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ORCHESTRA Project Deliverable: D4.3

Handbook on organisational, business and market models

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Version	**Date**	**Internal Review Milestone Reached (if relevant)**	**Summary of main changes introduced in this version**
0.1	2022-10-27	PCOS proposed	The table of contents of the deliverable has been defined, showing the planned overall structure of the document.
0.2	2022-11-03	PCOS approved	Approved if updated – no new review needed
0.4	2023-02-15	Intermediate proposed	Deliverable approximately 50% complete.
0.5	2023-02-22	Intermediate approved	Approved if updated – no new review needed
0.9	2023-06-02	External proposed	Deliverable complete and ready for release. Last internal review to identify remaining deficiencies.
1.0	2023-06-07	Released	

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About ORCHESTRA

The problem addressed by ORCHESTRA is that traffic caused by transport has many negative effects. There are congestions, delays, emissions and negative impacts on urban environments, and in case of disruptions, there may be huge consequences on the efficiency and timeliness. These challenges are hard to handle due to lack of coordination between the different transport modes.

The long-term vision of ORCHESTRA is a future where it is easy to coordinate and synchronise the traffic management of all modes to cope with diverse demands and situations. The overall objective of ORCHESTRA is to provide European policy makers, public authorities, transport providers and citizens with new knowledge and technical and organisational solutions to enhance collaboration and synchronising of operations within and across transport modes.

The project will:

- Establish a common understanding of multimodal traffic management concepts and solutions, within and across different modes, for various stakeholders and multiple contexts
- Define a Multimodal Traffic Management Ecosystem (MTME) where traffic managements in different modes and areas (rural and urban) are coordinated to contribute to a more balanced and resilient transport system, bridging current barriers and silos
- Support MTME realisation and deployments, through the provision of tools, models, and guidelines – including the integration of connected and automated vehicles and vessels (CAVs)
- Validate and adjust MTME for organisational issues, functionality, capability and usability
- Maximise outreach and uptake of project results through strong stakeholder involvement

ORCHESTRA's main advancements beyond state-of-the-art are related to four focus areas:

- MTME facilitated by: 1) a Polycentric Multimodal Architecture (PMA) specifying how systems collaborate. 2) Flexible organizational and business models. 3) Simulation and training tools. 4) Policy and regulatory recommendations. 5) Data governance and sharing framework
- Traffic orchestration supporting optimal traffic flows, adapted to current and foreseen situations and societal aspects. Data on ongoing and planned transports as well as other issues that may affect the traffic will be monitored and used in decision support and to facilitate resilience
- Coordination across modes and networks bridging current silos, ensuring best possible utilisation of transport system as a whole
- Traffic management supporting more optimal multimodal transport services and fleet operations, those carried out by CAVs included. Transport operations will be guided and controlled according to pre-defined rules and trade-offs between different optimisation targets.

The project will validate and evaluate the multimodal traffic management concept and related tools in its two Living Labs, both in Norway and Italy, covering the optimization of freight and person transport across road, rail, water and air.

Legal disclaimer

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Executive Summary

This document presents and establishes a framework for emerging and future organisational, business, and market models in the form of a handbook for MTME. This should serve as a guideline and highlight economic, ecologic, and social benefits and value exchanges across the stakeholders involved within the MTM network. The main results include:

- A combination of appropriate methods which produce a synthesis specific for MTM applications using the theories of Value Network Analysis, Triple Bottom Line framework, and New Institutional Economics.
- Answers the main research questions and establishes results through a literature review, two workshops conducted with the ORCHESTRA project partners and CoPs, and semi-structured expert interviews with professionals and academics in the fields of traffic management and transportation planning.
- Linking the central MTM archetypes and roles as defined in ORCHESTRA deliverable D3.1 to the presented business, organisational, and market models.
- Identifies issues and barriers related to data security and data sharing from a business perspective.
- Showcases three value network diagrams which serve as a holistic roadmap for emerging and future business models. The VNDs emphasise the most significant value exchanges within the MTM network and are presented under the three Target Vision scenarios as defined in ORCHESTRA deliverable D2.3.
- Identifies the necessary values that are critical for successful MTM functionality. These are presented in tables as stakeholder-specific and systemic values.
- Shows the current organisational traffic management structure using the example of road management and explains how this can be used as a basis to be transferred to other traffic networks such as rail, sea, and air.
- Connects the established organisational model to the three Target Vision scenarios as defined in ORCHESTRA deliverable D2.3, showcasing interactions of traffic management entities with the TO (data exchange).
- Presents cases where the regular work of the TO improves efficiency, network resilience, flexibility, and solves traffic disturbances. Areas where traffic orchestration becomes limited or impossible are also examined.
- Identifies conflicting requirements (critical infrastructure requirements, market requirements) for the market integration of a TO and identifies variables that determine market demand (price, orchestration quality, risk management) for private and public TOs.
- Further identifies challenges associated with competitive tendering as part of PPP and how this can impact competition and innovation.

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List of Abbreviations

Table 1 - List of abbreviations

Abbreviation	Explanation
AI	Artificial Intelligence
CAV	Connected Autonomous Vehicle
CoP	Community of Practitioners
DCB	Demand Capacity Balancing
ERTMS	European Rail Traffic Management System
EU	European Union
FO	Fleet Operator
HIP	Herøya Industrial Park
MTM	Multimodal Traffic Management
MTME	Multimodal Traffic Management Ecosystem
NET	Neoclassical Economic Theory
NIE	New Institutional Economics
NPRA	Norwegian Public Road Administration
NU	Network User
OEM	Original Equipment Manufacturer
PA	Public Authority
PPP	Public Private Partnership
TBL	Triple Bottom Line
TDM	Transport Demand Management
TMS	Traffic Management System
TO	Traffic Orchestrator
TSP	Transport Service Provider
TU	Transport User
UTM	Ultimate Traffic Management
VNA	Value Network Analysis
VND	Value Network Diagram

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List of Definitions

Table 2 - List of definitions

Definition	Explanation
Model types	Different models used to examine economic characteristics in the context of MTME.
Business Model	A business model describes the rationale of how an organisation creates, delivers, and captures value.
Sustainable Business Model	A model where sustainability concepts shape the firm's driving force and its decision making [so that] the dominant neoclassical model of the firm is transformed, rather than supplemented, by social and environmental priorities.
Market Model	The economic representation of supply and demand. The intersection of the supply and demand functions is called the market equilibrium.
Organisation	An organisation is a consciously coordinated social unit, composed of two or more people that functions on a relatively continuous basis to achieve common goals.
Organisational Model	An organisational model is a representation or description of the structure and operation of an organisation. It is a simplified representation that illustrates the relationships between different parts of the organisation and the interactions between different roles and responsibilities.
Network Organisational Model	A loosely linked alliance of organisations, each with their own specialised functions, working together towards a common goal. Allows organisations to maintain their own functional expertise while collaborating and sharing resources to achieve shared objectives. Emphasises flexibility and responsiveness, and is often used in industries such as technology, consulting, and professional services.
Value Network	A value network is any set of roles and interactions in which people engage in tangible and intangible exchanges to achieve economic or social good. Listed below are all terms related to VNA.
Value	A tangible or intangible quality, good, knowledge, benefit or service that is desirable or useful to its recipient so that they are willing to return a fair price or exchange.
Internal Value Network	An activity-focused set of relationships between individuals (e.g., the chief executive officer and the chief financial officer or team members) within and among work groups (e.g., those within and between the manufacturing, research and development, or sales departments) and between and among the various work groups that make up the

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Definition	Explanation
	organisation.
External Value Network	External-facing value networks include those between the organisation and its suppliers, its investors (including venture capitalists); its strategic business partners (e.g., a business with a complementary product) and its customers.
Tangible Exchange/Value	Tangible exchanges/values are contractual transactions involving goods, services, or revenue, including but not limited to physical goods, services, contracts, invoices, return receipts of orders, requests for proposals, confirmations, and payments. Knowledge products or services that directly generate revenue or are expected (contractual) and paid for as part of a service or good (e.g. reports or package inserts) are also considered tangible exchanges/values. The determination of whether a deliverable is considered tangible, or intangible is dependent on its contractual nature, not its physical nature.
Intangible Exchange/Value	Intangible exchange/value goes beyond the actual service and is not accounted for in traditional financial measures, such as a sense of community, customer loyalty, image enhancement or co-branding opportunities.
Informational Exchange/Value	Knowledge which covers exchanges of strategic information, planning knowledge, process knowledge, technical know-how, collaborative design, policy development etc. which flow around and support the core product and value chain.
Roles	Roles are represented as circles within a VND. These are real people in the network who carry out business. They can be individuals, small groups or teams, business units, whole organisations, or communities. In other words, they can be considered stakeholders of the respective businesses.
Transactions	Transactions, or activities, originate from one participant and end with another. These are denoted by an arrow in a VND, which acts as a directional link representing movement and denotes the direction of what passes between two roles.
Deliverables	Deliverables are the actual “things” that move from one role to another. A deliverable can be physical (e.g. a document or a table), or non-physical (e.g. a message or request that is only delivered verbally). It can also be a specific type of knowledge, expertise, advice, information about something, or favour or benefit that is bestowed upon the recipient.
Demand Capacity Balancing	When an imbalance in the network capacity and the transport demand are foreseen or occur, specific measures may be taken towards selected vehicles/vessels to reduce the traffic volume or to increase the capacity

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Definition	Explanation
	in the network.
Transport Demand Management	The traffic volume and type are influenced through measures taken based on well-defined conditions. This may be automated as a part of the traffic management during normal traffic situations, but measures and conditions may also be initiated to handle unnormal situations

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1 About this Deliverable

1.1 Why would I want to read this deliverable?

This deliverable provides an overview of organisational, market, and business models developed for the MTM ecosystem in the form of a handbook. The primary objective of these models is to ensure meaningful value exchanges and that all the stakeholders associated with MTME benefit from the system. These models have been designed to account for various scenarios, offering readers a comprehensive perspective on the ecosystem. Through this deliverable, readers will gain a deeper understanding of how the MTME ecosystem operates and how it has been designed to meet the needs of its various stakeholders from a business perspective.

1.2 Intended readership/users

The deliverable could interest a wide range of readers, from individuals with a general curiosity for the topic to researchers seeking insights into the current state of MTME from a business and organisational perspective. This document is considered a suitable starting point for readers looking to explore the organisational, business, and market-related aspects of MTME. Interested stakeholders and beneficiaries of H2020 projects working on future traffic management, the European Commission, are a few entities that benefit from the information presented in this deliverable.

1.3 Other project deliverables that may be of interest

Readers may find interesting information in other deliverables of ORCHESTRA. For example, D4.3 has taken inputs from the following partner deliverables:

- D2.2: Pre-studies on environmental analysis and drivers – This report provides a detailed analysis of drivers and barriers of the MTME from a social, economic, legal, and regulatory perspective.
- D2.3: Initial scenarios for multimodal traffic management – This report discusses Target vision scenarios in detail. Readers can gain in-depth knowledge about various scenarios via this report.
- D3.1: Initial use cases for multimodal traffic management – Readers can look deeply into stakeholder archetypes and their roles and responsibilities. It covers the initial parts of the ORCHESTRA Polycentric Multimodal Architecture (PMA).
- D6.2: Intermediate evaluation results from Living Labs – This report evaluates MTM based on Herøya and Malpensa living labs. The evaluations are qualitative as well as quantitative in nature based on KPI and KPA. The answered research questions (RQs) from D6.2 are RQs 7.1, 7.2, 8.1, 10.1, and 10.2.

1.4 Involvement in work

Partners involved in this report are FST, ISC, TUDELFT, SEA, DBL, HIP, and NPRA.

IKEM has been the work package's leader and the handbooks main author. FST and ISC contributed by identifying potential data security and data sharing concerns that stakeholders may

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have when participating in the MTM network. They provided insights into the security measures that can be taken to safeguard data while being shared within the MTME. NPRA contributed by sharing their expertise on the business aspects of multimodal traffic management and the organisational structure of the TO. SEA and HIP provided valuable inputs from Living Labs, highlighting the challenges faced on the real grounds. These inputs were utilised to formulate comprehensive business cases and organisational models. TUDELFT and DBL offered inputs on data-related issues and technical tools, which were further utilised to create synergy from a techno-economic perspective.

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2 Introduction

The challenges associated with managing the growing volume of traffic are manifold and cause high costs. For 2016 alone, the EU Commission estimates the external costs incurred by transport at almost one trillion euros, with road transport accounting for the lion's share of 83%. As the volume of traffic increases, the costs continue to rise. External costs are composed of environmental costs (44%), accidents (29%) and congestion (27%). Congestion costs alone amounted to around 267 billion euros in 2016.[1] The costs for the further development of transport infrastructure in the EU are also considered to be high, with an estimated demand of € 1.5 trillion in the period 2010-2030.[2] A possibility to reduce these costs involves improving the current traffic management systems. This is currently done in silos - with little to no communication between the different modes of transport on waterways, rail, air, and road, as displayed in Figure 1. Communication takes place within the silo entities A, B and C, but not beyond modes.

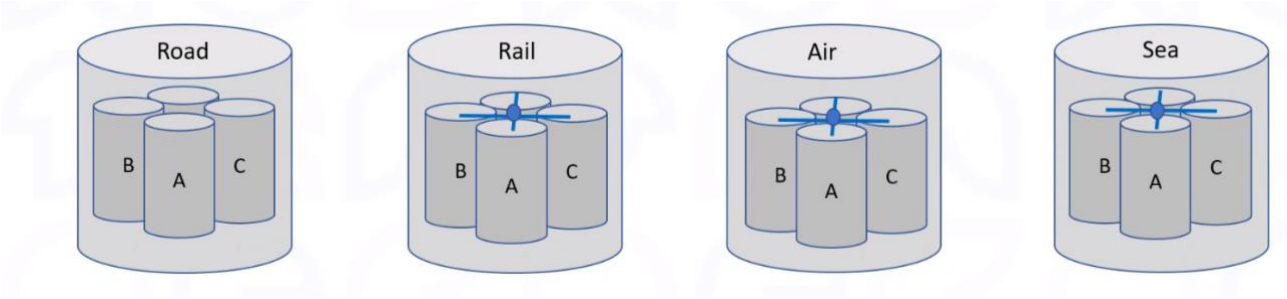

Figure 1 - Illustration of the current traffic management in silos. Source: Illustration from the joint project work in ORCHESTRA.

Connecting these networks and their capacities can help reducing congestion, accidents, and the further demand for transport infrastructure, lowering the respective costs for these fields as well. The topic of how a Multimodal Traffic Management Ecosystem (MTME) can be introduced and established is examined in the ORCHESTRA project. The main focus is on the introduction of the Traffic Orchestrator (TO), who receives, processes, and uses data from many different sources, including the aforementioned silos, to determine an optimal traffic network utilisation across all transport modes. This holds potential benefits for the relevant transport stakeholders, such as the Transport Service Providers (TSP), Fleet Operators (FO), Transport Users (TU), and Network Users (NU), but also requires their data as input. This is shown graphically in Figure 2.

[1] L Wijngaarden et al., *Sustainable Transport Infrastructure Charging and Internalisation of Transport Externalities: Executive Summary* (Publications Office, 2019), https://doi.org/10.2832/246834.

[2] European Comission. Directorate-General for Mobility and Transport, *White Paper on Transport: Roadmap to a Single European Transport Area: Towards a Competitive and Resource-Efficient Transport System* (Publications Office of the European Union, 2011), 14.

