the impact of different resources and operational changes. This enables pilots to predict the effects of various decisions through probabilistic assessments, helping them make informed choices about which resources to acquire and the best strategies to implement. Ultimately, this approach allows pilots to optimize resource use, improve circularity, and enhance overall performance and sustainability outcomes.

4.3 Environmental KPIs

Aligned with the Tec4MaaSEs Sustainability Framework, the KPIs within the environmental pillar are categorized into various sub-groups, including carbon footprint, resources, pollution and waste, Life Cycle Assessment (LCA), as well as opportunities and innovation.

- **Carbon Footprint**: this category includes KPIs related to measuring greenhouse gas emissions, including carbon dioxide (CO_2) and methane (CH_4).
- **Resources**: this category includes indicators that reflect resource consumption throughout the value chain, such as energy use, water usage, fossil fuel depletion, and more.
- **Pollution and Waste**: the KPIs of this category address different types of waste, including electronic waste, scrap materials, and packaging waste, as well as indicators that reflect their management, such as the quantity of reused components utilized in manufacturing processes.
- **LCA**: the KPIs in this category are indicators used to assess the industry's Life Cycle, covering aspects not included in the resources and carbon footprint categories, such as land use.

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- **Opportunities and Innovation**: this KPI category includes indicators that evaluate the performance or adoption of greener technologies, sustainable building structures and management, as well as the use and management of sustainable energy sources.

Table 2: Environmental KPIs

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Carbon Dioxide (CO_2)	Amount of CO2 released from the activities across the supply chain	kg_{eq}	Carbon footprint	Sustainability
Methane (CH4)	Amount of CH_4 released from the activities across the supply chain	kg_{eq}	Carbon footprint	Sustainability
Water stress/ consumption	Amount of water consumed across the industrial processes	L	Resources	Sustainability
Amount of water reused	Amount of water reused across the industrial processes	L	Resources	Sustainability, Circularity
Amount of water treated	Amount of water treated before returning to the ecosystem	L	Resources	Sustainability, Circularity
Energy consumption	Amount of energy consumed across the supply chain	kWh	Resources	Sustainability
Renewable Energy	The percentage of total amount of energy sourced from renewable resources within a specific timeframe	%	Resources	Sustainability
Use of RES/RES integration	Amount of energy produced by RES	kWh	LCA/Resources	Sustainability, Resilience
Fossil fuels depletion	Amount fossil fuels reduction (or energy from RES) in consumed energy mix	kg or kWh	LCA/Resources	Sustainability, Resilience
Transportation processes	Consumptions related to the transportation/ logistics (i.e., energy)	DOC	Resources	Sustainability
Green logistics	Amount of emissions during logistics activities (warehousing and transportation)	kg	Resources	Sustainability, Resilience
Supply chain waste	Amount of generated waste	kg	Pollution and Waste	Circularity
Recycling rates	Amount of recycled waste	kg	Pollution and Waste	Circularity

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Use of biodegradable materials	Amount of biodegradable materials produced/used	kg	Pollution and Waste	Circularity
Packaging materials and waste	Amount of waste from packaging material	kg	Pollution and Waste	Sustainability
Waste from Electrical and Electronic Equipment (WEEE)	Amount of WEEE waste	kg	Pollution and Waste	Sustainability
Scrap Waste	Amount of scrap waste	kg	Pollution and Waste	Sustainability
Scrap Rate	The percentage of materials or products that are discarded during the manufacturing process due to defects	%	Pollution and Waste	Sustainability
Resource Utilization	Percentage of use of non-renewable resources across the supply chain	%	Resources	Sustainability, Resilience, Circularity
Consumption of virgin raw materials	Amount of virgin raw material consumed	kg	Resources	Sustainability, Resilience, Circularity
ISO22400 for traditional manufacturing	ISO Certification that the company/industry meets the certification standards	-	Opportunities and Innovation	Sustainability, Resilience, Transparency
ISO59020 for measuring and assessing circularity	ISO Certification that the company/industry meets the certification standards	-	Opportunities and Innovation	Circularity

4.4 Social KPIs

Following the Tec4MaaSEs Sustainability Framework, social performance KPIs are organized into four sub-categories: human capital, product assessment, stakeholders, and opportunities.

- **Human Capital**: this category encompasses KPIs related to health and safety, work management, employee training and development, labour standards, inclusion, and diversity.
- **Product Assessment**: this category includes KPIs that address various aspects of safety, such as chemical safety, financial product safety, product quality and safety, as well as data privacy and security.
- **Stakeholders**: this category focuses on KPIs associated with external stakeholders (e.g., suppliers and partner companies), including controversial sourcing and value chain accountability.
- **Opportunities**: KPIs in this category evaluate access to healthcare, financial services, opportunities in nutrition and health, and work-life balance.

Table 3: Social KPIs

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Health and Safety	Assessment health and safety conditions in the industrial company	Qualitative	Human Capital	Resilience
Diversity, Equity and Inclusion	Assessment of gender equity issues, inclusion and diversity in the industrial company (i.e., proportion of women/ men employees)	Qualitative	Human Capital	Transparency
Training and Staff development	Availability and implementation of training programs and staff development activities	Qualitative	Human Capital	Resilience
Chemical safety	The industrial company meets the standards for safety from chemical materials	Qualitative	Product Assessment	Resilience, Transparency
Product safety and quality	The industrial company meets the standards for product safety and quality	Qualitative	Product Assessment	Resilience, Transparency
Privacy and data security	The industrial company runs in compliance with the regulations for privacy and data security	Qualitative	Product Assessment	Transparency
Transparency within the Supply Chain	The level of transparency regarding the quality and origin of the materials, the processing, etc.	Qualitative	Product Assessment	Transparency
Controversial Sourcing	Origin of materials or products (involvement in harmful or unethical practices)	Qualitative	Stakeholders	Transparency, Traceability
Supply Chain Liability	The legal responsibility of the industrial company for actions or shortcomings across its supply chain	Qualitative	Stakeholders	Transparency, Traceability
Customer satisfaction	Level of satisfaction of costumers from the product use	Qualitative	Stakeholders	Resilience
Partners Engagement	Measures the organization's ability to keep partners and collaborate effectively	Qualitative	Stakeholders	Networking

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Employee satisfaction	Level of satisfaction of employees in the company	Qualitative	Human Capital	Resilience
Access to Health Care	Level of access of employees to medical services, treatment, and healthcare resources	Qualitative	Opportunities	Resilience
Access to Finance	Level of access to external funding (i.e., research funding programs, loans, etc.)	Qualitative	Opportunities	Economic Advantage, Sustainability
Work-Life Balance	Level of balance between professional responsibilities and personal time	Qualitative	Opportunities	Resilience

4.5 Governance KPIs

In line with the Tec4MaaSEs Governance Framework, governance KPIs are categorized into areas such as regulatory compliance, risk management, ethical business practices, board compensation, and other aspects representing corporate governance and corporate behavior [13]. Accordingly, the governance KPIs in Tec4MaaSEs are organized into the following categories:

- **Corporate Governance**: this category includes KPIs that reflect the rules and processes guiding a company's direction and management, such as its organizational structure, ownership, advisory board, and related elements.
- **Corporate Behavior**: This category encompasses KPIs that evaluate a company's ethical standards, core values, and social responsibility toward its customers, stakeholders, and the broader community.
- **Litigation Risks and Corruption:** this category focuses on KPIs that address a company's efforts to mitigate litigation risks and prevent corruption incidents [14].

Table 4: Governance KPIs

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Board diversity	Level of differentiation in backgrounds, skills and characteristics of an industrial company’s board of directors	Qualitative	Corporate Governance	Transparency
Anti-competitive practices	Number of practices that an industrial company follows to gain an advantage in the market (i.e., price fixing, bid rigging, market allocation, etc.)	Number of practices applied in a year	Corporate Behavior	Transparency

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Tax transparency	Frequency of openly disclosing information of the industries about tax payments and strategies	Number of sharing information in a year	Corporate Behavior	Transparency
Compliance Rate	The extent to which manufacturing processes adhere to industry standards and regulations	Qualitative	Corporate Behavior	Transparency
Business ethics	Number of practices for ensuring ethical principles i.e., environmental responsibility, product quality and safety	Number of practices applied in a year	Corporate Behavior	Transparency
Expenses and fines on litigation incidents	Expenses and fines on filings, lawsuits related to anti-competitive behavior, anti-trust and monopoly practices	€	Litigation Risks and Corruption	Transparency
Litigation risks payments	Payments for addressing litigation incidents	€	Litigation Risks and Corruption	Transparency
Percentage of revenues in regions with TI corruption	Percentage of revenues in regions with TI corruption below 0.6	%	Litigation Risks and Corruption	Transparency

4.6 Economy and Growth KPIs

The Economy and Growth pillar includes categories such as financial performance, customer orientation, and growth strategies.

- **Financial**: This category includes KPIs that assess the company's economic performance, such as market share, revenue growth, and circularity-specific metrics like net cost savings from circular activities.
- **Customer**: This category focuses on KPIs that reflect customers' impact on the company's economic performance, including metrics like customer retention, customer profitability, and others.
- **Growth perspective**: the KPIs of this category reflect the growth potential, with indicators such as revenue growth, employee retention, employee productivity, and more.

Table 5: Economy and Growth KPIs

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Market share	The percentage of sales of a product related to all sales of that product for a specific time period i.e., per month, and for a specific	Depends on the case/ available data, usually in € per	Finance	Economic advantage

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
	geographic area (i.e., at national level)	specific month, per specific area		
Asset utilization	How effectively the company uses its own assets to generate revenue	Qualitative	Finance	Economic advantage, Resilience
Net cost savings due to circular activities	Assessment of savings that come from circular activities (i.e., re-use of materials or secondary raw materials, treatment of water to enter the process, etc.)	€	Finance	Economic advantage, Circularity
Customer acquisition	Number of new incoming customers per year	-	Customer	Economic advantage
Customer retention	Perception of customers remaining or leaving, per year or specific period	% (±)	Customer	Resilience
Customer profitability	Assessment of net profit generated by individual customers	€	Customer	Economic advantage
Delivery reliability	The percentage of deliveries that did not meet the agreed terms (quantity, time, etc.)	%	Customer	Resilience
Customer defective product ratio	The percentage of defective products received by customers compared to the total number of products they receive	%	Customer	Resilience
Negotiation Time	Time spent in contact/negotiation activities with suppliers or customers, in relation to the whole order delivery	%	Growth perspective	Economic advantage
Employee retention[9]	Perception of employees remaining or leaving, per year or specific period	% (±)	Growth perspective	Resilience
Productivity growth	Percentage of increase in output/value generated per unit, for a specific time period	%	Growth perspective	Economic advantage, Resilience

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Revenue growth	Percentage of increase in revenues/sales generating income, for a specific time period	%	Growth perspective	Economic advantage
Compound Annual Growth	Annual growth rate of an investment over a specific period of time, longer that 1 year	%	Growth perspective	Economic advantage, Resilience
Marketing	Measures the effectiveness and scale of the company's marketing program, including the use of multiple channels, steady flow of campaigns, and effective messaging to key personas.	Customer Acquisition Cost (CAC) (USD)	Growth perspective	Economic advantage, Resilience

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5 Pilot Deployments

In this section we present the value network deployment configurations of the above framework.

5.1 Negotiation flows per Value Network

The following figures present the negotiation flows that are applicable to all pilots. These are relevant to all VNs wish some exceptions with regards to the availability of a resource decomposition tool (see Figure 7). In general, the negotiation and business agreement framework consist of three main phases:

- Phase 1: Resource modelling and publishing:
- Phase 2: Start negotiation:
- Phase 3: Negotiation finalization (agreement/rejection):

Phase 1: Resource modeling and publishing

This is the starting point where organizations model their resources as Digital Twins (DTs) and their existing value networks.

The process starts with the possibility of decomposing the manufacturing service. This is optional (depending on the case) and can be done through decomposition tools. In the case of VN1 there is no need for decomposition (as we have electronic board as a whole). In VN2 the mold can be decomposed through an internal tool (owned by the pilot organizations) and in VN3 this will be done through Aibel's interna systems and semantically enhanced through the IMF editor.

Then the consumer creates the AAS models of the resource through the factory level DT and such model is also retrieved in the supply chain DT to create the existing ecosystem (value network) which later will be instantiated for each potential provider.

The consumer can select through the marketplace to publish a new resource. Through this process, the consumer can select either to publish in an open way (public) or in more restricted by selecting specific potential providers through the marketplace organization registry. Another option is the organization to use the auto-matching functionality which will provide some potential providers based on the capabilities.

At this phase the consumer (where searching for a potential provider) can have access also to some organization KPIs (provided by the balanced scorecard) such as environmental indicators, etc. the Balanced scorecard gives this information also to the auto-matching service to be used in the selection process.

Once the resource is published and potential providers are selected, the consumer selects to publish the resource. The marketplace will then notify the potential providers about a new potential collaboration.

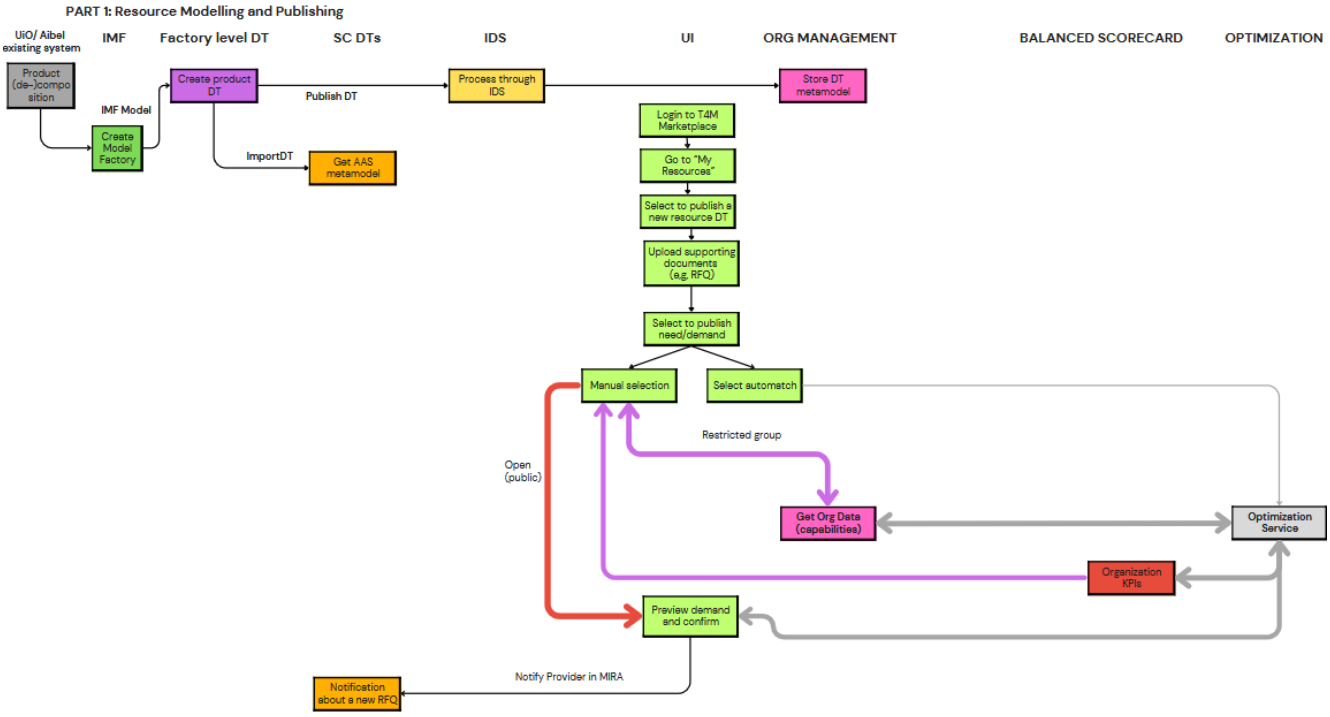

Figure 7: Negotiation flow: Phase 1: Resource modelling and publishing

Phase 2: Confirm interest and start negotiation

Upon receipt of the notification by the providers, the latter can select either to confirm their interest or not. If yes, then the negotiation process starts (phase 2a Figure 8). This process can have a straightforward negotiation and agreement or go through negotiation loops (phase 2b).