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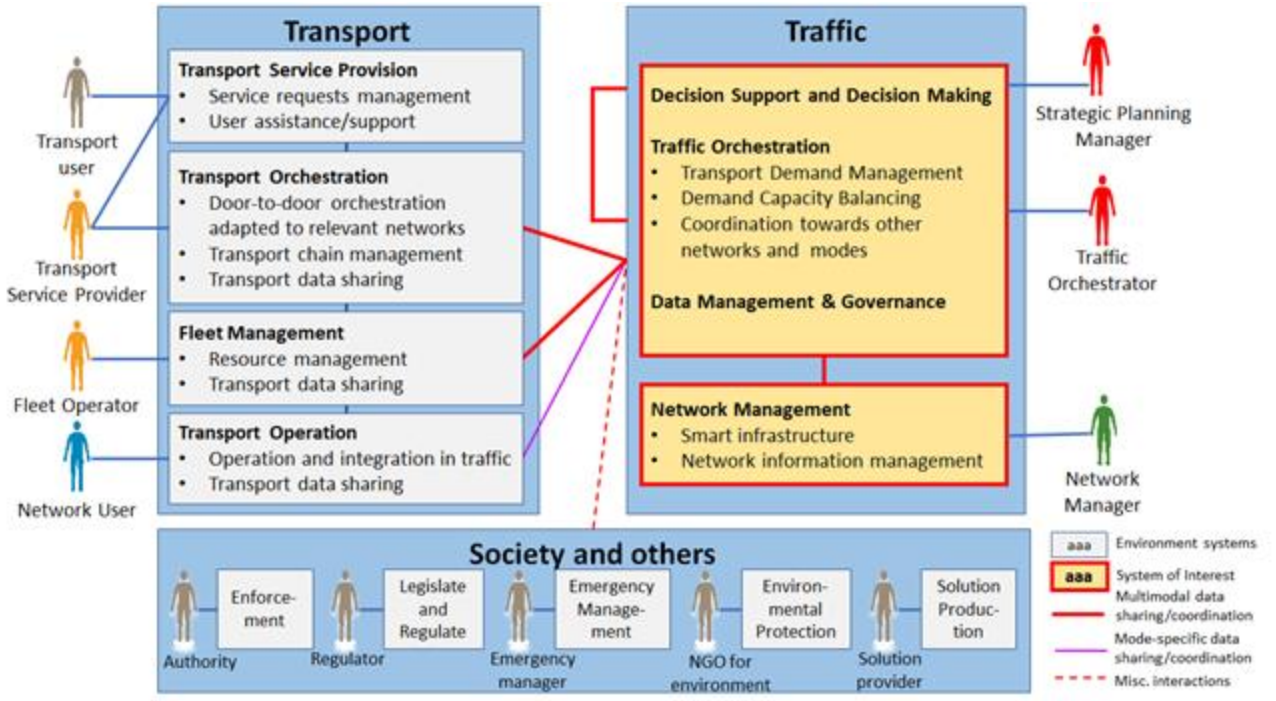

Figure 2 - Relevant stakeholders in the field of MTM and their tasks. Source: Natvig et al.[3]

This handbook addresses the issue of how organisational, market and business models can be developed that are suitable for the introduction of multimodal traffic management (MTM). The research question therefore is:

"How can organisational, market, and business models be designed to optimally facilitate MTME, promote collaboration between relevant stakeholders and achieve economic, social, and ecologic benefits?"

To examine this question, we will build on preliminary research carried out in the project, especially with regard to the initial target vision of MTM, the scenarios describing traffic management in different situations, and the fields of application.

Structurally, the theoretical basis on which the handbook is based on will be presented first. In this context, it is important to emphasise that MTM is still at an early stage of research and concrete information on cost structure, revenue stream or profit structure is not yet available or foreseeable. In order to reflect the holistic nature of the ecosystem of MTM, the value network analysis (VNA) is chosen as the central theoretical approach. It goes beyond the pure consideration of financial profits and also includes intangible and informational values, which are often of a social or environmental nature. This approach is supplemented by the triple bottom line (TBL) framework, which measures the value of the work of companies or organisations not only in terms of profit, but also in terms of social and environmental benefits. The result is a Value Network Diagram (VND), which is conceived as a holistic variant of a business model for the stakeholders under consideration

[3] Marit K. Natvig et al., 'Initial Use Cases for Multimodal Traffic Management.', 28 February 2022, 21.

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and has been expanded to include both social and environmental values. Emerging and future business models may use the VNDs developed in this handbook as a holistic roadmap to further understand the benefits of being part of the MTM network. Furthermore, they will be able to see beyond just the economic perspective and structure their models in a way that also gives importance to social and ecologic perspectives. Furthermore, the theories of new institutional economics (NIE) and neoclassical economic theory (NET) are used as a basis for the organisational and market model. These are particularly relevant for a consideration of transaction costs as well as supply and demand.

Given the early stage of research on MTM, concrete quantitative data on costs and financial benefits of the system are not yet available. Accordingly, the Methodology chapter utilises qualitative methods such as literature review, workshops analysis and semi-structured expert interviews. The chapter concludes by outlining how the respective organisational models and VNDs are created. In the following chapter, the results are presented. First, the core findings of the qualitative research methods such as literature review, workshops and interviews are presented. Based on this, an organisational model, market model and several VNDs are created. The organisational model examines the structure, responsibilities, and mechanisms for ensuring a functioning traffic orchestration system. In the market model, the relevant variables that influence the supply and demand of traffic orchestration are examined in more detail. In the VNDs, additionally created values in the three scenarios business as usual (BAU), foreseen and unforeseen disturbances are shown and explained in more detail. Finally, a conclusion is drawn.

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3 Theoretical Background

This chapter is dedicated to creating a theoretical toolkit to answer the research question. Conventional business model approaches focus primarily on financial aspects. That is why, as a first step, a definition for business models that go beyond pure financial motivation will be established. A tripartite approach was chosen to emphasise ecological and social aspects in addition to economic ones. Contrary to conventional approaches, VNA offers a broad perspective and includes not only contractually regulated physical-financial value creation but also informational and intangible value creation. This is further supported by the TBL framework, which pays particular attention to value creation from ecological and social aspects in addition to economic ones. As a result, a modified VNA is created, enriched by ecologic and social considerations. The theory of NIE, which is based on NET, complete the framework, focusing on supply and demand as well as transaction cost optimisation.

Besides the theories mentioned, other approaches were taken into consideration as well. Other value network theories, such as Clayton Christensen's network[4], are dominated by economic aspects and focus on product enhancement and the company's internal benefits. However, the approach is limited to a single company and does not address other stakeholders or the entire ecosystem. Furthermore, Stabell and Fjeldstad[5] mention different kinds of value configuration strategies. However, these strategies are limited to the company itself and need to consider other relevant stakeholders from a business perspective. Their approach is customer-centric and focused on creating economic advantages for companies. As a result, a modified version of VNA has proven to be adequate for the purpose of this examination. In the following sections, the theories are explained and merged in a synthesis.

3.1 Business models

A business model is a general term often used to describe how a company generates profits. The word "business model" has become an important term in Information Systems and Information and Communication Technologies.[6] Although it is a broad term today, there is no uniform definition yet. Several researchers have defined business models according to their expertise. Some of the definitions which are used widely are mentioned below:

- "A business model describes the rationale of how an organisation creates, delivers, and captures value."[7]

[4] Clayton M. Christensen and Richard S. Rosenbloom, 'Explaining the Attacker's Advantage: Technological Paradigms, Organizational Dynamics, and the Value Network', *Research Policy* 24, no. 2 (1 March 1995): 233–57, https://doi.org/10.1016/0048-7333(93)00764-K.

[5] Charles B. Stabell and Øystein D. Fjeldstad, 'Configuring Value for Competitive Advantage: On Chains, Shops, and Networks', *Strategic Management Journal* 19, no. 5 (1 May 1998): 413–37, https://doi.org/10.1002/(SICI)1097-0266(199805)19:5<413::AID-SMJ946>3.0.CO;2-C.

[6] Mutaz M Al-Debi, Ramzi El-Haddadeh, and David Avison, 'Defining the Business Model in the New World of Digital Business', *AMCIS 2008 Proceedings*, 2008, 2.

[7] Alexander Osterwalder and Yves Pigneur, *Business Model Generation* (John Wiley & Sons, Inc., Hoboken, New Jersey, 2010).

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- "A business model consists of four interlocking elements that, taken together, create and deliver value. The four elements are Customer Value Proposition, Profit formula, key resources, key processes."[8]
- "A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams."[9]
- "The organisation's logic for creating value. The business model for a profit-oriented enterprise explains how it makes money."[10]

These definitions take into consideration the economic aspects of a firm. Therefore, the business models developed based on these definitions focus heavily on generating profit for the firm and creating financial value for themselves and their shareholders. However, definitions that go beyond this are rare. A sustainable business model can be defined as "a model where sustainability concepts shape the firm's driving force and its decision making [so that] the dominant neoclassical model of the firm is transformed, rather than supplemented, by social and environmental priorities."[11]

From an MTME perspective, sustainable business models represent an opportunity to benefit society and implement environmentally friendly solutions. They must also create value for stakeholders associated with the MTM ecosystem. As explained in the introduction, VNA is considered a holistic variant of a business model, taking into account several dimensions beyond conventional business models. This will be examined in more detail in the following chapters.

3.2 Value network analysis

The VNA was developed in 1993 by Verna Allee and was adapted in 1997 for intangible asset management.[12] A value network is a set of roles and interactions in which people engage in tangible and intangible exchanges to achieve economic or social good.[13] As such, VNA considers tangible and intangible values beneficial to the stakeholders. The term value is defined as a tangible or intangible quality, good, knowledge, benefit or service that is desirable or useful to its recipient so

[8] Mark W. Johnson, Clayton M. Christensen, and Henning Kagermann, 'Reinventing Your Business Model', *Harvard Business Review*, 2008, 16.
[9] Alexander Osterwalder, Yves Pigneur, and Christopher L. Tucci, 'Clarifying Business Models: Origins, Present, and Future of the Concept' (Communications of the Association for Information Systems, July 2005), 11, https://doi.org/10.17705/1CAIS.01601.
[10] LJ Cantrell and J Linder, 'Changing Business Models: Surveying the Landscape', *Accenture Institute for Strategic Change* 15, no. 1 (2000): 142–49.
[11] Wendy Stubbs and Chris Cocklin, 'Conceptualizing a "Sustainability Business Model"', *Organization & Environment* 21, no. 2 (1 June 2008): 103, https://doi.org/10.1177/1086026608318042.
[12] Verna Allee, 'Value Network Analysis and Value Conversion of Tangible and Intangible Assets' (Emerald Group Publishing Limited, 2008), https://ocw.tudelft.nl/wp-content/uploads/Value_network_analysis_and_value.pdf.
[13] Verna Allee.

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that they are willing to return a fair price or exchange.[14] In this context, three types of values are further defined:

- **Tangible values** are contractual transactions involving goods, services, or revenue, including but not limited to physical goods, services, contracts, invoices, return receipts of orders, requests for proposals, confirmations, and payments. Knowledge products or services that directly generate revenue or are expected (contractual) and paid for as a part of a service or good (e.g. reports or package inserts) are also considered tangible exchanges. Whether a deliverable is tangible or intangible depends on its contractual nature, not its physical nature.[15]
- **Intangible values** cover exchanges of value and benefits that go beyond the basic service and are not accounted for in traditional financial measures, such as a sense of community, customer loyalty, image enhancement or co-branding opportunities.[16]
- **Informational values** cover exchanges of strategic information, planning knowledge, process knowledge, technical know-how, collaborative design, and policy development, which flow around and support the core product and value chain.[17]

Traditionally, only financial assets were considered to generate value for businesses. VNA deviates from the conventional method and considers financial and non-financial assets for generating value for businesses. The underlying objective of VNA is to identify value which can be generated via intangible assets. The intangible assets include human knowledge, professional expertise, indirect benefits, contacts, favours, etc. On the contrary, tangible assets include financial resources, such as products, services, goods, etc. It is essential to highlight that VNA focuses on macro-level benefits. Which is particularly fitting for multistakeholder environments. Value networks consider values necessary for an organisation's operation and growth. As such, they can be used for impact assessments before and after the service has been implemented.[18]

There are two kinds of value networks: internal and external. Internal value networks include activity-focused sets of relationships between individuals (e.g., the chief executive officer and the chief financial officer or team members) within and among work groups (e.g., those within and between the manufacturing, research and development, or sales departments), and between and among the various work groups that make up the organisation.[19] External value networks include those between the organisation and its suppliers, its investors (including venture capitalists); its strategic business partners (e.g. a business with a complementary product); and its customers.[20] External value networks focus on the benefits of all stakeholders, whether tangible or intangible. Figure 3 showcases a visual representation of internal and external value networks. Value flow

[14] Verna Allee, 'The Art and Practice of Being a Revolutionary', *Journal of Knowledge Management* 3, no. 2 (1 January 1999): 121–32, https://doi.org/10.1108/13673279910275576.
[15] Verna Allee, 'Value Network Analysis', 7.
[16] Verna Allee, 7.
[17] Trond Foss, 'A Value Network for the Use of Driverless Pods in Public Transport and Mobility on Demand.' (SINTEF Community, n.d.).
[18] Trond Foss, 'Impact Evaluation of Value Networks for ITS Services.' (ITS World Congress 2017 Montreal, 29 October 2017).
[19] Verna Allee, 'Value Network Analysis', 2.
[20] Verna Allee, 2.

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within a company/department falls under internal value networks. However, when a cluster of companies/organisations come together and form an ecosystem, the exchange of values in this ecosystem is known as an external value network.

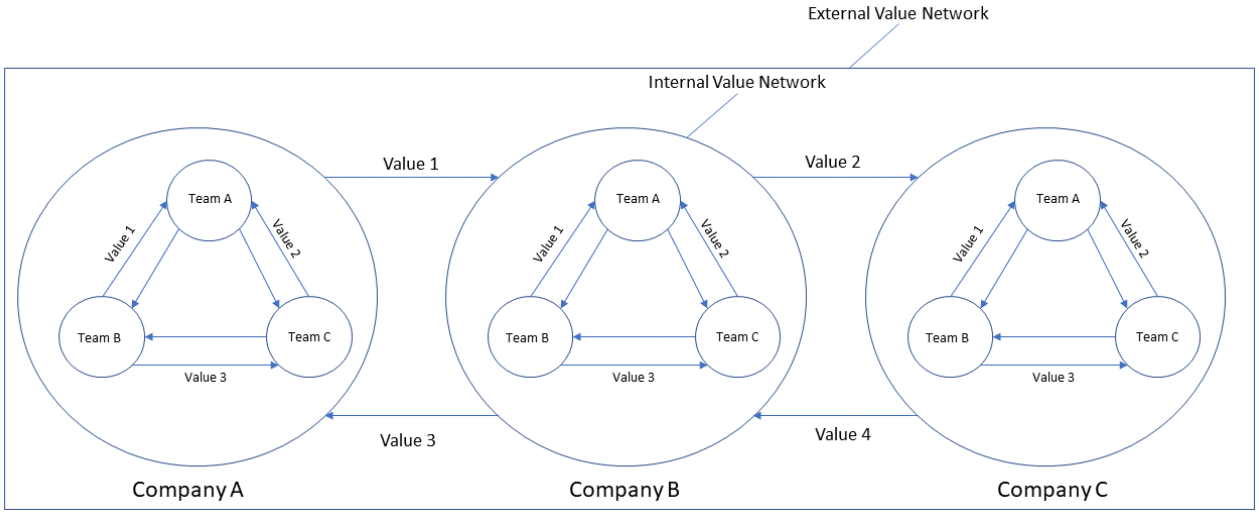

Figure 3 - Depiction of internal and external value network. Source: Own depiction.

The mapping method consists of three simple elements, Roles, Transactions and Deliverables:[21]

- Circles represent roles; these are real people in the network who carry out business. They can be individuals, small groups or teams, business units, organisations, or communities. In other words, they can be considered stakeholders of the respective businesses.
- Transactions or activities originate with one participant and end with another. The arrow is a directional link that represents movement and denotes the direction of what passes between two roles.
- Deliverables are the actual "things" that are moving from one role to another. A deliverable can be physical (e.g., a document or a table) or non-physical (e.g., a message or request only delivered verbally). It can also be a specific type of knowledge, expertise, advice, information about something, or favour or benefit that is bestowed upon the recipient.

There is a growing trend of using VNA for AI-based solutions. VNA is being used in creating AI-based new business models, which can support implementing the creative sides of the product. Based on that, the created business models are flexible and dynamic, promoting collaboration among the entire system's stakeholders.[22] There are several aspects where VNA has proven helpful. Among them is the automation of the manufacturing industry, AI services with intelligent metering,

[21] Verna Allee, 10.

[22] Platform Lernende Systeme, 'Creating Value from Data. Potentials of Data and AI-Based Value Networks' (Platform Lernende Systeme, 6 July 2020), 6, https://en.acatech.de/publication/creating-value-from-data-potentials-of-data-and-ai-based-value-networks/.

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building decentralised and resilient cloud storage infrastructure, a data platform for sustainability reporting, greenhouse monitoring and others.[23]

VNA is also used in mobility, such as organising driverless pod systems, traffic, road information services, and MaaS ecosystems. Experts from these projects believe that "a value network is an effective, generic, and flexible mapping tool for illustrating and analysing the implementation and operation of a system".[24] Figure 4 shows what a value network for ITS service In-vehicle traffic and road information can look like. The important things to note here are the value exchanges taking place among the stakeholders. The value network highlights different categories of values exchanged in an ecosystem: financial, informational, and immaterial. The value network for ITS services offers a macro perspective to the readers on the tangible and intangible assets of ITS services. Dedicated steps could be taken to generate tangible outcomes from informational and immaterial values. The method offers flexibility in categorising different values. The values across the stakeholders are classified into three categories: financial, information, and intangible. Based on the outcome of the value network, it can be identified how informational and intangible values can create a tangible result for the stakeholders.

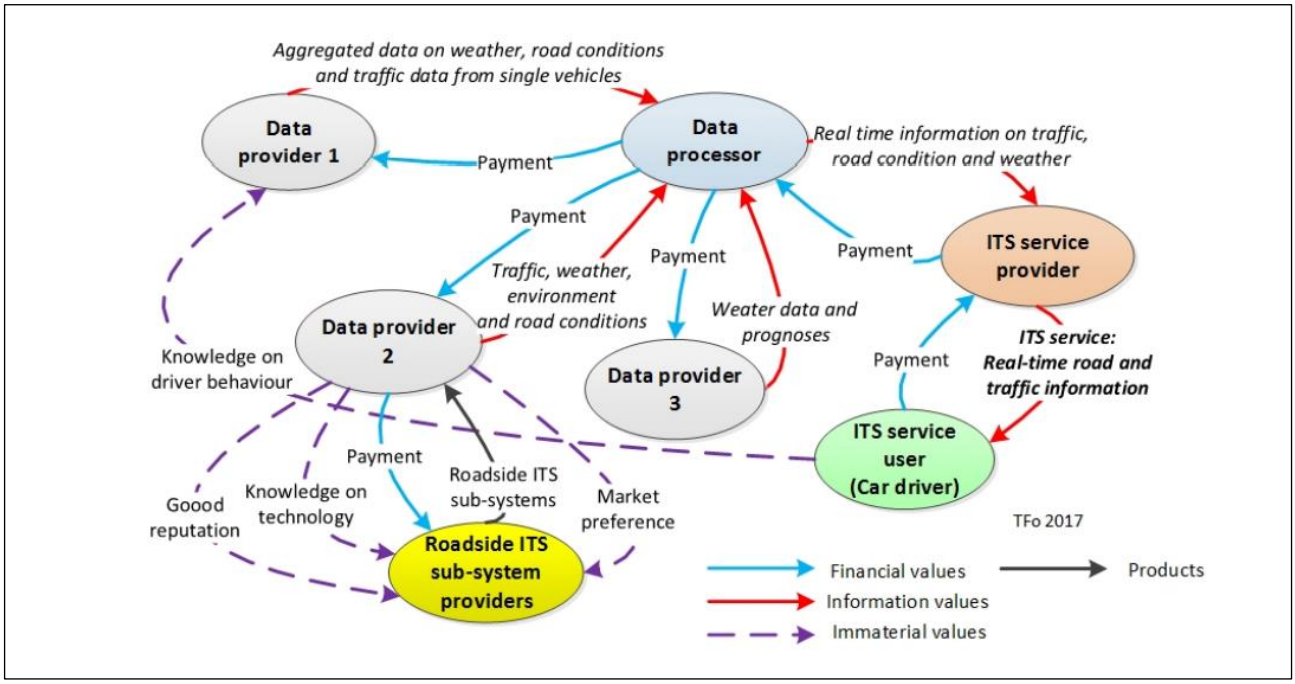

Figure 4 - Value network for ITS service. Source: Foss (2017)[25]

By applying VNA, different values crucial for fostering collaboration and flexibility within MTME are emphasised. With the help of VNA, we can pinpoint which specific values could benefit particular stakeholders. These benefits need not be economical but can also be categorised into

[23] Platform Lernende Systeme, 'Creating Value from Data'.
[24] Trond Foss, 'A Value Network for the Use of Driverless Pods in Public Transport and Mobility on Demand.'
[25] Trond Foss, 'Impact Evaluation of Value Networks for ITS Services.', 8.

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technological or reputational benefits. This way, we can estimate the role of each stakeholder present in the ecosystem. If a stakeholder is transmitting more values and needs to receive more incoming values, a disparity can be created in the ecosystem. Ideally, such situations should be avoided. However, many economic constellations contain certain stakeholders, that play a critical role in an ecosystem compared to others. In MTM, this might be the case for the TO. As such, it is important to develop a framework for the regulation of the TO in order to mitigate power disparities in the ecosystem. In summary, VNA enables the identification of different value exchanges taking place among stakeholders from a social, economic, and ecologic perspective.

However, there are also some limitations to VNA:

- As qualitative theory, quantitative economic aspects are out of the scope of the approach.
- The reliance on the assessment of value.[26] Value is often assessed based on individual perceptions and interpretations, which can vary greatly depending on the context and the individuals involved. This can lead to inconsistencies in identifying and measuring value within a network. In order to avoid this, a framework must be created that categorically classifies values.
- VNA can oversimplify complex interactions and dynamics within a network.[27] For example, VNA focuses on identifying and measuring value flows but does not always capture the nuances and intricacies of the relationships and interactions underlying those flows. This can limit the utility of VNA in understanding and managing complex networks.
- While the methodology provides a framework for understanding and analysing value networks, it does not offer clear guidance on implementing or operationalising the insights gained.

In conclusion, with the help of VNA, we can identify tangible, intangible and informational values of the MTME. Based on that, besides financial aspects, we can interpret and promote social and environmental aspects in particular.

3.3 Triple bottom line framework

TBL is an accounting framework introduced by John Elkington in 1997.[28] It goes beyond the traditional measures of profits, return on investment, and shareholder value and includes environmental and social dimensions.[29] These three dimensions are called “the three Ps”: profit, people, and planet.[30] A graphical representation of this can be found in Figure 5. TBL aims to give equal weight and attention to social, ecological, and economic aspects. The following example can

[26] Verna Allee, ‘Value Network Analysis’, 5–24.
[27] Liu, S., and Park, H. J., ‘The Application of Value Network Analysis in Business: A Literature Review’ (Journal of Open Innovation: Technology, Markeet, and Complexity, 2015), 7.
[28] John Elkington, ‘ACCOUNTING FOR THE TRIPLE BOTTOM LINE’, *Measuring Business Excellence* 2, no. 3 (1 January 1998): 18–22, https://doi.org/10.1108/eb025539.
[29] Timothy F. Slaper and Tanya J. Hall, ‘The Triple Bottom Line: What Is It and How Does It Work?’ (Indiana Business Research Center, Indiana University Kelley School of Business, 29 December 2013), http://web.mit.edu/afs.new/athena/course/2/2.813/www/readings/TripleBottomLine.pdf.
[30] Puneeta Goel, ‘Triple Bottom Line Reporting: An Analytical Approach for Corporate Sustainability.’, *Journal of Finance, Accounting & Management* 1, no. 1 (July 2010): 27–42.

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clarify the perspective of the approach: If a profitable company disposes of hazardous chemicals into a river, the individual profit may be high ("single bottom line"), but the social and environmental costs that the general public has to bear may exceed these profits and cause a negative result under the TBL. This can also have negative repercussions for the company. In today's interconnected world, such practices damage the reputation of companies and can lead to rejection or even boycott. In addition, legislation, and compensation mechanisms, such as emissions trading, can also cause an increased relevance of all three dimensions. Accordingly, the relevance of running a sustainable business has been growing increasingly. As a result, corporations often utilise the TBL framework to improve the sustainability index within their business.

Figure 5 - Graphical representation of the TBL framework. Source: Moon[31].

- **Profit:** Profit is the first component of the TBL. Historically, company's strategies focused on increasing profits and decreasing costs. However, if external costs are incurred, as described in the example above, a profit-oriented approach is not sustainable.
- **People:** The second component of TBL consists of people. Understanding a company's potential for societal influence is crucial. In the past, businesses invested a lot of time and energy in gaining shareholders' approval. TBL emphasises creating value for all parties involved, including clients, staff, and society. Overall, it has become more critical for a business that its good or service serves the larger community.
- **Planet:** The final pillar emphasises how important it is for every company to take steps to reduce its carbon footprint. Many companies have achieved this by lowering their energy usage, streamlining their shipping processes, converting to renewable energy sources, etc.

[31] Flora Moon, '25 Years Ago I Coined the Phrase "Triple Bottom Line." Here's Why It's Time to Rethink It.', expressworks, *25 Years Ago I Coined the Phrase "Triple Bottom Line." Here's Why It's Time to Rethink It.* (blog), 17 July 2018, https://www.expressworks.com/organizational-change-capacity/25-years-ago-i-coined-the-phrase-triple-bottom-line-heres-why-its-time-to-rethink-it/.

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Many researchers have used TBL as a theoretical approach to analyse various mobility elements, including green logistics, multimodal transportation, etc. For instance, TBL is being used as a reference framework for making intermodal logistics transportation greener.[32] Furthermore, the framework has been used for sustainable cities and freight transport development.[33] TBL can also be considered an essential element of sustainability to improve the effectiveness of public transit.[34] The TBL approach considers the long-term impact of an organisation's activities on the environment, society, and the economy. The economic aspect of MTME is vital, as it affects the financial sustainability of the ecosystem. However, social, and environmental factors must also be considered. For instance, reducing traffic congestion and accidents can have significant social benefits. It can reduce the number of injuries and fatalities on the roads, improving the overall quality of life for commuters. In addition, reducing carbon emissions can have significant environmental benefits, such as improving air quality and reducing the adverse effects of climate change.

The TBL framework also comes with certain limitations, these include:

- A lack of measurement and an exact mechanism for computing each dimension. Profit, for instance, can be determined from balance sheets and profit & loss accounts and expressed in euros. However, tracking and calculating social and ecological development is quite challenging. Some progress has been made in ecological areas, such as the computation of carbon emissions, carbon footprint, and emission certificates. On how to assess social progress, however, there is disagreement.
- TBL does not consider the trade-offs that may exist. For instance, an organisation may focus on environmental sustainability by reducing its carbon footprint, which may come at the cost of economic performance. Similarly, if an organisation invests in social programs, that may come at the cost of environmental or economic performance.
- Highly competitive markets can make it difficult for small and medium-sized companies in particular to give equal weight to the three aspects of TBL.

In summary, TBL, especially in combination with VNA, offers a broader perspective on the values that companies and organisations can generate.

3.4 Neoclassical economic theory & new institutional economics

NIE is based on and modifies NET. NET also allows for a fundamental understanding of economic processes and markets, which is important for the creation of market models. Therefore, a basic introduction to NET will be given first, before NIE will be explained in more detail in the following.

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[32] Kevin Kiy and Florian Scanvic, 'Intermodal Transportation within Green Supply Chain Management and Green Logistics.' (Jönköping, Jönköping University, 2018), https://www.diva-portal.org/smash/get/diva2:1216630/FULLTEXT01.pdf.

[33] Marzena Kramarz and Edyta Przybylska, 'Multimodal Transport in the Context of Sustainable Development of a City', *Sustainability* 13, no. 4 (2021), https://doi.org/10.3390/su13042239.

[34] Patrick Miller et al., 'Public Transportation and Sustainability: A Review', *KSCE Journal of Civil Engineering* 20, no. 3 (1 April 2016): 1076–83, https://doi.org/10.1007/s12205-016-0705-0.

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3.4.1 Neoclassical economic theory

NET is based on the concept of homo economicus. Homo economicus acts in a self-interest maximising way and on the basis of (quasi) perfect information. The theory assumes scarcity of resources and labour. Individuals have a need for leisure and consumption. According to their personal utility preference of these two parameters, they offer their labour power to the labour market to balance out their income and leisure time in a utility maximising way. Companies produce products with the two inputs labour and capital and strive for profit maximization, which they achieve by minimising costs and optimising output according to the market structure.[35] A long-term business case only exists if revenues exceed expenses and production can cover costs or generate a surplus. The theoretical point at which available resources are optimally used is called the Pareto optimum. "The Pareto point is optimal in the sense that it signifies that a society has fully realized its potential output. It is operating at the outer limit of its productive capability, given the technology and resource endowments available to it. (...) This refers to the total quantity of goods it could potentially produce with its given production function and its initial resource endowments"[36]. In modern economies, deviations from the Pareto optimum often occur, e.g. due to external influences, monopoly formation, information asymmetries or others.

Regarding market structures, in general, so-called perfect and imperfect markets can be distinguished. Perfect markets are characterised by perfect competition. Here, competitive pressure forces companies to minimise costs absolutely. Imperfect markets refer to a situation, where perfect competition does not take place. This can be due to structural reasons (natural monopoly, state-regulated markets) or because few companies dominate the market (oligopoly). Both represent a deviation from the Pareto optimum.[37]

An illustration of supplying companies and demanding consumers can be found in Figure 6. The lower the price, the more demanding customers there are for a product. The higher the price, the more supplying companies there are for a product. Therefore, the supply and demand curves are in opposite directions. Market equilibrium occurs at the intersection of the supply and demand curves. Here, the equilibrium quantity Q* is demanded at the equilibrium price P*.

[35] Richard Wolff and Stephen Resnick, *Contending Economic Theories - Neoclassical, Keynesian, Marxian*, 2012, 51 ff., http://digamo.free.fr/wolffresnick12.pdf.
[36] Wolff and Resnick, 101.
[37] Klaus Schöler, *Grundlagen Der Mikroökonomik - Eine Einführung in Die Theorie Der Haushalte, Der Firmen Und Des Marktes*, 2011, 123, https://publishup.uni-potsdam.de/opus4-ubp/frontdoor/deliver/index/docId/5496/file/schoeler_mikrooekonomik_3aufl.pdf.

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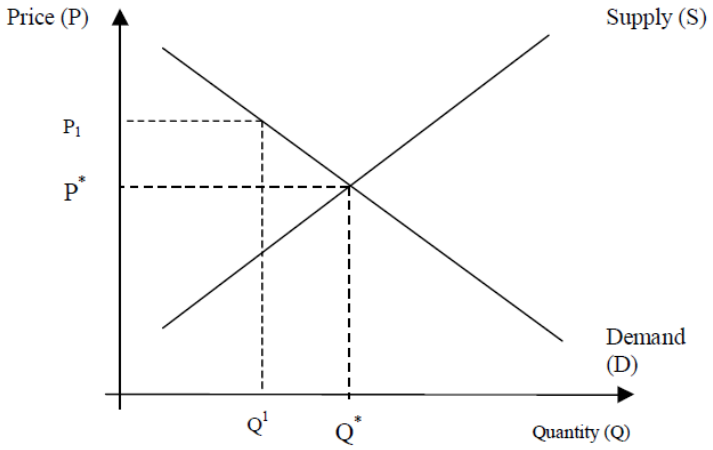

Figure 6 - Supply and demand curve. Source: Gomez (2005)[38].

This theoretical background is provided to serve as a basic foundation for both, NIE and subsequent research on business and market models with regard to the MTME.

3.4.2 New institutional economics

NIE theory considers the constrained rationality of economic stakeholders and thus is an adaptation of neoclassical theory.[39] It assumes that economic stakeholders have imperfect information and limited knowledge. The stakeholders interact through institutions, which are defined as companies, markets, and contracts.[40] Based on the neoclassical view of homo economicus, stakeholders act in a utility-maximising way, but on the basis of their limited information. This leads to opportunism, i.e. the exploitation of the existing information gap to their own advantage. In this process, institutions have two primary functions. The first is the motivational function. If a stakeholder's behaviour is associated with disadvantages for him, he, as homo economicus, will adjust his behaviour accordingly in order to maximise his benefit. On the other hand, the institutions also have a coordination function. They create the necessary security and reliability to simplify and coordinate the cooperation of the stakeholders. The central object of the theory is transaction costs, which occur in many ways in the interaction of stakeholders and significantly influence their behaviour.[41]

As part of NIE, primarily three sub-theories have developed, which focus on different aspects within the theory construct. These are the property rights theory, the principal agent theory, and the

[38] Pavel Gomez, *Effects of the Regulatory Change of 1996 on the Investment and Efficiency Behaviour of the Local Telecommunications Firms*, 2005, 22, https://www.researchgate.net/publication/264347487_Effects_of_the_Regulatory_Change_of_1996_on_the_Investment_and_Efficiency_Behaviour_of_the_Local_Telecommunications_Firms_The_Case_of_the_American_Providers_of_Local_Telephone_Services.