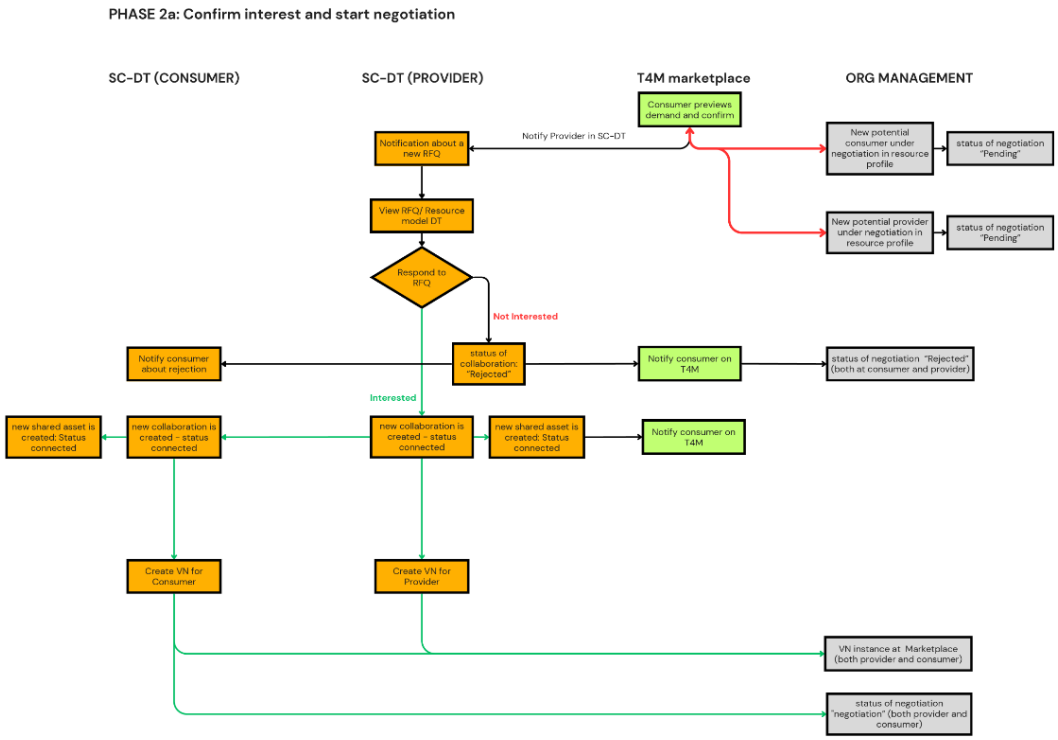

Figure 8: Negotiation flow: Phase 2a: Confirm interest and start negotiation

Negotiation loops have the form of requests and responses. This applies mainly in VN#3 where for Aibel case has different phases of negotiation exchanging also relevant information (documents, modified IMF models) in line with Aibel's procedure.

This can also apply to the other value networks in the case that an order's details can be negotiated (e.g. the delivery date, cost).

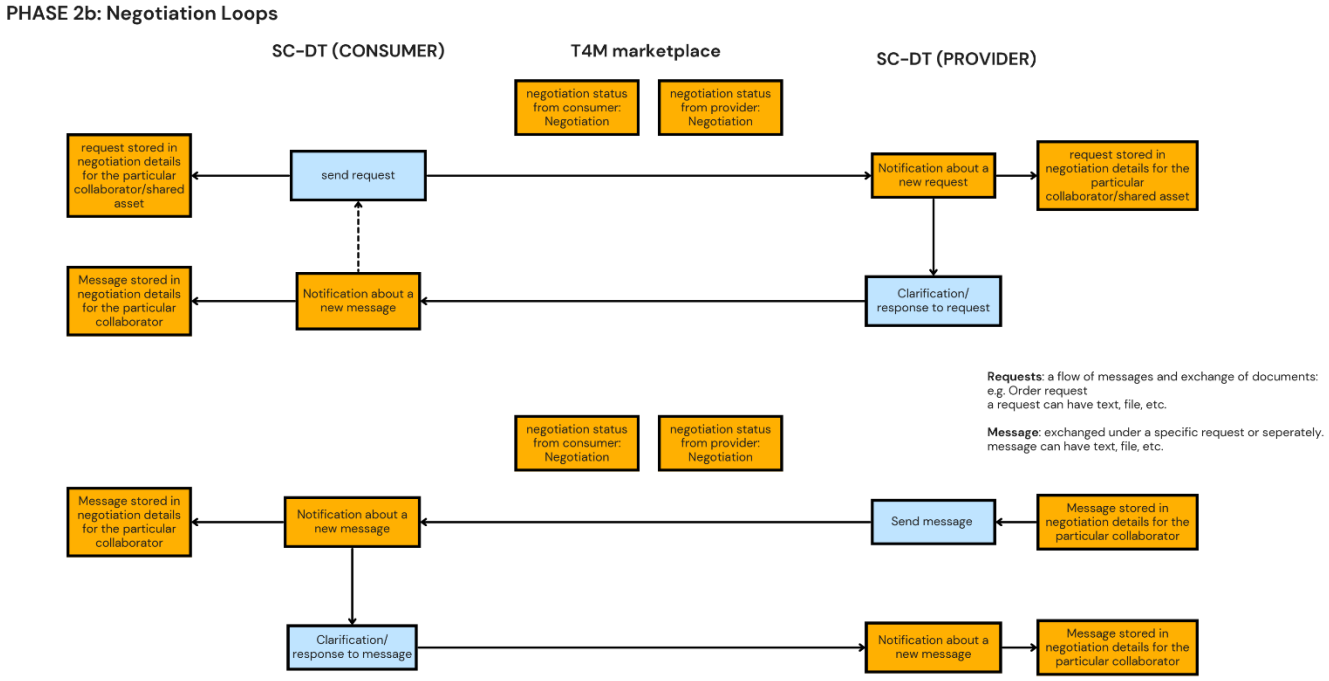

Figure 9: Negotiation flow: Phase 2b: Negotiation loops

Phase 3: Negotiation finalization (agreement/rejection)

At any time of the negotiation both the consumer and provider can accept or reject the process leading to its termination. The agreement is performed by the consumer while the rejection can be from both organizations.

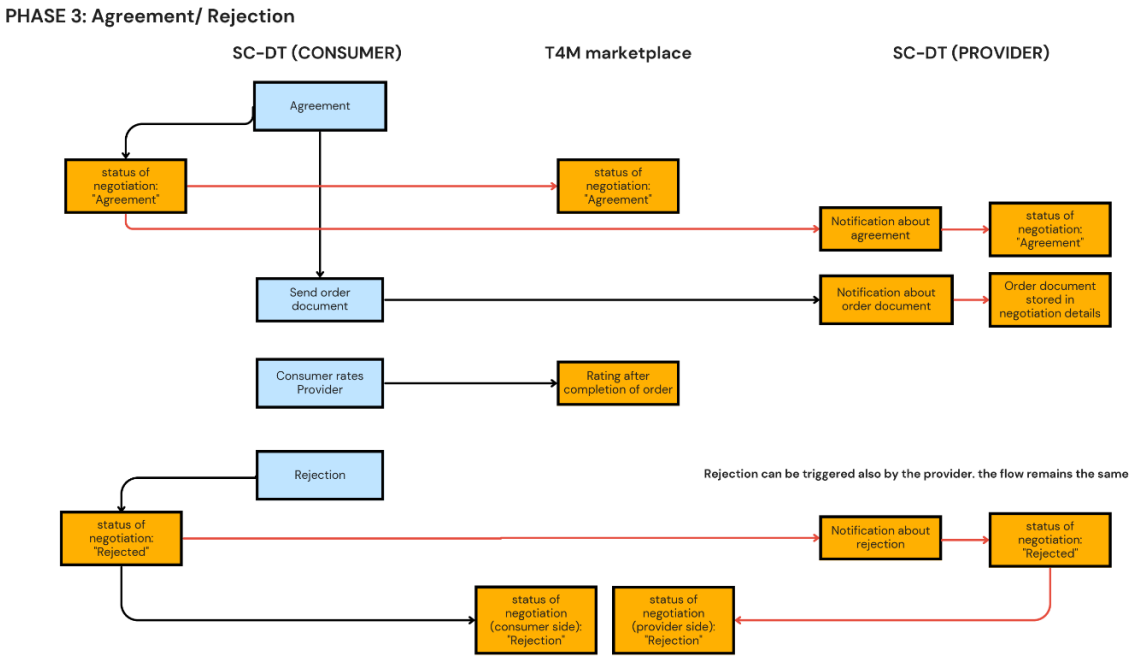

Figure 10: Negotiation flow: Phase 3: Agreement/Rejection

5.2 Data Governance per value network

T4M Data Space covers three different Manufacturing as a Service scenario represented by three value networks (i.e., Value Network 1, Value Network 2 and Value Network 3) which share sensitive and valuable industrial data as described in D2.1 (Reference cases and actionable models for reconfigurable value networks and service decomposition V1.).