[39] Rebecca Bayer, 'Institutionenökonomische Allgemeinbildung', 2013, 9.

[40] Oliver Williamson, *The Economic Institution of Capitalism* (New York, 1985), 15.

[41] Stefan Plettendorff, 'Die Neue Institutionenökonomik : Die Anwendung einer volkswirtschaftlichen Theorie auf das Archivwesen' (Fachhochschule Potsdam, 2014), https://opus4.kobv.de/opus4-fhpotsdam/frontdoor/index/index/docId/961.

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transaction cost theory. All theories focus on the contract as most important institution.[42] The **property rights theory** is based on the premise that there are rights of disposition to every object. The transfer, use and enforcement of these objects incur costs. The rights of disposition are codified mainly by contracts, but also rules and norms. The more the rights of disposition are divided among several stakeholders and constrained by institutional rules, the lower is the efficiency of the economic interactions of the stakeholders and the higher are the associated transaction costs. Accordingly, the rights of disposition should be structured so that the sum of the transaction costs (for the use, transfer, and enforcement of the rights of disposition) and the allocation losses are minimised. This can be achieved if the partial rights are bundled as far as possible with the use of an object or resource and allocated to the respective stakeholder.[43]

The **principal-agent theory** sheds light on the information asymmetry between two interacting economic stakeholders. If one economic stakeholder is dependent on another, the actors enter into an agency relationship. The agent has a knowledge advantage over the principal, which he can exploit opportunistically to his advantage. The problems that arise can be divided into hidden characteristics, intentions, information, and hidden actions.[44] This implies monitoring and control costs as well as signalling and guarantee costs for the principal. The former are incurred by the principal through controls and monitoring by which he attempts to influence the agent's behaviour in his favour. The latter arise when the principal tries to compensate for his information deficit and thus reduce the information gap. This problem can be solved or reduced by signalling and screening. By signalling, the agent makes clear in advance which characteristics his service covers. By screening, the principal obtains information about the agent's characteristics before using the service. The careful design of institutions, e.g. by designing contracts that cover conceivable uncertainties and gaps, enables the minimisation of effort and transaction costs that would otherwise be incurred to close the information gap.[45]

Transaction cost theory deals with the transfer of goods or services between economic stakeholders. Central to this is the transfer of rights of disposition and not the exchange of goods per se. The theory identifies five types of costs associated with such an exchange. These are the

- **initiation costs** through the provision of information and advice
- **agreement costs** through negotiations or legal advice
- **settlement costs** through transport and process control
- **control costs** through monitoring measures and quality controls
- **adjustment costs** through renegotiations and contract amendments[46]

The level of these transaction costs depends in particular on the uncertainty of the stakeholders, the frequency of the transactions and the factor specificity. The uncertainty of the stakeholders refers to exogenous uncertainty factors such as potential changes in dates, conditions, and prices, which are unpredictable and may result in contract changes. Behavioural uncertainties are also included, since

[42] Matthias Erlei, Martin Leschke, and Dirk Sauerland, *Neue Institutionenökonomik*, 2016, 42.
[43] Plettendorff, 'Die Neue Institutionenökonomik', 17.
[44] Elisabeth Göbel, *Neue Institutionenökonomik*, 2002, 100.
[45] Plettendorff, 'Die Neue Institutionenökonomik', 18.
[46] Arnot Picot, Ralf Reichwald, and Rolf Wigand, *Die Grenzenlose Unternehmung - Information, Organisation Und Management*, 2001, 49.

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each stakeholder, as a utility-maximising homo economicus, tries to interpret the institutional leeway in his favour. If a transaction has a high frequency, synergy effects can occur through long-term contracts and mutual dependencies. Factor specificity describes the reallocation potential of specific investments. If little or no reallocation can be made, the investing stakeholder is (highly) dependent on the partner's compliance with the contract, which entails an imbalance in the relationships between the stakeholders and thus a potential for exploitation by the non-invested stakeholder. Thus, the institutional framework to minimise transaction costs is central to this theory as well.

In summary, according to the theory, it is considered beneficial to bundle partial rights with the use of an object or resource and allocate them to the respective stakeholder. Furthermore, information asymmetries between stakeholders should be reduced by covering gaps and uncertainties through institutions such as contracts. Finally, the five sources of transaction costs should be considered by creating a framework for:

- barrier-free information access
- efficient negotiation and (legal) advice
- control of transport and process
- control of goods
- renegotiations and amendments

This is depicted in Table 3.

Table 3 - Types of transaction costs and how to reduce them. Source: Own depiction.

Transaction Type	Initiation	Agreement	Settlement	Control	Adjustment
Solution: Creating a framework for	Signaling & screening Barrierfree information access	Efficient negotiation and advice	Control of transport and process	Control of goods	Renegotiation and amendments

3.5 Synthesis

This chapter focuses on combining the different theoretical approaches. As no single theory has proven to be sufficient in order to answer the research question, it is necessary to use a combined analytical approach. A synthesis is generally understood as the unification of two or more components, elements, or features into a new, higher-level entity.

The central element of this synthesis is the VNA. As a process analysis method, it sheds light on the creation of value within the organisation or ecosystem under consideration. The term value goes

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beyond financial aspects and is therefore divided into tangible, intangible, and informational values. The main result of this method is the VND, which graphically depicts the value-creating interactions within the ecosystem under consideration. VNA is supplemented and modified by NIE and TBL. As a primarily economic analysis tool, NIE enables a perspective of economic optimisation through (transaction) cost minimisation and the mitigation of information asymmetries. This perspective is complementarily used to account for informational and partly for tangible values (knowledge products). The TBL framework further extends the approach to include the social and environmental dimensions. Consequently, a purely profit-oriented view of a company is no longer appropriate since the actions of companies also have social and ecological repercussions. This means that a company can operate profitably per se, but the social and ecological costs, and thus possibly also the macroeconomic costs, can turn out to be negative from a macro perspective.

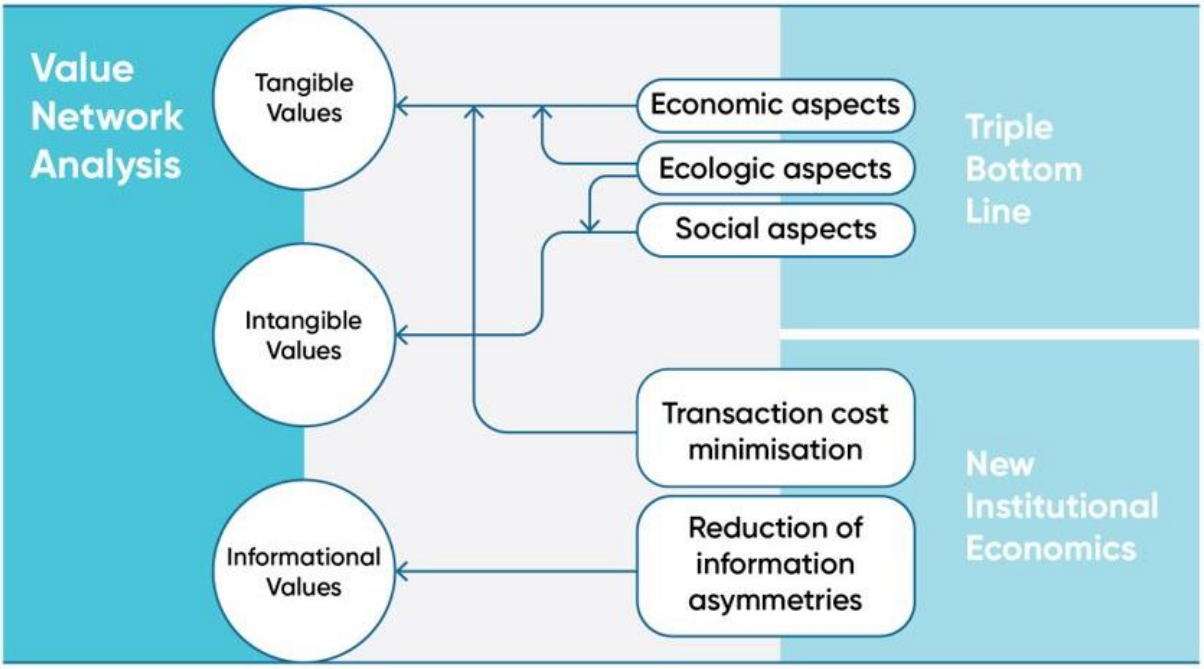

Figure 7 - Illustration of the modified theory strands. Source: Own illustration.

Figure 7 illustrates the main aspects of the different theories and how they are integrated to formulate a theoretical synthesis. The arrows highlight how individual aspects of each theory are integrated and associated with one another. For instance, tangible values comprise transaction cost optimisation from NIE and economic aspects of TBL. Intangible values are comprised of social aspects of TBL. Informational values are associated with the reduction of information asymmetries from NIE. Ecologic aspects from TBL are an exception and can be categorised into tangible and intangible values. This depends on the description and nature of the value in a given situation. Integrating different theoretical approaches enables the creation of modified VNDs that provide a more accurate understanding of the environmental and social value creation in addition to traditional economic analysis.

In conclusion, by combining these theoretical approaches, it is possible to create holistic strategies that consider the full range of values associated with a system such as MTME. This allows for a

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more comprehensive understanding of the potential impacts and opportunities associated with the system and enables decision-makers and involved stakeholders to make more informed choices regarding the allocation of resources and the development of new initiatives.

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4 Methodology

The methodology section discusses different methods utilised for data collection purposes in this handbook. In general, MTM is still in its initial stage, so limited quantitative data is openly available. This handbook therefore focuses on qualitative methods. The data is obtained through three primary methods:

- Literature review:
  Particularly regarding the understanding of MTM from a business, organisational, and market perspective.
- Workshops:
  1. Workshop organised with the community of practitioners (CoPs) and project partners: Using initial data obtained from the literature review, a workshop was conducted along with industry professionals and project partners to gain a deeper understanding of the MTM as an ecosystem and the role of the TO within it along with potential methods of creating different business opportunities.
  2. Workshop organised with the project partners was conducted to further comprehend value creation and transmission among the stakeholders of MTME, possible organisational structures were explored for the TO, and roles of various stakeholders like public authorities (PA) and tech companies were discussed in detail.
- Semi-structured expert interviews:
  Conduction of several interviews with experts from relevant fields to verify initial findings on value networks as business models and improving stakeholder collaboration.

4.1 Literature review

A literature review was conducted to analyse the state of research regarding MTM as well as sources relating to organisational and market models. The literature review regarding MTM focused on identifying the status quo and the latest trends in the field of MTM from an economic, social, and ecological perspective. Emphasis has been given to passenger and freight transportation. Extensive keyword-based research has been carried out to identify relevant scientific sources. The relevant keywords are “Multimodal Traffic Management”, “Traffic Management Ecosystems”, and “Integrated Traffic Management”. It is essential to address that MTM is still at an initial stage of development. Therefore, little significant research has been done in the field. To overcome this limitation, an extended list of keywords, including “Innovative Business Models”, “Organisational Models”, “AI-based business models”, “Mobility Platforms”, “Software-as-a-service”, and “Traffic Management”, was utilised. The scientific sources under examination consist of various scientific articles, research papers, audit reports. In addition to scientific sources, this report utilised other deliverables that conducted detailed literature reviews and yielded insightful findings on MTM. Specifically, reports such as the ORCHESTRA deliverables D2.2 and D2.3 were also analysed and taken into consideration.

D2.2 focused on pre-studies on environmental analysis and drivers, a literature review from an economic perspective was conducted there. This report offered insights into the current economic state of MTM, as well as the techno-economic challenges, gaps, and barriers of MTME. Additionally, the report discussed the environmental-economic and socio-economic drivers of

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MTME. As for D2.3, it provided an analysis of initial scenarios for MTM target vision under different scenarios. The report delved into the various information exchanges and support structures necessary to facilitate effective MTM among stakeholders. In summary, reviewing these sources provided valuable contributions to the study of MTM.

In the context of an organisational model for MTM, information from the ORCHESTRA deliverables D2.3 and D3.2 were mainly used as basis for the analysis. Sources outside the ORCHESTRA project work were examined especially in connection with existing traffic management structures. In particular, the structure of local and national authorities in the field of road traffic management in Germany were examined more closely. In particular, information from the federally owned Autobahn Ltd., Hessen Mobil and the EU Commission proved valuable in this context. Regarding the market model, information from D2.3 and D3.2 was used. Furthermore, the theoretical background was particularly relevant as a basis for the analysis (see chapter 3.4) as well as information on the advantages and disadvantages of insourcing and outsourcing and on tendering processes. For this purpose, a Google Scholar search was conducted to find fitting sources.

4.2 First Workshop analysis

To verify the initial research and gain more profound knowledge in MTM, the first workshop under T4.2 was conducted at the Herøya Industrial Park (HIP) with the ORCHESTRA project partners and the CoPs. The CoPs is made up of experts who are associated with the project. These experts come from diverse backgrounds and have expertise in fields related to MTM. To begin with, the workshop participants were presented with theoretical information on VNA, TBL, the MTM ecosystem and stakeholder archetypes. The workshop presentation consisted of basic information on creating VNDs and parameters for identifying external interactions for a VND. The parameters are listed below:

- Must be advantageous or adds value to recipient stakeholder.
- Value should be enabled by Multimodal Traffic Orchestration/MTM.
- Interactions must be directly influenced by/related to the enabling toolkits offered by ORCHESTRA's reference architecture.
- Knowledge flow which covers strategic intelligence on planning/processing information, is an interaction on the value network (informational value).
- Intangible benefits not covered by financial measures are interactions listed on the value network (e.g. benefits to the society/community).

In the next step, participants were provided with a handout which consisted of several external interactions. These interactions were used for reference purposes. Based on the experience and expertise of workshop participants, they came up with a new set of interactions.

The workshop further consisted of a group activity where four groups were created. Each group was asked to create two sets of VNDs (i.e. TO-TSP-FO and TSP-FO-NU). A detailed definition of the MTM stakeholders and their respective roles can be seen in Figure 2. Once the diagrams were created, each group presented their results and discussed vital interactions. The results of the workshop are discussed in detail in section 5.3.

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4.3 Data collection through semi-structured expert interviews

To gain a deeper understanding about the topic of MTM from an economic perspective, semi-structured expert interviews were conducted with experts from living labs, CoP members and other key stakeholders. The objective was to examine the assessments of experts on the given topic of MTM from an economic perspective. The method of semi-structured expert interviews was chosen because, on the one hand, it allows a focus on selected thematic clusters of interest and, on the other hand, it favours the flexibility of the interviewees to ask follow-up questions, give feedback and to set own priorities.

4.3.1 Choice of interviewees

The interviewees were selected based on their expertise and experience in the field of MTM. To select the interviewees, online research was conducted regarding the relevant stakeholders. Furthermore, personal contacts and references from partners were used to get in touch with experts from academic institutions, research institutions, public and private companies. Interviews were conducted with experts from the following backgrounds:

- An academic expert at the Technical University of Berlin. The Interviewee is associated with several European research projects focussing on future trends in the transport industry and sustainable mobility solutions.
- The managing Director at ITS Norway. ITS Norway is a member of the ORCHESTRA project, conducts research in the field of ICT combined with transportation. The Interviewee utilised the VNA method in their previous research projects and is an expert in dealing with VNDs.
- A researcher at the National Academy of Science and Engineering known as Acatech. Acatech is a non-profit public entity working on scientific topics. Their goal is to reduce the gap between engineering and scientific applications. The interviewee also worked closely with “EU Mobility Dataspace” during the initial stage and has experience in projects like Intelligent Traffic Management, designing of autonomous driving systems and further digitalisation projects.
- An employee at the HIP and Bouvet in Norway. They also worked at the Norwegian Public Roads Administration (NPRA). HIP is a private company; they are land and infrastructure owners and serve the industries in the park. HIP is associated as a Living Lab in the ORCHESTRA project and working closely with the researchers of ORCHESTRA. The interviewee has experience in the field of digitalisation, traffic handling, autonomous systems, autonomous and connected vehicles with a focus area in logistics.

4.3.2 Structure and evaluation of interviews

At the beginning of the interview, the experts were provided with some basic prerequisite information such as general terminologies, definitions, the general idea of the project and primary information on VNDs. This was done in order to acquaint the interviewees with the questions and give them a general understanding about the research project. Furthermore, the focus laid on identifying applicable business models to facilitate MTM with special regard not only to economic benefits, but also social and ecologic ones.

The interview questions were divided under two main research question areas:

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Research question A: What business/organisational model can be applied to optimally facilitate MTM and achieve economic, social, and ecologic benefits?

Research question B: How can a resilient and flexible business model be designed to promote collaboration and increase macroeconomic benefits for the relevant stakeholders?

The interview was designed to last for approximately 1 hour and had four main sections. The four sections were introduction, general questions, economic section, and discussion questions. General questions focussed on business models and comparable approaches of business modelling practices relevant to MTM. Discussion questions included open ended questions and follow up questions based on the expert's background and knowledge. The economic section was the central pillar of the interview and comprised of several topics. The main topics discussed in the economic section were as follows:

- Validation of the approach via VNA.
- Relevance of TBL in an organisation and its implementation on ground level.
- Attractiveness of MTME for companies.
- Collaborative relationships between the TO, TSP, and FO as well as other relevant stakeholders.
- Improving flexibility in the existing business models. Flexible switching of transportation providers in case of disruptions.
- Real-time data exchange between relevant stakeholders for accurate and precise traffic information.
- Role of authorities, regional governments, and transport authorities for successful implementation of MTME.

The interviews were recorded and transcribed to further evaluate the results. A signed consent form was provided by the interviewees which covered the permission to record the interview. Interview protocols were created based on the questionnaires and inputs from the interviewees. These protocols were used to further analyse the results of the interviews. The results of the semi-structured expert interviews are discussed in section 5.4, and the interview protocols are attached in the appendix (see Appendix A.1).

4.4 Second workshop analysis

The focus of the second workshop was on answering critical questions that emerged after the analysis of the first workshop followed by the semi-structured expert interviews in order to achieve a conclusive version of the models and diagrams presented in this handbook. These challenges were summarised into six key areas, where the main research question addressed during the workshop is underlined:

Type of Data Shared

Comprehensive, time-accurate individual data such as the real-time location of vehicles, the planned route, and the transported cargo allow optimal traffic orchestration since it is then possible to react flexibly. However, this requires legal compliance with data rights such as the GDPR.

According to the findings in the workshop, historical data is comparatively uncritical to use because it does not interfere with the data rights of individual stakeholders. However, it is less accurate than

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precise individual data on cargo and real-time location. Historical data could accordingly lead to inferior results in traffic orchestration.

In this context, the question arises as to how this conflicting issue can be resolved. To what extent does data protection law allow the collection and processing of individual and time-accurate data? Is it possible to combine relatively uncritical personal and time-accurate data together with historical data? Or must the pure use of historical data be resorted to?

Data Sharing Mechanism

The idea of MTM is based on the benefits of additional, comprehensive information that can be provided regarding traffic. This data is collected by companies, such as transportation companies, and institutions, such as weather research institutes or government agencies, and processed by an institution such as the TO. Much of this data has value, may include trade secrets, and is often protected by data protection laws.

In this respect, the question of the data sharing mechanism arises. It is conceivable to create a legal basis according to which there is an obligation to share data with a protected institution such as the TO. This would have the advantage that extensive data would be available for processing already at the start of the system and, accordingly, the system would be able to make precise calculations and provide qualitative results from the beginning. But it is questionable to what extent the creation of such an obligation conflicts with existing data protection law.

Another option is an incentive system for data sharing, i.e., data monetization. In this case, the data provided by companies is paid for with financial resources. In return, the service of data processing and the calculation of optimal routes or optimal network utilisation would in all likelihood also require payment from companies that use MTM. In this case, there is a possibility that the quality of the system is compromised. If few companies join the system, the processing of insufficient data will lead to low-quality results from the system, which will also be a disincentive for already participating companies to remain in the system. A negative snowball effect, in which customers leave the system due to low quality data and the quality continues to drop further as a result, causing more customers to give up, would be imaginable in this scenario.

In the context of this conflicting situation, the question arises to what extent does a legal obligation to share data conflict with current data law?

System Launch

The system is especially qualitatively functional if as much traffic-related data as possible is supplied. If a legal obligation to share data is not chosen or proves impossible, data monetisation is a likely scenario. In this scenario, companies would sell their traffic-related data to the TO and pay for the traffic orchestration service in return. If this offer does not reach enough potential customers in the initial phase, the amount of traffic data received and therefore the quality of traffic orchestration will be low. A combination of the two approaches is also conceivable. For example, a legal obligation to share data classified as non-critical could be introduced and, in addition, incentives to share further data could be created.

So here the question arises about the measures to make the system attractive from the very beginning. For example, financial benefits such as an attractive fixed price for data packages for a limited period of time, degressive (i.e., decreasing over time) subsidies for participating companies, tax breaks, and similar measures would be feasible. At the same time, it must be remembered that

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government incentives are paid for by taxpayers' money and are thus limited. Non-financial incentives are also possible, such as priority parking, or green certificates.

In this respect, the aim here is to collect ideas as well as advantages and disadvantages of certain incentives for the system launch. In the case of financial incentives, potential costs in particular should be weighed up against the level of the incentive.

What is the most cost-efficient way to incentivise the early participation in the system?

Hedging Mechanism

By providing a variety of business-related data, such as the exact cargo of a delivery, the planned route and the real-time location, companies make themselves potentially vulnerable. If such data is shared and then hacked or leaked, the financial damage can be severe. In this respect, it is important on the one hand figure to credibly insure against potential data leaks and on the other hand to protect against the event of damage. If this is not the case and companies do not weigh their data in safety or are not protected against the event of damage, there is an increased risk as a result of joining the system, which can have a deterrent effect and make the system unattractive.

In this respect, it is important to consider the extent to which corresponding securities can be provided by government stakeholders and how an insurance concept could be designed.

How can PAs ensure the safety of the system? How can an insurance framework be designed, that is both, secure and affordable?

Nature of the Stakeholders

For the TO in particular, it has not yet been definitively determined in which role it will appear. This mainly concerns the organisational form. It is conceivable that the TO will be a private-sector, state or mixed stakeholder, a so-called private-public-partnership. In addition, in view of the rapidly advancing development of AI, the question arises as to what degree the task would actually be performed by humans, or not largely by AI under human supervision.

In this respect, it is important to discuss the effects of the organisational form of the TO. If it is privately owned, a business model including revenue sources and profit must be designed. If it is state-run, its responsibilities, rights and duties must be defined. If the TO acts as an AI, special consideration must be given to the additional risks that arise and how they can be hedged.

So, what needs to be considered for these different organisational forms? Which organisational form is preferable under which situation?

Role of PAs

Another critical question is to what extent PAs would be involved. On the one hand, cooperation with PAs helps inform about occurring events, which can also have traffic consequences. On the other hand, the question arises to what extent PAs could be involved in the administration of MTM and form a regulatory framework. PAs can force companies to collaborate, especially during disruptions. Interview results have revealed some aspects where the PAs role could benefit the system. For instance, the presence of PA could enable trust among the stakeholders in MTME. It will be assured to the stakeholders if a PA oversees data storage and monetisation facilities. In addition, PAs can use their political influence and attract big tech companies to participate in MTME. On the contrary, experts also suggested that the system would be more beneficial if the local transport authority were associated with MTME. Since local transport authorities are aware of

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local bottlenecks, they can take a proactive approach to fix disruptions and congestion compared to regional authorities. However, if a PA is involved in MTME, they must be regulated and mandated to cooperate on a multimodal level.

In this respect, it is important to establish and understand the role of PAs and their integration and tasks in the system. What tasks do PAs perform in MTM?

These questions were raised to the Orchestra project partners during the plenary meeting in Berlin. The results of the workshop are discussed in section 5.5, and the workshop handouts are attached in the appendix (see Appendix A.2).

4.5 Model creation

This section discusses the creation organisational models and VNDs for MTME. The aim is to establish a flexible and resilient framework by integrating the TO into existing traffic management structures. The organisational model emphasises loosely linked alliances of specialised organisations working together. The example of road traffic management in Germany is examined to explore the integration of TO into the existing system. The organisational model aims to be flexible and resilient in handling unforeseen disturbances.

Additionally, the creation of VNDs for different target vision scenarios in MTM is discussed. These VNDs highlight the central stakeholder archetypes and prioritise the values associated with each scenario, including business-as-usual, foreseen disturbances, and unforeseen disturbances. By extracting relevant values from various sources and classifying them into tangible, informational, and intangible categories, the essential values for MTME operations are identified. Stakeholder-specific and systemic values are differentiated, with the latter benefiting all stakeholders in the ecosystem.

4.5.1 Value network creation

As a result of this handbook, business models in the form of VNDs which involve the central MTM archetypes are created for each of the three target vision scenarios (as described in D2.3), where the priority values under each situation are highlighted. These scenarios comprise of the BAU case, the foreseen disturbances case, and the unforeseen disturbances case.

To create the VNDs, the relevant values are extracted from the source material (literature, expert interviews, workshops, etc.) and then listed and classified into the value types: tangible, informational, intangible. This list is then shortened according to predefined criteria. The idea here is to consider only those essential values from an operational point of view of the MTME. Furthermore, these values also showcase how to facilitate the MTME optimally. The chosen criteria ensure an optimal fit of the values to each situation under examination. In a qualitative data analysis such as the one conducted in this handbook, frequent mentions, or special emphasis on certain aspects in the literature or in interviews can provide valuable indications. It should be noted that values are usually assigned to stakeholder relations (e.g. TO-TSP) and should be formulated accordingly. If value is generated beyond transaction-based values between stakeholders, it is possible to graphically depict this in addition to the VND as overall systemic values. To help understand how the value flow moves from one stakeholder to the other, an example is shown in the Figure 8 below between the TO and TSP. The TSP provides the TO with traffic related data and

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payment for their services, and in return the TO provides guidance under different traffic situations, along with real-time updates on traffic regulations and measures.

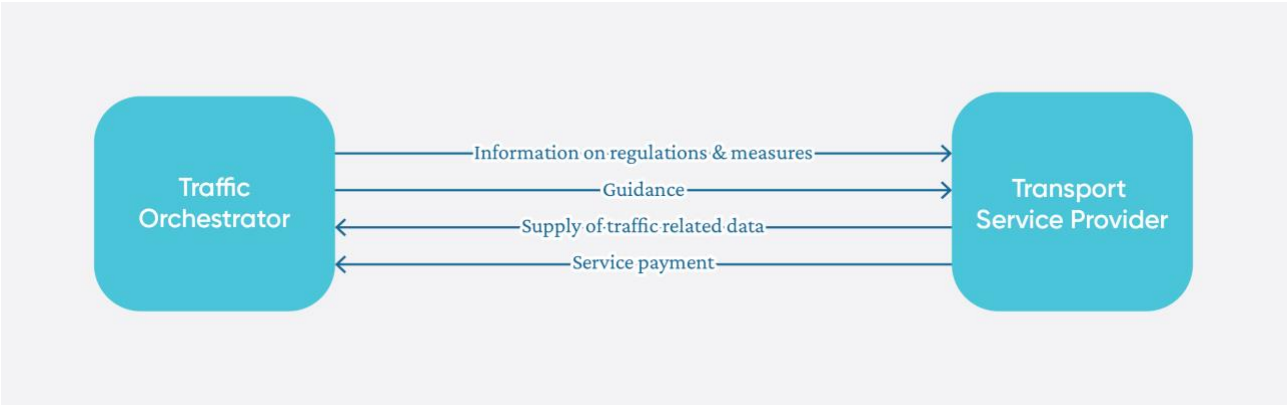

Figure 8 – Example of value flow between TO and TSP. Source: Own Depiction.

In a next step, the values obtained are reduced by elimination or by summarising existing values into general values that are merged together. It is important to note that the values are further classified as stakeholder specific values and systemic values. In stakeholder specific values, the value flow occurs from one stakeholder to another, as for systemic values, they are values that benefit all the stakeholders in the ecosystem as a result of successful MTM operation. Finally, the roles are arranged logically (e.g. main actor in the middle, orchestrator on top, etc.) and connected by the final values in the form of transaction arrows. As a result, the VND is created. For reasons of simplicity, in the graphical representation, only priority values are depicted in the VNDs of scenarios 2 and 3 that occur in the case of foreseen or unforeseen disturbances compared to the BAU-VND presented under scenario 1.

4.5.2 Organisational model creation

This chapter addresses how to create an organisational model for MTM. The central idea is to integrate the TO into the existing traffic management structure in a flexible and resilient framework. The term organisation is defined as a consciously coordinated social unit, composed of two or more people that function on a relatively continuous basis to achieve common goals.[47] An organisational model is defined as "a representation or description of the structure and operation of an organisation. It is a simplified representation that illustrates the relationships between different parts of the organisation and the interactions between different roles and responsibilities."[48] This is usually visualized in an organisational chart. The purpose of the organisational model is to explain the responsibilities of the different actors in the context of traffic orchestration and to create a model that is both resilient and flexible, particularly in the context of different scenarios such as foreseen and unforeseen disturbances. For a complex system with a multitude of differently specialized

[47] Stephen P. Robbins, *Organizational Behavior : Concepts, Controversies, Applications*, 7th ed, Prentice Hall International Editions (Englewood Cliffs, NJ: Prentice-Hall International, 1996).
[48] Cambridge Dictionary, 'Definition of Organisational Model', 5 April 2023, https://dictionary.cambridge.org/dictionary/english/organizational-model.

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actors like MTM, the format of the network organisational model is particularly suitable. This can be described as a loosely linked alliance of organisations, each with their own specialised functions, working together towards a common goal. Each organisation maintains their own functional expertise while collaborating and sharing resources to achieve shared objectives. The model emphasises flexibility and responsiveness, and is often used in industries such as technology, consulting, and professional services.[49]

Traffic management in the respective transport modes of air, water, rail, and road is organised differently, is complex and differs in part also in different countries. Optimal integration of a new entity such as the TO therefore requires a case-by-case assessment. A presentation of the entire structure is thus outside the scope of this handbook. This is why the status quo of the responsibilities and organisational structure of the local and national authorities will be examined and broken down in more detail using an example. This example is the road traffic management in Germany. In a next step, the options for integrating the TO will be into this system will be examined. The resilience and flexibility of the model is particularly evident in the case of unforeseen disturbances. So, in conclusion, it will be shown how these can be handled within the framework of the model.

4.5.3 Market model creation

A market model describes the supply and demand structure in a specific market sector. In particular, it examines factors that can influence supply and demand, such as product or service quality, prices, soft factors such as environmental and social sustainability, etc. In perfect competition, the higher the price and thus the higher the potential margin, the more suppliers enter the market, while consumers increasingly demand the good when prices are low. This results in opposing supply and demand functions. The point at which these functions intersect is referred to as the market equilibrium (see chapter 3.4.1). In many markets, however, there is no perfect competition. Rather, most markets range between the extremes of free market with (almost) perfect competition and a state market model which, especially in the case of natural monopolies (railways, telecommunications, etc.), has defined a state monopoly enterprise entirely without competition. The spectrum between these two extremes can be called the regulated market model, in which companies are subject to more or less strong state regulation, but still operate in competition.

For the creation of the market model, factors are first analysed that determine the demand for the service of traffic orchestration as a central element of MTM. Furthermore, criteria relating to the supply structure are identified, which enable an assessment of the market regarding the spectrum of the regulated market. Finally, the challenges posed by these criteria in relation to security requirements on the one hand and competition and innovation requirements on the other are examined.

[49] Richard L. Daft and Dorothy Marcic, *Understanding Management* (Cengage Learning, 2022), 226 pp.