- **Value Network 1 (VN1)**: VN1 focuses on the manufacturing and distribution of electronic boards (EBs) to produce white goods. This process involves interactions among (1) MaaS Consumers who place orders for EBs (represented by the Arctic Romania Washing Machine Factory -AR and Arcelik Bolu Cooking Appliances Factory - AB), and (2) MaaS Providers responsible for designing, developing, and supplying the EBs to the consumers for their final products 1 and 2, (represented by Arcelik Çerkezköy Electronic Factory - AC and Karel Electronics - KE).

- **Value Network 2 (VN2)**: VN2 represents a dynamic manufacturing ecosystem within the plastic injection moulding domain, where three companies collaborate by assuming flexible roles as both MaaS Consumers and MaaS Providers of manufacturing services. This ecosystem operates across three key service types: additive manufacturing (with or without finishing processes), machining, and plastic injection moulding. Each company's role is determined by the specific use case. For instance, Moldes URA will consume additive manufacturing services and can provide machining capabilities to others in the network. Similarly, ERREKA balances its role by consuming both additive manufacturing and machining services while offering plastic injection moulding services. Meanwhile, Tekniker serves primarily as a provider of additive manufacturing and machining services but may also consume machining services in particular situations. This collaborative framework fosters a flexible and interconnected manufacturing environment, enabling companies to adapt their roles based on evolving needs and opportunities within the ecosystem.

- **Value Network 3 (VN3)**: VN3 focuses on constructing facilities for the hydrogen market. AIBEL serves as the Engineering, Procurement, and Construction (EPC) contractor, responsible for designing, developing, and delivering the facility. In this role, AIBEL acts as the Maas Consumer, while the companies supplying the required equipment for the facility function as MaaS Providers.

Across all value networks, the information exchanged between participants may include sensitive details that must be carefully managed according to each participant's internal policies. In every case, establishing a Non-Disclosure Agreement (NDA) has been identified as essential to ensure the confidentiality of any information shared by the consumer during the provision of manufacturing services.

Section 2.3.3 outlines the Governance Framework for the T4M Data Space, designed to create a secure, decentralized, and collaborative ecosystem that enables "Manufacturing as a Service" with trust, openness, and standardization. All participants must follow the core principles and operating model, confirming compliance with the established policies to engage in each use case. Additionally, each participant must define their data offering (the specific data they provide) and set usage conditions by selecting appropriate policy classes from the IDSA Usage Control Policy Templates in Appendix A: IDSA Usage Control Policy Templates.

Table 6 provides a preliminary summary of the data to be shared within each value network, as described in D2.1.

Table 6: Preliminary data exchange per value network

Value Network	Maas Role	Data Shared
VN1	MaaS Providers Arcelik (ARC) and Karel	Share datasets detailing: • production capabilities (e.g., catalogue of electronic boards they can produce) • capacities, including machine availability (e.g., production planning) and raw material status (e.g., material usage history and inventory).
VN2	Maas Consumers Moldes URA (URA), ERREKA, and Tekniker depending on the specific case	Share datasets detailing: • manufacturing resources capabilities (e.g., machine specifications), • manufacturing resources capacity (e.g., availability and schedules), • manufacturing resources usage.
	Maas Providers Moldes URA (URA), ERREKA, and Tekniker depending on the specific case	Share datasets which may be subject to IPR considerations, including: • product specifications (e.g., CAD files, 2D drawings) • process parameters.

Value Network	Maas Role	Data Shared
VN3	Maas Consumers AIBEL	Share datasets including system information and technical requirements
	Maas Providers Potential provider	Share datasets including product information and system requirements

The data offering for each participant is currently being detailed, along with the applicability of usage policy templates for these datasets. The results will be presented in the revised version of this deliverable (i.e., D2.4).

5.3 AI models Governance per value network

This section will be elaborated in the second version of the Governance Framework, scheduled for Month 24. This future version will define the AI models for each value network and outline their associated governance strategies in greater depth.

5.4 Sustainability Framework per Value Network per Pilot

In this section, the Sustainability Framework is applied to each value network of the Tec4MaaSEs pilots. A generic list of adaptable and customizable KPIs, aligned with the pillars of environment, society, governance, and economy and growth, was previously developed as a foundation. Each pilot reviewed this list and selected the indicators most relevant to their value networks, incorporating pilot-specific KPIs from the DoA and Task 2.1.

The following tables present the selected KPIs, focusing on the tailored indicators chosen by each pilot to align with their organizational needs and sustainability goals. It is important to note that not all indicators will be used within the scope of the project. Each pilot will undergo a data coverage analysis to identify a representative set of KPIs and monitor data through the scorecard tool.

Additionally, the pilot-specific KPIs of each organization are demonstrated, showcasing both the baseline values and the outcomes achieved through Tec4MaaSEs' contributions.

Table 7: Selected KPIs – Value Network #1

KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model	Arcelik	Karel
Carbon Dioxide (CO2)	Environment	Amount of CO2 released from the activities across the supply chain	Kgeq	Carbon footprint	Sustainability	No	Yes
Energy consumption	Environment	Amount of energy consumed across the supply chain	kWh	Resources	Sustainability	Yes	Yes
Fossil fuels depletion	Environment	Amount fossil fuels reduction (or energy from RES) in consumed energy mix	kg or kWh	LCA/Resources	Sustainability, Resilience	Yes	No
Transportation processes	Environment	Consumptions related to the transportation/ logistics (i.e., energy)	DOC	Resources	Sustainability	Yes	Yes
Green logistics	Environment	Amount of emissions during logistics activities (warehousing and transportation)	kg	Resources	Sustainability, Resilience	Yes	Yes
Supply chain waste	Environment	Amount of generated waste	kg	Pollution and Waste	Circularity	Yes	Yes
Recycling rates	Environment	Amount of recycled waste	kg	Pollution and Waste	Circularity	Yes	No
Use of biodegradable materials	Environment	Amount of biodegradable materials produced/used	kg	Pollution and Waste	Circularity	Yes	No
Packaging materials and waste	Environment	Amount of waste from packaging material	kg	Pollution and Waste	Sustainability	Yes	Yes
Waste from Electrical and Electronic Equipment (WEEE)	Environment	Amount of WEEE waste	kg	Pollution and Waste	Sustainability	Yes	Yes
Scrap Waste	Environment	Amount of scrap waste	kg	Pollution and Waste	Sustainability	Yes	No
Scrap Rate	Environment	The percentage of materials or products that are discarded during the manufacturing process due to defects.	%	Pollution and Waste	Sustainability	Yes	No
Resource Utilization	Environment	Percentage of use of non-renewable resources across the supply chain	%	Resources	Sustainability, Resilience, Circularity	Yes	No
Consumption of virgin raw materials	Environment	Amount of virgin raw material consumed	kg	Resources	Sustainability, Resilience, Circularity	Yes	No
ISO22400 for traditional manufacturing	Environment	ISO Certification that the company/industry meets the certification standards	-	Opportunities and Innovation	Sustainability, Resilience, Transparency	Yes	Yes
ISO59020 for measuring and assessing circularity	Environment	ISO Certification that the company/industry meets the certification standards	-	Opportunities and Innovation	Circularity	Yes	Yes
Health and Safety	Society	Assessment health and safety conditions in the industrial company	Qualitative	Human Capital	Resilience	Yes	Yes

KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model	Arcelik	Karel
Diversity, Equity and Inclusion	Society	Assessment of gender equity issues, inclusion and diversity in the industrial company (i.e., proportion of women/ men employees)	Qualitative	Human Capital	Transparency	Yes	Yes
Training and Staff development	Society	Availability and implementation of training programs and staff development activities	Qualitative	Human Capital	Resilience	Yes	Yes
Chemical safety	Society	The industrial company meets the standards for safety from chemical materials	Qualitative	Product Assessment	Resilience, Transparency	Yes	Yes
Product safety and quality	Society	The industrial company meets the standards for product safety and quality	Qualitative	Product Assessment	Resilience, Traceability	Yes	Yes
Privacy and data security	Society	The industrial company runs in compliance with the regulations for privacy and data security	Qualitative	Product Assessment	Transparency	Yes	Yes
Transparency within the Supply Chain	Society	The level of transparency regarding the quality and origin of the materials, the processing, etc.	Qualitative	Product Assessment	Transparency	Yes	Yes
Controversial Sourcing	Society	Origin of materials or products (involvement in harmful or unethical practices)	Qualitative	Stakeholders	Transparency, Traceability	Yes	Yes
Supply Chain Liability	Society	The legal responsibility of the industrial company for actions or shortcomings across its supply chain	Qualitative	Stakeholders	Transparency, Traceability	Yes	Yes
Customer satisfaction	Society	Level of satisfaction of costumers from the product use	Qualitative	Stakeholders	Resilience	Yes	Yes
Partners Engagement	Society	Measures the organization's ability to keep partners and collaborate effectively	Qualitative	Stakeholders	Networking	Yes	Yes
Employee satisfaction	Society	Level of satisfaction of employees in the company	Qualitative	Human Capital	Resilience	Yes	Yes
Access to Health Care	Society	Level of access of employees to medical services, treatment, and healthcare resources	Qualitative	Opportunities	Resilience	Yes	Yes
Access to Finance	Society	Level of access to external funding (i.e., research funding programs, loans, etc.)	Qualitative	Opportunities	Economic Advantage, Sustainability	Yes	Yes

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KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model	Arcelik	Karel
Work-Life Balance	Society	Level of balance between professional responsibilities and personal time	Qualitative	Opportunities	Resilience	Yes	Yes
Board diversity	Governance	Level of differentiation in backgrounds, skills and characteristics of an industrial company's board of directors	Qualitative	Corporate Governance	Transparency	Yes	Yes
Anti-competitive practices	Governance	Number of practices that an industrial company follows to gain an advantage in the market (i.e., price fixing, bid rigging, market allocation, etc.)	No of practices applies in a year	Corporate Behavior	Transparency	Yes	Yes
Tax transparency	Governance	Frequency of openly disclosing information of the industries about tax payments and strategies	No of sharing information in a year	Corporate Behavior	Transparency	Yes	Yes
Compliance Rate	Governance	The extent to which manufacturing processes adhere to industry standards and regulations.	Qualitative	Corporate Behavior	Transparency	Yes	Yes
Business ethics	Governance	Number of practices for ensuring ethical principles i.e., environmental responsibility, product quality and safety	No of practices applies in a year	Corporate Behavior	Transparency	Yes	Yes
Expenses and fines on litigation incidents	Governance	Expenses and fines on filings, lawsuits related to anti-competitive. behaviour, anti-trust and monopoly practices	€	Litigation Risks and Corruption	Transparency	Yes	Yes
Litigation risks payments	Governance	Payments for addressing litigation incidents	€	Litigation Risks and Corruption	Transparency	Yes	Yes
Percentage of revenues in regions with TI corruption	Governance	Percentage of revenues in regions with TI corruption below 0.6	%	Litigation Risks and Corruption	Transparency	Yes	Yes
Market share	Economy & Growth	The percentage of sales of a product related to all sales of that product for a specific time period i.e., per month, and for a specific geographic area (i.e., at national level)	Depends on the case/ available data, usually in € per specific month, per specific area	Finance	Economic Advantage	Yes	Yes
Asset utilization	Economy & Growth	How effectively the company uses its own assets to generate revenue	Qualitative	Finance	Economic advantage, Resilience	Yes	Yes
Net cost savings due to circular activities	Economy & Growth	Assessment of savings that coming from circular activities	€	Finance	Economic advantage, Circularity	Yes	Yes

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KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model	Arcelik	Karel
		(i.e., re-use of materials or secondary raw materials, treatment of water to enter the process, etc.)					
Customer acquisition	Economy & Growth	Number of new incoming customers per year	-	Customer	Economic Advantage	Yes	Yes
Customer retention	Economy & Growth	Perception of customers remaining or leaving, per year or specific period	% (±)	Customer	Resilience	Yes	Yes
Customer profitability	Economy & Growth	Assessment of net profit generated by individual customers	€	Customer	Economic Advantage	Yes	Yes
Delivery reliability	Economy & Growth	The percentage of deliveries that did not meet the agreed terms (quantity, time, etc.).	%	Customer	Resilience	Yes	Yes
Customer defective product ratio	Economy & Growth	The percentage of defective products received by customers compared to the total number of products they receive.	%	Customer	Resilience	Yes	Yes
Negotiation Time	Economy & Growth	Time spent in contact/negotiation activities with suppliers or customers, in relation to the whole order delivery	%	Growth perspective	Economic Advantage	Yes	Yes
Employee retention	Economy & Growth	Perception of employees remaining or leaving, per year or specific period	% (±)	Growth perspective	Resilience	Yes	Yes
Productivity growth	Economy & Growth	Percentage of increase in output/value generated per unit, for a specific time period	%	Growth perspective	Economic advantage, Resilience	Yes	Yes
Revenue growth	Economy & Growth	Percentage of increase in revenues/sales generating income, for a specific time period	%	Growth perspective	Economic Advantage	Yes	Yes
Compound Annual Growth	Economy & Growth	Annual growth rate of an investment over a specific period of time, longer that 1 year	%	Growth perspective	Economic advantage, Resilience	Yes	Yes
Marketing	Economy & Growth	Measures the effectiveness and scale of the company's MaaS marketing activities, including the use of multiple channels, steady flow of campaigns, and effective messaging to key personas.	Customer Acquisition Cost (CAC) (USD)	Growth perspective	Economic advantage, Resilience	Yes	Yes

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Table 8: KPIs per Pilot Use Case – Arcelik

KPIs and Description	Baseline	Ex-post
Production Capacity Utilization Rate	88%	92%
Order Fulfilment Rate (OTIF)	82,91%	95%
Material Stocks	2,7	1
Finished product stock keeping	3 days	To be defined

Table 9: KPIs per Pilot Use Case – Karel

KPIs and Description	Baseline	Ex-post
Production Capacity Utilization Rate	77%	90%
Order Fulfilment Rate (OTIF)	36%	90%
Material Stocks	2,7	1
Finished product stock keeping	3 days	To be defined

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Table 10: Selected KPIs – Value Network #2

KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model	ERREKA	URA	Tekniker
Carbon Dioxide (CO2)	Environment	Amount of CO2 released from the activities across the supply chain	Kgeq	Carbon footprint	Sustainability	Yes	Yes	Yes
Water stress/ consumption	Environment	Amount of water consumed across the industrial processes	L	Resources	Sustainability	Yes	Yes	Yes
Energy consumption	Environment	Amount of energy consumed across the supply chain	kWh	Resources	Sustainability	No	Yes	Yes
Fossil fuels depletion	Environment	Amount fossil fuels reduction (or energy from RES) in consumed energy mix	kg or kWh	LCA/Resources	Sustainability, Resilience	No	No	Yes
Transportation processes	Environment	Consumptions related to the transportation/ logistics (i.e., energy)	DOC	Resources	Sustainability	Yes	Yes	Yes
Green logistics	Environment	Amount of emissions during logistics activities (warehousing and transportation)	kg	Resources	Sustainability, Resilience	No	Yes	Yes
Ecotoxicity, freshwater	Environment	Amount of toxic substances (lubricants) mixed with freshwater	L	Pollution and Waste	Yes	No	No	Yes
Supply chain waste	Environment	Amount of generated waste	kg	Pollution and Waste	Circularity	Yes	Yes	Yes
Recycling rates	Environment	Amount of recycled waste	kg	Pollution and Waste	Circularity	Yes	Yes	Yes
Use of biodegradable materials	Environment	Amount of biodegradable materials produced/used	kg	Pollution and Waste	Circularity	No	Yes	Yes
Packaging materials and waste	Environment	Amount of waste from packaging material	kg	Pollution and Waste	Sustainability	Yes	Yes	Yes
Scrap Waste	Environment	Amount of scrap waste	kg	Pollution and Waste	Sustainability	Yes	Yes	Yes
Scrap Rate	Environment	The percentage of materials or products that are discarded during the manufacturing process due to defects.	%	Pollution and Waste	Sustainability	No	Yes	Yes
Resource Utilization	Environment	Percentage of use of non-renewable	%	Resources	Sustainability, Resilience, Circularity	No	Yes	Yes

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KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model	ERREKA	URA	Tekniker
		resources across the supply chain						
Consumption of virgin raw materials	Environment	Amount of virgin raw material consumed	kg	Resources	Sustainability, Resilience, Circularity	No	Yes	Yes
ISO22400 for traditional manufacturing	Environment	ISO Certification that the company/industry meets the certification standards	-	Opportunities and Innovation	Sustainability, Resilience, Transparency	No	Yes	Yes
ISO59020 for measuring and assessing circularity	Environment	ISO Certification that the company/industry meets the certification standards	-	Opportunities and Innovation	Circularity	No	Yes	Yes
Health and Safety	Society	Compliance with ISO 45101 for managing and assessing organizational resilience	Qualitative	Human Capital	Resilience	Yes	Yes	Yes
Diversity, Equity and Inclusion	Society	Assessment of gender equity issues, inclusion and diversity in the industrial company (i.e., proportion of women/ men employees)	Qualitative	Human Capital	Transparency	Yes	Yes	Yes
Training and Staff development	Society	Availability and implementation of training programs and staff development activities	Qualitative	Human Capital	Resilience	Yes	Yes	Yes
Size of Company	Society	Measures the organization's scale, often by employees, revenue, or production capacity	Qualitative	Human Capital	Economic Advantage	No	No	Yes
Chemical safety	Society	The industrial company meets the standards for safety from chemical materials	Qualitative	Product Assessment	Resilience, Transparency	Yes	Yes	Yes
Product safety and quality	Society	The industrial company meets the standards for product safety and quality	Qualitative	Product Assessment	Resilience, Traceability	Yes	Yes	Yes
Privacy and data security	Society	The industrial company runs in compliance with the regulations for privacy and data security	Qualitative	Product Assessment	Transparency	Yes	Yes	Yes

KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model	ERREKA	URA	Tekniker
Transparency within the Supply Chain	Society	The level of transparency regarding the quality and origin of the materials, the processing, etc.	Qualitative	Product Assessment	Transparency	Yes	Yes	Yes
Controversial Sourcing	Society	Origin of materials or products (involvement in harmful or unethical practices)	Qualitative	Stakeholders	Transparency, Traceability	Yes	Yes	Yes
Supply Chain Liability	Society	The legal responsibility of the industrial company for actions or shortcomings across its supply chain	Qualitative	Stakeholders	Transparency, Traceability	Yes	Yes	Yes
Customer satisfaction	Society	Level of satisfaction of costumers from the manufacturing service	Qualitative	Stakeholders	Resilience	Yes	Yes	Yes
Partners Engagement	Society	Measures the organization's ability to keep partners and collaborate effectively	Qualitative	Stakeholders	Networking	Yes	Yes	Yes
Employee satisfaction	Society	Level of satisfaction of employees in the company	Qualitative	Human Capital	Resilience	Yes	Yes	Yes
Access to Health Care	Society	Level of access of employees to medical services, treatment, and healthcare resources	Qualitative	Opportunities	Resilience	Yes	Yes	Yes
Access to Finance	Society	Level of access to external funding (i.e., research funding programs, loans, etc.)	Qualitative	Opportunities	Economic Advantage, Sustainability	Yes	Yes	Yes
Work-Life Balance	Society	Level of balance between professional responsibilities and personal time	Qualitative	Opportunities	Resilience	Yes	Yes	Yes
Board diversity	Governance	Level of differentiation in backgrounds, skills and characteristics of an industrial company's board of directors	Qualitative	Corporate Governance	Transparency	Yes	Yes	Yes
Anti-competitive practices	Governance	Number of practices that an industrial company follows to gain	No of practices applies in a year	Corporate Behavior	Transparency	No	Yes	Yes

KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model	ERREKA	URA	Tekniker
		an advantage in the market (i.e., price fixing, bid rigging, market allocation, etc.)						
Tax transparency	Governance	Frequency of openly disclosing information of the industries about tax payments and strategies	No of sharing information in a year	Corporate Behavior	Transparency	No	Yes	Yes
Compliance Rate	Governance	The extent to which manufacturing processes adhere to industry standards and regulations.	Qualitative	Corporate Behavior	Transparency	No	Yes	Yes
Business ethics	Governance	Number of practices for ensuring ethical principles i.e., environmental responsibility, product quality and safety	No of practices applies in a year	Corporate Behavior	Transparency	No	Yes	Yes
Expenses and fines on litigation incidents	Governance	Expenses and fines on filings, lawsuits related to anti-competitive behavior, anti-trust and monopoly practices	€	Litigation Risks and Corruption	Transparency	No	Yes	Yes
Litigation risks payments	Governance	Payments for addressing litigation incidents	€	Litigation Risks and Corruption	Transparency	No	Yes	Yes
Percentage of revenues in regions with TI corruption	Governance	Percentage of revenues in regions with TI corruption below 0.6	%	Litigation Risks and Corruption	Transparency	No	Yes	Yes
Market share	Economy & Growth	The percentage of sales of a product related to all sales of that product for a specific time period i.e., per month, and for a specific geographic area (i.e., at national level)	Depends on the case/ available data, usually in € per specific month, per specific area	Finance	Economic Advantage	No	Yes	Yes
Asset utilization	Economy & Growth	How effectively the company uses its own assets to generate revenue	Qualitative	Finance	Economic advantage, Resilience	No	Yes	Yes
Net cost savings due to circular activities	Economy & Growth	Assessment of savings that coming from circular activities (i.e., re-use of materials or	€	Finance	Economic advantage, Circularity	No	Yes	Yes

KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model	ERREKA	URA	Tekniker
		secondary raw materials, treatment of water to enter the process, etc.)						
Customer acquisition	Economy & Growth	Number of new incoming customers per year	-	Customer	Economic Advantage	Yes	Yes	Yes
Customer retention	Economy & Growth	Perception of customers remaining or leaving, per year or specific period	% (±)	Customer	Resilience	No	Yes	Yes
Customer profitability	Economy & Growth	Assessment of net profit generated by individual customers	€	Customer	Economic Advantage	No	Yes	Yes
Delivery reliability	Economy & Growth	The percentage of deliveries that did not meet the agreed terms (quantity, time, etc.).	%	Customer	Resilience	Yes	Yes	Yes
Customer defective product ratio	Economy & Growth	The percentage of defective products received by customers compared to the total number of products they receive.	%	Customer	Resilience	Yes	Yes	Yes
Negotiation Time	Economy & Growth	Time spent in contact/negotiation activities with suppliers or customers, in relation to the whole order delivery	%	Growth perspective	Economic Advantage	No	Yes	Yes
Employee retention	Economy & Growth	Perception of employees remaining or leaving, per year or specific period	% (±)	Growth perspective	Resilience	No	Yes	Yes
Productivity growth	Economy & Growth	Percentage of increase in output/value generated per unit, for a specific time period	%	Growth perspective	Economic advantage, Resilience	No	Yes	Yes
Revenue growth	Economy & Growth	Percentage of increase in revenues/sales generating income, for a specific time period	%	Growth perspective	Economic Advantage	No	Yes	Yes
Compound Annual Growth	Economy & Growth	Annual growth rate of an investment over a specific period of time, longer that 1 year	%	Growth perspective	Economic advantage, Resilience	No	Yes	Yes