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5 Data collection

This section highlights the main findings from different methodologies. It comprises the subchapters literature review, first workshop, semi-structured expert interviews, second workshop and data security concerns. The objective of each method was to identify essential values from the business and organisational perspective. Readers can identify values as they are highlighted in bold. A further detailed description of each value is provided in the respective section. Some results appear across multiple methods of data collection. For example, if a result appears in the literature research, the interviews, and the workshops, it is likely that it is a result of high relevance.

5.1 Input from other deliverables

The preliminary work on MTME in the ORCHESTRA project provides an important basis for this handbook. Therefore, the target vision scenarios from D2.3 in particular, but also other important aspects from other deliverables, will be described below. The target vision provide functional solutions for how the MTM system would ideally work under different situations. The models developed in this handbook are closely linked to these scenarios. The scenarios address three different traffic management situations regarding people and freight transport, namely business as usual situations, foreseeable disturbances, and unforeseeable disturbances, and how four different stakeholder archetypes, namely TO, FO, TSP, and NU, use and are supported by the functionality provided by the systems and tools involved, and the value or effects achieved. In addition, the scenarios assume that all barriers and gaps in the MTM ecosystem are removed, resulting in "successful" and "ideal" MTM operations.

Scenario 1: Traffic management of BAU case

In transportation systems, minor incidents and events occur during traffic flows. These can be managed without causing significant disruptions to the overall traffic flow, thereby avoiding the need to transfer traffic to alternative networks or modes. During normal operations the TSP is responsible for adjusting the transport chains to meet the needs of NUs and TUs. At the same time, the FO is responsible for controlling and regulating transport operations. In addition, the FO monitors ongoing transport operations progress to ensure smooth and efficient execution. The TO continuously receives input from different actors and sources to ensure seamless transport through networks and modes. For example, the TO receives planned transport information from TSPs, including details on time schedules, transport types, and other relevant information. It also receives information on planned and ongoing transport operations from FOs, including the type of operation, start and end points, route, destination, load type, capacity, and load factor. Additionally, the TO receives real-time information from NUs on their network use, such as updates on the FO's time schedule.

With these inputs, the TO uses tools to monitor and gain awareness of current and upcoming situations, including real-time data and historical information to support predictions. The TO then communicates relevant information to other actors, via open information channels to TSPs and FOs that subscribe to information on certain transport operations or parts of the network. The TO also takes transport demand management (TDM) measures, such as regulating speed or controlling access to certain areas, based on predefined rules to optimise traffic flow. TDM is the traffic volume

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and type influenced through measures taken based on well-defined conditions. This may be automated as a part of the traffic management during normal traffic situations, but measures and conditions may also be initiated to handle unnormal situations.[50]

When abnormalities the system cannot handle are detected or predicted, the system notifies the TO to trigger manual actions. The TO then uses decision support tools to decide on the best course of action, such as alternative ways to handle the situation or taking manual measures towards individual NUs. The TO may also introduce new TDM measures to avoid congestion related to public events. TSPs use tools to plan transport chains according to shippers' wishes and requirements, avoiding networks where problems are expected. The FO reports its planned or re-planned operations to the respective TOs, including start and end points, route, destination, schedule, load type, capacity, and load factor.

In summary, the TO employs a variety of tools, inputs, and actors to manage normal transport operations, including minor incidents that can be handled without much effect on traffic. By continuously monitoring and gaining awareness of the current and upcoming situations, the TO can take TDM measures, trigger manual actions when necessary, and introduce new measures to avoid congestion. Furthermore, through communication with TSPs and FOs, the TO enables seamless transport through networks and modes.

Scenario 2: Handling foreseen disturbances

Foreseen disturbances involve identifying potential situations and deciding how to address them through Demand Capacity Balancing (DCB) and dynamic utilisation of transport mitigation actions such as TDM measures. DCB is performed when an imbalance in the network capacity and the transport demand are foreseen or occur, specific measures may be taken towards selected vehicles/vessels to reduce the traffic volume or to increase the capacity in the network.[51] The aim is to minimise the impact of such disturbances by supporting transportation actors and coordinating with other networks and modes to ensure their readiness. Foreseen disturbances can arise from various causes, including scheduled maintenance, weather conditions, daily or seasonal traffic peaks, and specific events that may cause road or underground congestion.

The potential disruptions in a transportation system may include reduced capacity in specific networks, increased traffic in neighbouring networks, and the use of various mobility solutions such as micro-mobility, car sharing, ride-hailing, e-scooters, and connected autonomous vehicles (CAVs). Additionally, in underground metros, TOs monitor various data, including weather data, to detect extreme weather forecasts that may cause flooding in parts of the underground, thereby disrupting some metro lines. However, the situation can be planned and prepared in advance, as flooding is not expected until the next day. Furthermore, alternative transport networks can direct affected traffic, especially in overground urban networks, as some underground metro lines have limited capacity. The transport operations of FOs may also be affected due to increased traffic in other networks, but FOs can utilise the need for more transport due to problems in the metro. In

[50] Marit K. Natvig et al., 'ORCHESTRA Project Deliverable: D3.1', 5.
[51] Marit K. Natvig et al., 5.

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summary, foreseen flooding in the underground is expected to result in higher traffic density, affecting the NUs in the road network.

Scenario 3: Managing unforeseen disturbances

Unforeseen incidents in a network can be in the form of accidents, sudden obstructions such as vehicles blocking the network, avalanches, landslides, sudden floodings, and technical problems causing limited capacities, such as the reduced ability to control CAVs, sudden traffic orchestration outages in one governance area, or heavy traffic flow in one network due to the re-routing of passengers and freight.

One scenario is a significant accident on a main highway with high traffic volumes. After a short period of complete traffic flow stoppage, some traffic can pass. However, the capacity is reduced to less than 20% of the total capacity. Redirecting the affected traffic to alternative routes is limited, and private roads in a neighbouring network can be used as a short detour if the owner allows this, but large trucks cannot use them due to low bridges. Other detours will take up to two hours extra. In another scenario, the TO in a road network cannot function due to a technical outage. There are two options in such situations: a backup solution exists, and there is no need to close the network or operate with limited capacity, or the TO of another governance in the same network takes over the responsibility of the affected area. Close coordination with neighbouring networks is necessary to manage the traffic flow within a large transfer node such as an airport.

For example, a sudden, unforeseen technical problem in the rail network causes a stop in all rail transport to the airport. Buses are used to pick up train travellers for further transport to the airport. Travellers without boarding the train must find alternative solutions, and their TSP supports them. As it is close to a weekend, the roads are already congested. After a silent period with no arrivals from the rail network, many passengers arrive via the road network. This may cause delays in check-in, security control, and boarding. If boarding is delayed, planes must leave with fewer passengers, and those who arrive late at the airport may miss their flights. Finally, sudden, unforeseen accidents in the road network can affect freight transport by reducing network capacities. In such cases, TSPs have subscriptions to information from the TOs along the transport chains to enable better management of incidents.

Further Input from other deliverables

The target vision scenarios envision a favourable environment for the operation of the MTME. One of the crucial aspects highlighted in the target vision scenario is the **integration of CAVs**.[52] CAVs can make real-time information sharing accessible and valuable in traffic management, especially in the case of disruption/congestion. The vehicle owners can be notified in real-time about the congestion on their way ahead, and they can take an alternative route and avoid the congestion. From a business and economic perspective, it is beneficial to have vehicle manufacturers, especially Original Equipment Manufacturer (OEM) manufacturing CAVs this way, the OEMs can be integrated and associated with the MTME, and the entire ecosystem can be benefitted from real-

[52] Ludovic Vaillant et al., 'ORCHESTRA Project Deliverable: D2.1 Initial Target Vision for Multimodal Traffic Management Ecosystem', 30 November 2021, 18, http://www.orchestra2020.eu/.

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time information sharing and efficient traffic management. Optimisation[53] is another critical aspect addressed in the MTM target vision. With the implementation of a successful MTME, the stakeholders involved in MTME can optimise their products/services via efficient MTM. Optimisation can be achieved regarding modal split choices, route selection, etc. Optimisation can also be characterised by economic, societal, and environmental aspects. It can encourage more participation and improve the overall business and economic conditions of the MTME.

MTM is an attractive concept, especially for MaaS companies.[54] MTM can be helpful for MaaS companies to improve their services and better serve their customers in terms of modal choice, offering the shortest routes and avoiding congestion. Participation of MaaS companies is also beneficial to the entire MTME because MaaS companies withhold significant amounts of traffic-related data and are associated with several FOs and TSPs, which can be helpful in the event of a disruption/congestion. Based on the suggestions offered by experts during interviews[55] majority of respondents highlighted they currently rely on a traffic management software which is tailor-made and customised to their own needs. Some companies rely on the tracking/traffic data offered by Google Maps, Tom Tom or others since these companies can offer tracking/traffic-related data from different modes of transport and in bulk quantities. The data received from these is easy to integrate with the existing traffic management systems, and hence they have a preference over others. This highlights that companies have invested in and developed their personalised solutions. It is important to note that the business models designed for MTME must offer flexibility to the stakeholders to utilise their traffic management software alongside the traffic orchestration services provided by the TO. New business models must promote collaboration among the stakeholders; initial target vision scenarios[56] suggest that business models must encourage collaboration across borders and transport corridors. Business models must also promote green cooperation.[57] FOs and TSPs must be rewarded when they use green fleets or focus on sustainability in their daily operations. Traditional business models have long-term contracts that are not at all flexible.[58] New business models must offer flexibility to TSPs and FOs to switch their service providers, especially during disruption/congestion. It will engage the stakeholders to play proactive roles in resolving the disruptions.

5.2 Literature review

This section examines different research activities and projects conducted in the field of MTM. Additionally, it aims to examine the current state of MTM and to identify important and relevant values in this context.

[53] Ludovic Vaillant et al., 45.
[54] Benjamin Grosse et al., 'Pre-Studies on Environment Analysis and Drivers' (ORCHESTRA Project Deliverable: D2.2, 30 May 2022), 53.
[55] Benjamin Grosse et al., 60.
[56] Ludovic Vaillant et al., 'Initial Scenarios for Multimodal Traffic Management' (ORCHESTRA Project Deliverable: D2.3, 30 April 2022), 21.
[57] Marit K. Natvig et al., 'ORCHESTRA Project Deliverable: D3.1', 41.
[58] Marit K. Natvig et al., 41.

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The Traffic Management System (TMS)[59] research project focusses on resolving bottlenecks caused by traffic congestion. TMS gathers traffic-related data from various sources, including automobiles, traffic signals, and roadside sensors. These data are then processed in a Traffic Management Centre, which helps increase traffic efficiency. TMS relies on two factors: information collection and information processing. However, a critical challenge is the need for more traffic information to provide an accurate and complete picture. TMS relies on the supply of accurate and exact information in order to produce qualitative data. This highlights a significant value that is also necessary for the MTME: **accessibility to real-time traffic-related data**. This value should be considered a prerequisite for the MTME.

Artificial Intelligence (AI) based system known as Ultimate Traffic Management (UTM)[60] is aimed at predicting airport traffic flow and better managing human traffic through customs and boarding gates. One use case of UTM is at international borders, where congestion is a significant issue. The UTM is meant to smoothly manage cars and cargo vehicles at borders. However, there could be integrated usage of UTM with other traffic management solutions such as TDM and DCB. Efficient management of private and cargo vehicles can benefit cities and congested metropolitan areas. This highlights the critical value of **reducing congestions** across transport networks. From an MTME perspective, the system must minimise road congestion. The TO must take proactive measures and guide stakeholders so that the congestion can be avoided aforehand. AI systems are helpful to the freight industry. The AI system can help in the route planning of ships, route optimisation in real-time, reducing delivery costs, improving delivery time, and reducing layover times.[61] For freight forwarders, it can help the planning of trucks well in advance. With the help of AI, Transport Management Systems tools can design and organise **precise missions/assignments**. This value of managing exact missions/assignments is critical for the stakeholders of MTME. With the help of accurate traffic orchestration offered by the TO, stakeholders like FO and TSP can organise their missions/assignments efficiently with minimum delay.

Each Railway Infrastructure Manager is responsible for managing traffic in their respective region. In addition, each EU country has their own Traffic Management System. However, the efficiency of TMS is limited since it is not completely interconnected with the stakeholders. As a result, trains must face unnecessary delays throughout their journey. OPTIMA[62] focuses on developing a communication platform where all these TMS can interact with each other and improve overall traffic efficiency across the rail network. Furthermore, it ensures this platform has *standardised interfaces such as data structures and communication protocols* suggested by European Rail Traffic Management System (ERTMS). In MTME, the TO needs to manage raw data from different modes

[59] Allan M De Souza et al., 'Traffic Management Systems: A Classification, Review, Challenges, and Future Perspectives', *International Journal of Distributed Sensor Networks* 13, no. 4 (2017): 1550147716683612.

[60] Kelley Rickard, 'The Ultimate Traffic Management System: Making Traffic Work', 15 August 2014, https://www.researchgate.net/publication/282325343_The_Ultimate_Traffic_Management_System_Making_Traffic_Work.

[61] Sussane Boll-Westermann, 'AI Business Models for Travel and Transport.' (Lernende Systeme, 2020), https://www.plattform-lernende-systeme.de/publikationen.html.

[62] Gabriele Cecchetti et al., 'Communication Platform Concept for Virtual Testing of Novel Applications for Railway Traffic Management Systems.' (ELSEVIER B.V., 8 September 2021), https://www.sciencedirect.com/science/article/pii/S2352146522002307?via%3Dihub.

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of transport. Therefore, the data received and transmitted by the TO must be easy to integrate with other digital solutions/platforms. This raises a key concern of *data standardisation*. To have an efficient flow of information within MTME, stakeholders must follow common data standard formats. Standardised data formats can ease the integration of CAVs and provide real-time data for better traffic management purposes. In addition, it will allow transport authorities to create flexible solutions without vendor lock-ins.[63] A new solution is often not feasible because the switching cost is extremely high, and cities cannot afford it and are forced to use the services of existing vendors. Thus, focus should be on **implementing flexible solutions** which do not create dependency on one single vendor.

EU transport policy focuses on accelerating the digital transformation of the EU transport sector. Several initiatives (the mobility data space, iSHARE, Smart Otaniemi) enable the sharing of transport data for passenger and freight transportation in business to business, business to government, government to business, and government to government domains.[64] Sharing of transport data is an integral part of MTME. Interdisciplinary collaboration with mobility data-sharing initiatives can help construct sustainable business models for the stakeholders of the MTME. The future business models must offer **interoperability** to the involved stakeholders. The TO can collaborate with such data-sharing initiatives and encourage the stakeholders of the MTME to share their data. This way, stakeholders can participate in the MTME and get associated with EU-wide data-sharing initiatives. Mobilithek[65] is a data-sharing platform developed by the Federal Ministry of Digital and Transport. It acts as a marketplace of mobility-related data for transport authorities, start-ups, companies, and infrastructure managers. The data is shared, which is only relevant to transport policy, for instance, road safety or public transport-related data. Companies interested in data sharing can exchange data on this platform and try out new business models in an ethical manner.

Revenue generation in the public transport and traffic sector is not a priority. Often authorities are under the compulsion to reduce congestion and get the disruption under control at the earliest. When considering MTM, the hurdles to revenue generation still apply. Funding from the government can be an alternative. **However, this will make the entire MTME system dependent on such funding schemes and public financing.** Hence there needs to be a radical approach to revenue generation of the MTME. Future business models should focus on generating revenue and how the revenue generated can be channelled effectively throughout the ecosystem.[66]

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[63] Paul Grefen et al., 'Creating Agility in Traffic Management by Collaborative Servie-Dominant Business Engineering.' (HAL, 17 January 2017), https://hal.inria.fr/hal-01437936/document.

[64] Christoph Mertens, 'Workshop on the Common European Mobility Data Space.' (European Commission, 2 December 2021), 2, https://digital-strategy.ec.europa.eu/en/events/workshop-common-european-mobility-data-space.

[65] BMDV, 'Mobilithek - Germany's Data Plattform That Gets You Moving', Government, *Mobilithek - Germany's Data Plattform That Gets You Moving* (blog), 1 July 2022, https://bmdv.bund.de/SharedDocs/EN/Articles/DG/mobilithek.html.

[66] Steve Kearns et al., 'STRIA Roadmap Network and Traffic Management Systems.', November 2016, 34, https://trimis.ec.europa.eu/sites/default/files/2021-04/stria_roadmap_-_network_and_traffic_management_systems_0.pdf.

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5.3 First workshop

This section focuses on the workshop results and insights obtained in collaboration with the CoP members and project partners. The workshop provided new insights on key stakeholders and values being exchanged in the ecosystem. The results facilitated in understanding how each stakeholder can improve their services and benefit their respective business. The key stakeholders' archetypes for MTME include the TO, TSP, FO, NU, and TU. However, the participants highlighted new stakeholders who are critical for MTM. These stakeholders are primarily PA, OEMs and Solution Providers (IT/Tech companies). During the workshop, the participants designed their own VNDs based on their own experience and expertise.

A central result of this was transmission of data. In particular, the real time location, the planned route, and the transported cargo represent important data. Historical data, for example on the network utilisation/capacity, can also be implemented. This data can be obtained from the companies owning the vehicles/fleet. Data on network utilisation/capacity can also be obtained from local and regional transport authorities. Further information, such as expected weather conditions and upcoming events (e.g. by PA) is also used. This can be summarised as **supply of transport and traffic-related data** to the TO. This cumulated information is processed by the TO and used to calculate ideal routes, ideal network utilisation across all modes and thus contributes to the reduction of congestions, accidents, and disruptions in traffic. This can be summarised as the **guidance** of the TO. This processed data is then transmitted to the stakeholders in order to establish optimal, dynamic route recommendations.

The participants pointed out, that recipient stakeholders can further optimise their business this way, as it offers higher planning security and efficiency while reducing risk. For instance, FO and TSP can better manage and plan their resources and offer more reliable services to their customers. Moreover, the workshop participants highlighted that TO and PA are likely to work closely together, not on an administrative level but on a daily operations level. Another idea pointed out by the participants is the **feedback mechanism**. According to this, stakeholders constantly sharing real time traffic data in the network and receiving feedback on the choices they make can greatly benefit the system. The TO will receive feedback to the suggestion/guidance offered to other stakeholders. It is imperative for the TO, to analyse the repercussions caused by their suggestions/guidance so that they can improve their services in the future.

Moreover, some systemic benefits of MTM were also discussed. MTM enables the **optimal utilisation of the whole transport network across all modes**, which also implies reduced emissions and costs. This also allows **avoiding unnecessary expansion of transport infrastructure**, since the existing network is optimally utilised, and the utilisation of standard and alternate routes is known through the supply of traffic-related data. Companies and private individuals also benefit from **more available time and greater planning security**. Taking into consideration the three different categories of values, workshop participants highlighted that the MTME network will be dominated by tangible values, followed by informational values and intangible values.

5.4 Semi-structured expert interviews

This section focuses on the results of four conducted semi-structured qualitative interviews with representatives of the following companies: ITS Norway, Technical University of Berlin, HIP,

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Lernende Systeme/ACATECH. In the following, the central results of the interviews are presented. A full summary of the interviews can be found in the appendix (see Appendix A.1).

Both the focus on environmental and social aspects in addition to financial ones and the VNA approach were positively received by the interviewees. From an organisational perspective, it was emphasised that especially data standardisation, easy admission to the system, e.g. through free access can provide an efficient and user-friendly architecture of the system and thus reduce transaction costs. With regard to the added value created, it was emphasised that a contingency plan of the TO contributes to its ability to mitigate traffic disturbances. As part of the value flow, this is represented as part of the **guidance** of the TO. As in the workshop results, the relevance of the type of data submitted to the TO was also pointed out. Ideally, this should include the financial value and importance of goods (e.g. hazardous goods or equivalent), their real time location, capacity, and desired route. Regarding the value flow, this can be summarised as **supply of traffic-related data**. Furthermore, the ability of the TO to **promote and prioritise green transport** was highlighted. The increased reliability, security and sustainability of the system can also lead to increased **customer loyalty**. Another potential benefit emphasised by participants was the increased **flexibility in route planning** for FOs, allowing for expanded customer acquisition beyond long-term supply contracts.

The interviewees also compared other projects to the idea of MTM. For instance, the Port of Los Angeles developed a “Marine Exchange” system. It is a non-profit entity created by member companies which guide vessels and vehicles by offering timeslots for entering the port. Many companies have overcome their initial scepticism and are now highlighting its benefits. Benefits include improved daily operations, and it was observed that there was a significant reduction in congestion. **Over time, companies started to trust this system and acknowledged the advantages of the guidance and information received from “Marine Exchange”**. Furthermore, the participating companies trusted that a non-profit entity does not aim to support/favour a particular business/stakeholder. Instead, the objective is to handle the congestion with the best available resources efficiently.

Furthermore, software accessibility was given a high priority in the “European Mobility Dataspace” during its initial phase. This initiative was developed in an open-source format and all companies were able to sign up for free and exchange their data. A similar approach with low barriers of entry could also be beneficial for MTME.

In addition to the potential benefits of MTM, challenges and other issues to consider were also discussed during the interviews. First of all, the basis of data transmission can be mentioned here. **A legal obligation to share relevant data or an incentive system that enables data monetisation are conceivable**. A legal obligation must comply with existing data protection laws, such as the General Data Protection Regulation and the Data Governance Act and is hence limited by these. Data monetisation can also open up an additional revenue stream for companies but raises the question of potential costs. **The vulnerability of such an abundance of data should also be mentioned**. The participants particularly emphasised the need to protect this in a reliable and sustainable way. Especially if the TO were to be a government stakeholder, there must be corresponding assurances from the government. Insurance against cyberattacks to cover large-scale damage would also make sense. Without such risk reduction, the field of operation could appear unattractive to many companies, which can be critical, especially during the market ramp-up phase. If additional costs are incurred for participants during the market ramp-up phase, **temporary**

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financial support, especially for small to medium-sized companies, was also mentioned as an option to enable system entry. Ultimately, the system is primarily based on user data and thus offers great advantages especially if many users participate at an early stage. In this respect, a rapid market ramp-up is vital. Furthermore, some options regarding the organisation of the stakeholders were discussed. In this respect, the question was raised **whether the TO should be a government body, a public-private partnership, or a private stakeholder**. The interviewees tended to involve the state in this regard, as only the state can provide the necessary assurances and authority to react. The interviewees also acknowledged that the TO can be completely private in specific scenarios, however only at a small to medium scale. In addition, it was pointed out that at the time of implementation, that AI could take over the job of the TO, since such a quantity of data would be difficult to manage by humans.[67]

5.5 Second workshop

The literature review, first workshop, and expert interviews offered insights on critical value exchanges happening in the MTME. Not only did they highlight necessary stakeholder-specific relations, but they also presented overall systemic advantages which are beneficial to the entire ecosystem and society in general. After analysing the results from the first workshop session and the semi-structured expert interviews conducted, it became clear that some key questions must be answered and further investigated in order for the business and organisational models to be further developed.

During the 'Organisational Models and Business Aspects' interactive session held at the ORCHESTRA plenary meeting in Berlin, the attending project partners were divided into six groups as part of a workshop exercise, where each group focused on answering one of the stated challenges. In this section, the documented conclusions for each of these critical challenges are summarised and presented as collectively described by the project partners.

- Concerning **data shared**, it is crucial to understand to what extent does data protection law allow the collection and processing of individual and time-accurate data? And if it is possible to combine relatively uncritical personal and time-accurate data together with historical data? Or must the pure use of historical data be resorted to? The participants highlighted that the use of historical traffic data is comparatively less problematic than real-time data and data pertaining to specific routes, which may result in higher quality outcomes. However, the acquisition of such data could be susceptible to data protection concerns. **It is unclear to what extent data protection laws permit the collection and processing of individual and time-accurate data**. Nevertheless, it may be feasible to utilise temporary data for a single trip, subject to an individual agreement per trip. Combining relatively uncritical personal and time-accurate data with historical data poses a challenge for data aggregation. The usage of historical data, though, is not entirely ideal as it disregards current traffic conditions and disturbances.

[67] Tremendous progress related to AI can already be observed today. The latest example of this process is the ChatGPT software. Refer to Sylvain Duranton, 'ChatGPT — Let The Generative AI Revolution Begin', 2023, https://www.forbes.com/sites/sylvainduranton/2023/01/07/chatgpt3let-the-generative-ai-revolution-begin/?sh=7c31d343af15.

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- As for the **data sharing mechanism**, it therefore becomes necessary to realise to what extent a legal obligation to share data conflicts with current data law. The participants emphasised that **the potential conflict between a legal obligation to share data and current data protection laws is a challenging issue**. Nevertheless, one potential solution could be the use of temporary data. While a legal obligation to share data may have significant advantages, it can also be problematic from a data protection perspective, particularly when sensitive data is involved. An alternative approach could involve mandatory sharing of an insensitive minimum set of data, with the optional monetisation of additional data. For passengers, sharing their data could lead to benefits, such as being considered in the event of a traffic disruption. Furthermore, incentives or rewards should be provided to encourage data sharing. Such incentive systems should be straightforward to implement and should not impose further administrative burdens and duties.
- With regards to the **system launch**, the MTM network's successful functionality greatly depends on the quality and amount of traffic data supplied. Given the responses from the semi-structured interviews, it became apparent that low entry barriers along with financial support during the market ramp-up can also contribute to the early usability of the system. To build further on these conclusions, the question of what **the most cost-efficient way is to incentivise early participation in the system** was raised during the workshop. The participants suggested improving the treatment for individuals who share their data by tweaking the optimisation algorithm at zero cost. Incorporating data-sharing into existing 'green efforts' that lead to tax breaks could also be a viable option. Living Labs or demonstrations that showcase the system's effectiveness could boost trust and encourage more stakeholders to participate. Moreover, involving significant OEMs in pilots and providing bonus point systems and soft incentives could also prove effective. Finally, temporary degressive subsidies may be employed to promote early participation in the system.
- The value of the **hedging mechanism** depends on the reliability of the state insurance and guarantee systems, which reduces the risk for companies and customers, and enhances the system's attractiveness. This poses the questions of how PAs can ensure the safety of the system? And how can an insurance framework be designed that is both secure and affordable? The answers from the participants point out that PAs can ensure the safety of the system by designing an insurance framework that is both secure and affordable. To establish a viable business case for insurance companies, risk minimisation is critical, including anonymising data prior to transmission, implementing cybersecurity certification standards, and establishing a trustworthy government framework and political will. This particularly applies to voluntarily provided, possibly sensitive input data, from companies or private individuals, as companies and private individuals will not be inclined to voluntarily provide their data if they are not thoroughly protected. The valuation of data is therefore considered challenging, and standardisation is necessary to prevent legal conflicts.
- Understanding the **nature of the TO** is essential when creating organisational models that revolve around traffic management and ensuring the success of a transportation network. It is therefore necessary to outline whether they are conceived as a private or public stakeholder, or as a PPP, and which type of organisational form is preferred under which situation. This along with the idea of AI assisting or potentially replacing the TO in the future were questions that were raised during the workshop. To summarise the concluded

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results, private TOs operate based on profit and rely on user-generated traffic data to provide optimisation recommendations, which are paid for by the users. Public TOs are financed through public funds and are viewed as a service to the common good, aiming to improve climate, pollution, security, and safety. PPP-TOs are managed by the PA, with private TO companies operating on behalf of the PA and being compensated by the PA. Regarding the use of AI to assist or replace the TO, opinions suggest that AI development is exponentially improving, and that it is essential for automation and will be able to handle most situations. AI's learning capability will enhance its potential, but human control is necessary to ensure confidence in AI's output, hence AI will primarily be used for decision support applications in traffic orchestration. Standardisation and regulation of operations is crucial to ensure common trust in the hierarchy. Public actors are often preferred at the top of the hierarchy, depending on the country and the trust that people place within their respective government. Hence, the EU must mandate data sharing within the infrastructure and standardise operations for all actors.

- Finally, the **degree of involvement of PAs** in MTM is relevant to both data provision and administrative functions, as well as the emergence of further regulations. To comprehend and establish the role of PAs and their integration and tasks in the system, it is fundamental to identify the specific duties performed by them in relation to MTM. The participants believe that these duties include the collection of data at the national level, with the PA acting as the intermediary service provider for data. Additionally, the establishment of regulations and policies, as well as standardisation, is the responsibility of the PA, with states defining the regulations to be followed by transport operators. Furthermore, the PAs are tasked with defining the rules that TOs must adhere to, such as the data that infrastructure managers must share with NUs.

5.6 Data security concerns

By analysing the results, the need to clarify some issues related to data sharing emerged. The first and main problem related to this topic is the economic and reputational loss caused by possible bad management of the activities. Since there are companies within the project partners in ORCHESTRA with relevant experience in data security topic (direct experience on the field, market research and secure data management projects), the expertise to clarify this topic is therefore provided.

Develop trust-based mechanisms that establish high levels of trust in the data source and separately in the trustworthiness of the data, allows business to align appropriate data use with your business goals, both within and outside an organisation.

But there are some negative impacts of sharing data from an organisation point of view that can stop most organisation:

- **Dependence on external suppliers**: In general, dependency on an external provider is the biggest disadvantage of data sharing via a data pool. Its technical stability and security standards are one thing, but you also trust the provider in terms of its innovative strength and economic stability.
- **Lack of security:** Data sharing is often set up via central data pools where all participating companies can provide and access data. With central data pools, the

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participating companies have to hand over the security of their most sensitive data – and rely on an external provider. Many agreements on data sharing are already failing here. After all, it is difficult to find a data pool provider that meets the security standards of all participants. This problem becomes clearer when you consider that a huge amount of sensitive data can be accessed due to a single data leak in the data pool.

- **Lack of traceability:** Lack of traceability of data access was a cause for concern. In concrete terms, this means that once the sensitive data has been shared with another company or uploaded into a data pool, companies can no longer trace who is actually reading their data and who is working with it.
- **Accountability**: Due to the lack of traceability, no one can really be held accountable – and all the companies are usually left with the damage whose data has been leaked.
- **Surrender of data sovereignty:** When using a data pool, you do not have the detailed choice of which data you want to release at a specific time to whom. Rather, all data necessary for operation is always visible to all participants.
- **Possibility of technical errors**.
- **Loss of reputation over a data breach.**
- **Share the same standardised data.**

All of these problems occur mainly with data sharing via a central data pool. Therefore, using a decentralised system can be a solution for those problems; data is not stored centrally on an external server – it is only exchanged between the two parties, in a relation one to many, where one sender exchanges the data with one or many receivers. In addition, only data that is actually needed for the next work process is exchanged, and only to the participant who needs it.

The orchestrator, through the Data Intermediator (DI), manages identity and data directly through partners inside a consortium and not storing them, will speed the productivity without the normal problematic over the classic data sharing.

Ensuring that:

- In the event of a data leak huge amounts of sensitive data can never be disclosed. Only those data can be tapped that were exchanged at the time of the hack.
- A business always retains data sovereignty and only release data that is actually needed by your business partners.
- You are never technically dependent on an external provider – and the continuation of your production is entirely in your hands.
- Even in the event of damage, you can trace who caused it. In this way you can identify sources of error and, if necessary, also hold the party responsible for the damage accountable.

Another point of view to take in consideration when implementing an orchestrator may be the way it redirects information to the end user. Since many businesses can have benefit from a disruption (e.g. another company can take over cargo), the orchestration may consider a way to share profit over a disruption or a way to sharing customers without losing business, so every organisation can build trust over it. An example of this topic can be found over the Amazon's shipping methods: sometimes when amazon cannot ship a package in time, it gives the package over another shipping

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provider, and they split the gain in two. In the following chapter, these challenges will be addressed and included in the development of an organisational model.

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6 Models

This section presents VNDs as well as organisational and market models in the context of MTME. With regard to VNDs, it explores three scenarios: BAU, foreseen disturbances, and unforeseen disturbances, to understand stakeholder-specific and systemic values within the network. The BAU scenario includes a comprehensive VND, showcasing tangible, intangible, and informational values being exchanged directly and achieved systemically throughout the ecosystem. The subsequent scenarios focus on critical values that must be prioritised during disruptive situations. The VNDs emphasise the importance of cooperation and highlight benefits to the MTM stakeholders. The tables provided further elaborate on all the mentioned stakeholder-specific values and systemic values in the VNDs.

Regarding organisational models, for the TO as a new central element within traffic management, an overview of the current organisation of traffic management is provided and potential options for integrating the TO are explored. This includes considering whether the TO should function as an externalised service provider or be directly incorporated into existing traffic management structures. Furthermore, the model provides for resilience mechanisms in the event of disruptions.