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KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model	ERREKA	URA	Tekniker
Marketing	Economy & Growth	Measures the effectiveness and scale of the company's MaaS marketing activities, including the use of multiple channels, steady flow of campaigns, and effective messaging to key personas.	Customer Acquisition Cost (CAC) (USD)	Growth perspective	Economic advantage, Resilience	No	Yes	Yes

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Table 11: KPIs per Pilot Use Case – ERREKA

KPIs and Description	Baseline	Ex-post
Machine Capacity Utilization Rate	To be defined	+10%
Investment cost in stored parts	To be defined	Reduction of inventory cost of spare parts around by 25%
Material Stocks	To be defined	25%

Note: * The baseline value will be calculated at the beginning of the validation phase

Table 12: KPIs per Pilot Use Case – URA

KPIs and Description	Baseline	Ex-post
Machine Capacity Utilization Rate (Resources capacity use)	To be defined	+15%
Order Fulfilment Rate (OTIF)	To be defined	-25%
Material Stocks	To be defined	-15%

Table 13: KPIs per Pilot Use Case – URA

KPIs and Description	Baseline	Ex-post
Machine Capacity Utilization Rate	To be defined	+15%
Product lead time	To be defined	25%

Table 14: Selected KPIs – Value Network #3 (Aibel)

KPI Name	KPI Category	Description	Unit	Eligible for category	Cause-and-effect model
Carbon Dioxide (CO2)	Environment	Amount of CO2 released from the activities across the supply chain	Kgeq	Carbon footprint	Sustainability
Water stress/ consumption	Environment	Amount of water consumed across the industrial processes	L	Resources	Sustainability
Energy consumption	Environment	Amount of energy consumed across the supply chain	kWh	Resources	Sustainability
Scrap Rate	Environment	The percentage of materials or products that are discarded during the manufacturing process due to defects.	%	Pollution and Waste	Sustainability
Health and Safety	Society	Assessment health and safety conditions in the industrial company	Qualitative	Human Capital	Resilience
Chemical safety	Society	The industrial company meets the standards for safety from chemical materials	Qualitative	Product Assessment	Resilience, Transparency
Product safety and quality	Society	The industrial company meets the standards for product safety and quality	Qualitative	Product Assessment	Resilience, Traceability
Transparency within the Supply Chain	Society	The level of transparency regarding the quality and origin of the materials, the processing, etc.	Qualitative	Product Assessment	Transparency
Supply Chain Liability	Society	The legal responsibility of the industrial company for actions or shortcomings across its supply chain	Qualitative	Stakeholders	Transparency, Traceability
Anti-competitive practices	Governance	Number of practices that an industrial company follows to gain an advantage in the market (i.e., price fixing, bid rigging, market allocation, etc.)	No of practices applies in a year	Corporate Behavior	Transparency
Tax transparency	Governance	Frequency of openly disclosing information of the industries about tax payments and strategies	No of sharing information in a year	Corporate Behavior	Transparency

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Compliance Rate	Governance	The extent to which manufacturing processes adhere to industry standards and regulations.	Qualitative	Corporate Behavior	Transparency
Market share	Economy & Growth	The percentage of sales of a product related to all sales of that product for a specific time period i.e., per month, and for a specific geographic area (i.e., at national level)	Depends on the case/ available data, usually in € per specific month, per specific area	Finance	Economic Advantage
Customer profitability	Economy & Growth	Assessment of net profit generated by individual customers	€	Customer	Economic Advantage
Customer defective product ratio	Economy & Growth	The percentage of defective products received by customers compared to the total number of products they receive	%	Customer	Resilience
Negotiation Time	Economy & Growth	Time spent in contact/negotiation activities with suppliers or customers, in relation to the whole order delivery	%	Growth perspective	Economic Advantage
Revenue growth	Economy & Growth	Percentage of increase in revenues/sales generating income, for a specific time period	%	Growth perspective	Economic Advantage
Compound Annual Growth	Economy & Growth	Annual growth rate of an investment over a specific period, longer that 1 year	%	Growth perspective	Economic advantage, Resilience

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Table 15: KPIs per Pilot Use Case – Aibel

KPIs and Description	Baseline	Ex-post
Duration from receival until documents and information are imported and made available in the relevant systems	To be defined	To reduce the duration by 50%
The timespan between the submission of information and its issuance to the supplier	To be defined	To reduce the duration by 30%
Number of automated import/export processes	To be defined	5
Verification effort of comments and changes	To be defined	To reduce the duration by 30%

Conclusions

The activities carried out in WP2, particularly in the development of the Tec4MaaSEs Governance Framework, have resulted in the initial version of a comprehensive framework that integrates business, data, and AI governance with the Sustainability Balanced Scorecard (SBSC). Drawing from key inputs, such as pilot needs and established reference frameworks, the governance framework has been aligned with the project's objectives to support sustainable and circular value networks.

A detailed list of KPIs has been defined, allowing each pilot to select the most relevant indicators tailored to their specific industrial domains and value network requirements. This deliverable represents the first iteration of the Tec4MaaSEs Governance Framework, which will be further refined and expanded in D2.4 "Governance Framework v2", scheduled for Month 24.

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References

[1] Chandler, C., & McKenzie, S. (2023). Tool: Develop a Competitive Intelligence Scorecard as a Tech CEO, Gartner

[2] Chiu, M., & Scheibenreif, D. (2024) How to Manage Customer Experience Metrics, Gartner

[3] Dataspace Protocol Release 2024-1. (2024).

[4] European Commission. (n.d.). A European strategy for data | Shaping Europe's digital future. Retrieved from: https://digital-strategy.ec.europa.eu/en/policies/strategy-data

[5] European Commission. European data governance act | Shaping Europe's digital future. Retrieved from: https://digital-strategy.ec.europa.eu/en/policies/data-governance-act

[6] International Data Spaces Association. (2021). Governance for data space instances: Aspects and roles for the IDS stakeholders – Position paper (Version 0.1). Retrieved from https://internationaldataspaces.org/wp-content/uploads/IDSA-Position-Paper-Governance-for-Data-Space-Instances-Aspects-and-Roles-for-IDS-Stakeholders.pdf

[7] International Data Spaces Association. (n.d.). IDSA position paper usage control in the IDS. Retrieved from https://internationaldataspaces.org

[8] International Data Spaces Association. (n.d.). IDSA reference architecture model. Retrieved from https://internationaldataspaces.org/offers/reference-architecture/#:~:text=The%20IDS%2DRAM%20sets%20the,the%20architecture%20of%20data%20spaces

[9] Ishaq Bhatti, M., Awan, H. M., & Razaq, Z. (2014). The key performance indicators (KPIs) and their impact on overall organizational performance. Quality & Quantity, 48, 3127-3143.

[10] Kalaboukas, K., Kiritsis, D., & Arampatzis, G. (2023). Governance framework for autonomous and cognitive digital twins in agile supply chains. *Computers in Industry, 146*, 103857. https://doi.org/10.1016/j.compind.2023.103857

[11] Midor, K., Sujová, E., Cierna, H., Zarebinska, D., & Kaniak, W. (2020). Key performance indicators (kpis) as a tool to improve product quality. New Trends in Production Engineering, 3.

[12] Nagel, L., & Lycklama, D. (2021). Design principles for data spaces – Position paper (Version 1.0). Zenodo. https://doi.org/10.5281/zenodo.5105744

[13] Plooto HorizonEurope Project. (n.d.). Retrieved from https://www.plooto-project.eu

[14] Transparency International. (2022). Corruption Perceptions Index 2022. Retrieved from https://www.transparency.org/en/cpi/2022

[15] Wu, B., Wang, J., Cai, H., Shen, Y., Qu, B., & Fu, Y. (2024). Research on the Analysis Method of Production Safety Accidents Based on Accident Event Causal Association Diagram. Mining, Metallurgy & Exploration, 1-14.

Appendix A: IDSA Usage Control Policy Templates

The 21 policy templates from IDSA are explained as follows:

PT.1. Allow or inhibit the usage of the data

This class of policy is an abstract category that either gives permission or prohibits a specified IDS Data Consumer to operate specified action(s) on the Data Asset without further restrictions. As mentioned before, the action "use" is a very generic action that is utilized to express all targeted usages and therefore, includes fine-grained actions such as "read", "distribute", "print", "delete", "display", and so on. When the permission to “use” the data is issued, the Data Consumer is allowed to operate any of the actions on the data. To restrict the type of the actions that are allowed to be operated, the policy must address a particular action. For example, in a whitelisting approach, you want to allow your Data Consumer to read and display the data, therefore, you specify a policy that only permits the “read” and “display” actions.

PT.2. Restrict the data usage to specific connectors

The context of IDS allows assigning more than one connector to a particular IDS party. Therefore, this class of policy addresses the condition of restricting the usage of data to specific connectors of the specified IDS Data Consumer.

PT.3. Restrict the data usage to a group of systems or applications

The Data Usage Control scenarios demand further restrictions on the policies that either allow or inhibit the usage of data. To apply the requested restrictions such as restricting the data usage into the specific systems, the corresponding policy conditions are specified. This implies that the usage of the data is permitted or prohibited when the specified conditions are met. In a policy, the conditions are indeed the prerequisite to operate the action. For example, you can instantiate a policy of this class that allows only a specified risk management system or application to use your data. This policy class faces few limitations, i.e., to evaluate the conditions, it requires that the systems and the applications be certified. Thus, a Data Usage Control technology can validate the certifications and enforce the policy.

PT.4. Restrict the data usage to a group of users.

Additionally, an IDS Data Provider may demand to restrict the usage of the data to a specific group of users. This condition addresses either the membership or the role of the users. To enforce such a policy, a Data Usage Control technology has to check whether a user is a member of the specified organization or has a specific role from authorized resources.

PT.5. Restrict the data usage to specific locations

This class of policy addresses the restriction on the location of the Data Consumer. This condition refines the permitted or prohibited locations of the Data Consumers by region or bounding polygons. A bounding polygon shapes an area by indicating a www.internationaldataspaces.org // 77 set of geographical points. A policy may allow a specified Data Consumer to use data only when the assigned connector is located within the permitted area.

PT.6. Restrict the data usage for specific purposes

This category represents another highly demanded class of policy that restricts the usage of data to specific purposes. To formulate the purpose of usage in a policy and later on, enforce it to the system, we need to define licenses and certifications. This concept is still evolving in the context of International Data Spaces. “If the purpose is risk management, then allow the usage of data and else if the purpose is marketing, then inhibit the usage of data” is an example policy that is instantiated from this policy class.

PT.7. Restrict the data usage when a specific event has occurred

This class of policy represents the permission or prohibition of using data under specific conditions; in the circumstances that the usage of data must be restricted due to the occurrences of specific events, a policy of this type can be constructed. Like the previous classes and to specify policies such as “if an accident occurred, provide permission to read the geographic location” or “provide permission to a Data Consumer to use the data during the exhibition”, we need to formulate the events. Therefore, a Data Provider can specify the conditions that address “when accident occurred” or “during the exhibition”. The assumption is that a set of possible events are defined in the context of International Data Spaces and are available to the ones who specify the policies. As a result, a data usage control technology can interpret the events and restrict the data usage accordingly.

PT.8. Restrict the data usage to the security level of the connectors

The information model of IDS differentiates the connectors with respect to their security levels (i.e., base, trust and trust plus). This class of policy addresses the condition of restricting the usage of data to the security level of the connectors. Depending on what is specified in the condition, an assigned connector of a Data Consumer is allowed to use the data.

PT.9. Restrict the data usage to a specific time interval

The International Data Spaces customers require further time-based constraints, i.e., allow or inhibit the usage of data in a specified time interval. A policy, for example, specifies the permission to use the data from the beginning of September 2019 to the end of November 2019. The date and time conditions can be expressed in different ways. However, it is important that the system can interpret the date and time conditions that are specified in the policies. For example, if “xsd:dateTimeStamp” is used as the data type that defines the date and time in the policy, the system must also be able to read it and understand it.

PT.10. Restrict the data usage to a specific time duration

Another time-based constraint is to restrict the usage of data to a specific duration of time. For example, an instantiated policy from this policy class may allow a Data Consumer to use the data for a duration of three months. The permitted period may start from a given date and time. Moreover, the corresponding data type (e.g. “xsd:duration”) must be interpreted the same in all systems.

PT.11. Use the data not more than N times

This class of policy demands to restrict the numeric count of executions of the action. For example, a policy specifies that the data can be printed only once or it can be displayed not more than ten times or in total, data cannot be used more than N times. We can only apply this kind of policies to the cases in which, the

usage of data is countable. Therefore, a mechanism is needed that counts the usage of data and store it securely and locally, to enforce such a policy.

PT.12. Use data and delete it after

This class of policy gives permission to a specified IDS Data Consumer to use the Data Asset and requires the Data Consumer to delete the data after. A policy of this type shall be refined to clarify when the data must be deleted; it shall be immediately after the usage or after a delay period or before a specified date and time.

PT.13. Modify data (in transit)

In all cases, the policies allow the users to use the entire data, without modifications, after the conditions are met. However, there might be cases where data must be modified or partially anonymized before it is allocated to the user. The data modification must be done before the permission to use the data is granted. This class of policy represents the Data Usage Control use cases demanding to modify the data in transit; a Data Usage Control technology intercepts the data that is transmitted and applies the modifications on them.

PT.14. Modify data (in rest)

This class of policy demands for the data modifications or anonymizations before the permission to use the data is granted. In contrast to the previous policy class, it demands the modifications to be done when data is stored in a database. The Data Consumer is only allowed to use the data after certain modifications have been applied to the stored data.

PT.15. Log the data usage information

The IDS Data Provider requests to log the information of transferring data from their sites to their Data Consumer sites. Although, logging the information is a part of the International Data Spaces infrastructure, a Data Usage Control technology can occasionally apply the logging policies to the systems and log the usage information locally, as well. For example, it might log the information about the data anonymizations.

PT.16. Notify a party or a specific group of users when the data is used.

The studies show that the International Data Spaces Data Providers request to be notified in a stated situation. For example, we can specify policies of this type to request to notify the Data Providers, when their data has left their sites or when it is delivered to the data consumers. The formats and possibilities of the notifications depends on which platform is used, whether it is the notification system of International Data Spaces or, for example, a mailing system.

PT.17. Attach policy when distribute the data to a third-party.

An IDS Data Provider may specify additional data usage policies to be provided to the third parties. Here, the Data Consumer is obliged to pass the specified Data Usage Control policy to the third-party and demand for an agreement before further distributing the data.

PT.18. Distribute the data only if it is encrypted

In most of the cases, a Data Provider specifies a policy to give permission to one or more data consumers to use the data. Although, there might be cases in which the Data Consumer requires permission to further distribute the data to other users or third parties. This class of policy exclusively addresses the state of the

Data Asset in case of sharing it. For example, you can specify a policy of this type to demand your Data Consumer to share your data only if it is encrypted. A.1.19. Perpetual data sale restrictions The IDS platform provides the possibility to the Data Providers to sell their Data Assets. A Data Consumer has to fulfill the conditions that are specified in a data sale contract in order to buy the Data Assets. For example, a one-time payment must be made. This class of policy addresses the conditions that are associated to a data sale contract.

PT.20. Rental data restrictions

In contrary to the previous class of policy, this category addresses the conditions that are associated to a data rent contract. For example, a Data Usage Control technology must check frequently whether the monthly fee which is specified in the contract is paid by the Data Consumer.

PT.21. Restrict the data usage to specific state

This category represents a condition in which the usage of data is restricted to a specific state. This condition refers to an environment state but not the state of the Data Asset. Therefore, it is about the state of the contract and the connectors. If the contract is terminated or if the firewall is activated are examples for this restriction. The state of the Data Consumer connector and the contract must be known by the Data Usage Control technology, so the application can check whether the condition is fulfilled and issue permission to the Data Consumer to use the Data Asset.

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