The TO also has a significant impact on the market structure of stakeholders in the transport market. Therefore, the market model of the TO is crucial, along with the market models of logistics companies that benefit from reduced emissions and increased cost-efficiency. The market for TOs is particularly relevant as a new element in MTM. This chapter analyses factors influencing the supply and demand of TO services, considering market equilibrium and the spectrum of market models. It distinguishes between TO operation on public or predominantly public routes and private systems. The discussion focuses on the target state of traffic orchestration with MTM, while emphasising the importance of generating acceptance and demonstrating system advantages through transparent tests and pilot projects involving stakeholders in the market ramp-up phase.

6.1 Value network diagrams

This section presents the VNDs as business models under the three target vision scenarios: BAU, foreseen disturbances, and unforeseen disturbances. The values are categorised as tangible, informational, and intangible values. The VNDs highlight not only the economic benefits, but also the social and ecologic benefits that the system provides as described through the TBL framework. In the first scenario BAU, the complete VND is presented with all the value flows that exist within an MTM network, since all are considered essential. As for the second and third scenarios, only the priority values are presented to emphasise their importance for the effective functioning of the system under the described disturbance situations. This way, the primary values and benefits of cooperation for the stakeholders in the system will be highlighted for each scenario. A key assumption is that the MTM stakeholders work as intended, with no restrictions, delays, or breakdowns. The case of limited TO functionality is analysed in chapter 6.2.3.

It is important to mention that **the VNDs presented in the below scenarios assume a public or PPP model between the TO and PA**. In the first case, the PA gives the TO authority to react on its own on its behalf in any traffic situation. In a private model (e.g. HIP), the PA is not involved directly and is hence removed from the VND, and the TO is granted authority to react on its own

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from the stakeholders that exist in that private ecosystem. More information on the integration and categorisation of the TO can be found in chapters 6.2.2 and 6.3.2.

The values are illustrated in two forms:

1. Stakeholder-specific values - where the value is flowing from one stakeholder to the other.

2. Systemic values - values that benefit all the stakeholders within the MTM network.

The below-mentioned tables explain the different value flows taking place among the central MTME stakeholders across the three scenarios. Table 4 focusses on stakeholder specific values, describing the origin and destination of each value flow. It highlights each value's primary function and provides a detailed explanation of the value flow content. Table 5 focusses on systemic values that provide benefits to the society and all stakeholders within the system, where the value content is also described.

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6.1.1 Scenario 1: Business as usual

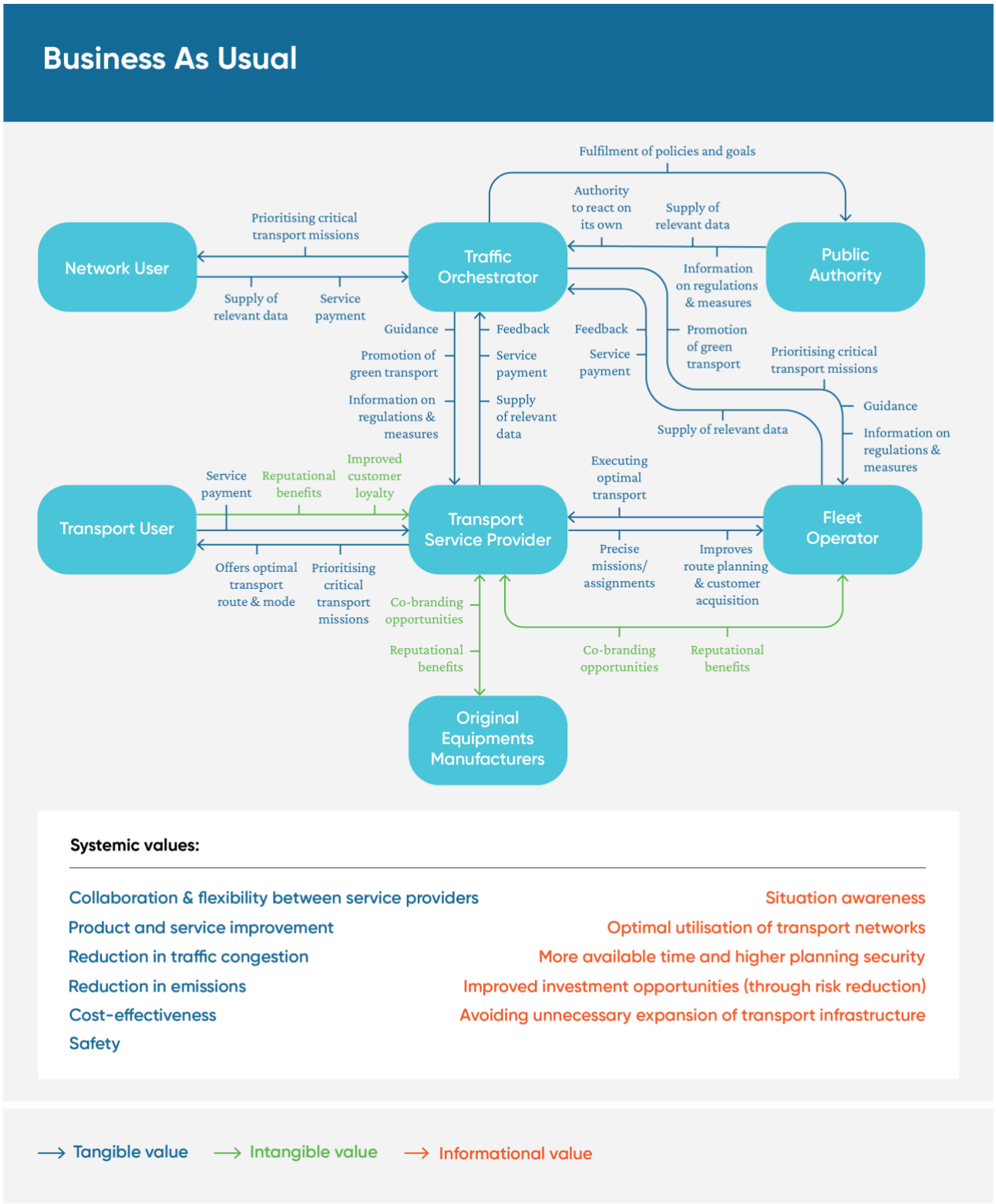

Figure 9 - Value Network Diagram - Business as usual. Source: Own Depiction.

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The VND of the BAU scenario highlights all necessary stakeholder-specific and systemic values for the successful functioning of an MTM network. Stakeholder-specific values are those that are important to individual stakeholders and may vary depending on their role in the network. After analysing and segregating the values into their respective types (tangible, informational, intangible), it became evident that most stakeholder specific values that exist fall under the tangible type. These values are often tangible in nature because they involve contractual transactions, such as services, invoices, payments, collaborations, and agreements. This means that if a value has a physical component, such as a TSP delivering goods or people, it can be considered tangible, not because of its physical nature, but because it is based on contractual arrangements. The remaining stakeholder-specific values are intangible, and these include improved customer loyalty, reputational benefits, and co-branding opportunities. These are values that go beyond the actual service and are not accounted for in traditional financial measures.

Systemic values, on the other hand, are those that benefit all stakeholders involved in the MTM network. These values may include aspects like safety, sustainability, and overall optimisation. For example, reducing traffic congestion not only benefits individual stakeholders, such as commuters and transportation providers, but also society as a whole by reducing pollution and improving public health. Another example would be cost-effectiveness, due to lower congestions and better utilisation of the transport modes and infrastructure, the transport costs for the industry and citizens will decrease. Through the conducted analysis, it became evident that most systemic values are categorised as informational and tangible. Informational values are ones that support or are a result of core values that flow within the network.

Overall, understanding the various values that underpin a system or network can help stakeholders work together more effectively and ensure that the system is operating in a way that benefits all parties involved. This VND serves as a holistic model for emerging and future business models, where social and ecologic values are considered and given importance as well as economic ones. The values illustrated in the VND are presented in detail in Table 4 below.

Table 4 - Value Network Analysis - Stakeholder specific values. Source: Own depiction.

From	Value	Value flow to	Description
PA, NU, TSP, FO	Supply of relevant data	TO	This data includes data such as transport, traffic, weather, network capacity and any other relevant data. The data must not contain any personal or sensitive information of users. Only the critical information essential for the operation of MTME should be disclosed.
PA	Authority to react on its own	TO	The administrative structure of TO comprises a public-private partnership (PPP) between a PA and TO. This arrangement grants authority to the TO to act independently in the event of disruptions. In case of foreseen and unforeseen disturbances, the TO is empowered to take charge and make critical decisions, such as road closures and coordination with emergency services.

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TO	Fulfilment of policies and goals	PA	Efficient traffic orchestration can assist PAs in accomplishing their transportation policies and goals by achieving desired targets. The outcomes derived from effective traffic orchestration can yield substantial value for PAs in terms of successfully realising their transportation objectives and policies.
TO, PA	Information on regulations & measures	FO, TSP, TO	A FO/TSP typically plan/commences their travel plan/transport chain without knowledge of any possible disruptions or the current status of their route. This lack of awareness often wastes time, harming the FO's/TSP's objectives. However, with the assistance of a TO, the FO/TSP can stay informed about the latest regulations and precautions being implemented along their route. This enables the FO/TSP to manage its fleet/transport operations optimally and take necessary precautions proactively. The TO receives real-time information on regulations and measures from the respective PA. Based on the received information, the TO can take necessary actions and transmit the updated information to the relevant stakeholders within the ecosystem.
FO, TSP	Feedback	TO	The suggestions provided by the TO to other stakeholders must be accurate and precise. This can be achieved over time with the help of self-learning and feedback mechanisms. Feedback from stakeholders is required so that the services of the TO can be improved in the long run. Feedback provided by TSP and FO is in real-time and hence it becomes a critical value especially during foreseen and unforeseen disturbance.
TO	Promotion of green transport	TSP, FO	The TO must undertake proactive measures to mitigate overall carbon emissions. One practical approach is promoting green transport in day-to-day operations. For instance, TO can make suggestions for available green vehicles/fleets, and the TSP/FO can utilise green vehicles to offer services to their customers. TSP/FO can also reduce their carbon footprint in this manner.
TO	Guidance	TSP, FO	In case of disruption/congestion, the TO can guide TSP and FO with alternate routes/transport plans to get out of the congestion as soon as possible. Also, during the foreseen disturbance, the TO can predict

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			an alternate route or suggest a change in the transport network to the TSP and FO to avoid disruption in the first place.
TO, TSP	Prioritising critical transport missions	NU, TU	Based on the requests of the NU and TU and considering the nature of the goods being transported, the TO and TSP can prioritise and organise transport missions accordingly. However, in the event of unforeseen disturbances, it becomes crucial to prioritise transport missions. For example, during a disruption, priority must be allocated to emergency service vehicles.
TSP, FO, TU, NU	Service payment	TO, TSP	The services offered by the TO, such as guidance and information on regulations and measures, are the source of revenue for the TO. However, ensuring network safety takes precedence in the event of an unforeseen disturbance. In such cases, resolving the disruption becomes the top priority rather than generating revenue. TSP receives service payment from TU in return of offering optimal transport route/mode.
FO	Executing optimal transport	TSP	Based on the guidance, information on current rules and regulations, and traffic orchestration offered by the TO. A FO can execute a transport mission for a TSP in an optimal manner.
TSP	Improves route planning & customer acquisitions	FO	With the help of guidance and real-time information on rules and regulations, TSP can efficiently plan the transport route for its FO to avoid any congestion in the first place. Accomplishing transport missions within designated timeframes can further enable the FO to attract new customers and enhance its business prospects.
TSP	Precise missions/assignments	FO	By utilising traffic orchestration services provided by TO, TSP can organise precise missions/assignments for the FO. Furthermore, these assignments can be pre-planned considering possible delays and congestion, allowing the selection of alternate routes resulting in increased efficiency.
TSP	Offers optimal transport route and mode	TU	As a result of implementing proactive measures and efficient traffic orchestration services provided by TO, a TSP can enhance its ability to cater to the needs of its TUs. This includes pre-planning TU journeys and providing sustainable transportation

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			alternatives while minimising delays.
TU	Improved customer loyalty	TSP	Providing optimal transport routes and modes can effectively enhance customer loyalty towards TSPs. For instance, if a MaaS application/aggregator can efficiently fulfil the needs of its TUs, TUs will display a preference for utilising the services of a dedicated MaaS application/aggregator.
TSP, OEM, FO	Co-branding opportunities	OEM, FO, TSP	Collaborating with MTME, TSP, OEM, and FO can establish co-branding opportunities and improve the ability to meet consumers' demands while generating revenue. However, it is imperative to note that in the event of unforeseen disruptions, it is essential to set aside any co-branding initiatives and focus on resolving the issue while ensuring the safety and security of the entire network.
TU, OEM, FO, TSP	Reputational benefits	TSP, OEM, FO	Being part of the MTM network can increase clients' trust in a TSP/OEM/FO, especially when positive ecological and social outcomes are evident. The MTM network represents companies that adhere to high sustainability standards, and being associated with it can positively impact the stakeholder's reputations. Stakeholders can establish and maintain high trust with their clients by committing to positive outcomes such as reduced carbon emissions.

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Table 5 - Value Network Analysis - Systemic values. Source: Own depiction.

Value	Description
Optimal utilisation of transport networks	The concepts DCB and TDM allow optimal utilisation of transport networks across all modes which create an overall benefit for all the stakeholders involved in the MTME.
Reduction in traffic congestion	Guidance and information on regulations and measures offered by the TO can help stakeholders better plan their journeys/operations, which creates an overall systemic advantage of reducing traffic congestion.
Safety	Ensuring safety across all transport networks is a critical value. In situations of foreseen/unforeseen disturbances, the safety of passengers, drivers, and cargo are given utmost priority. This is imperative in order to prevent any potential harm or damage to individuals or the surrounding environment. Maintaining a safe and secure transport system is critical for the well-being and security of the community as a whole and should therefore be a top priority in all transport-related decision-making processes.
Improved investment opportunities (through risk reduction)	Efficient traffic management can enhance the overall performance and stability of the MTME ecosystem, attracting more stakeholders to get associated with the ecosystem.
Product and service improvement	Companies and organisations affiliated with the MTME have the opportunity to enhance their current offerings to meet the demands and requirements of their customers and increase customer satisfaction more effectively. Companies and organisations can gain a competitive advantage in their respective markets and improve their overall performance.
Avoiding unnecessary expansion of transport infrastructure	PAs can efficiently use their resources instead of building new infrastructure like roads and bridges to avoid congestion. They can instead efficiently utilise multimodal transportation.

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More available time and higher planning security	TO can enable accurate prediction of traffic situations and provide real-time notifications of any upcoming traffic incidents or congestion. This can allow stakeholders to optimise their travel plans and transport operations, resulting in improved efficiency and reduced costs. Furthermore, the availability of advanced traffic data and analytics can help stakeholders make informed decisions and better plan their journeys, resulting in a more sustainable transportation system overall.
Collaboration & flexibility between service providers	Collaboration & flexibility is crucial in managing foreseen and unforeseen disturbances in the transportation network. TOs, TSPs, and FOs must adapt to changing circumstances and make quick decisions to minimise disruptions and ensure the safety of passengers, drivers, and cargo. This can include rerouting traffic, adjusting schedules, and coordinating with emergency services.
Reduction in emissions	The adoption of green transportation/fleets by stakeholders of the MTME can lead to a significant reduction in carbon emissions, thus making the MTME more sustainable. TOs can play a crucial role in promoting the usage of environmentally friendly vehicles among stakeholders.
Situation awareness	The data related to traffic, which is provided to the TO, plays a crucial role in enabling the TO to maintain situational awareness of various events occurring within the transportation network. By leveraging this data, the TO can obtain a comprehensive overview of the entire transport network, enhancing its ability to effectively manage traffic-related issues.
Cost-effectiveness	Cost-effectiveness is important in managing MTM. TOs, TSPs, and FOs must work together to minimise the economic impact of the disturbance. This can include optimising the use of resources, minimising the cost of alternative routes, and coordinating with insurance providers. Reducing the overall operational costs due to better management will be beneficial to the society.

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6.1.2 Scenario 2: Foreseen disturbances

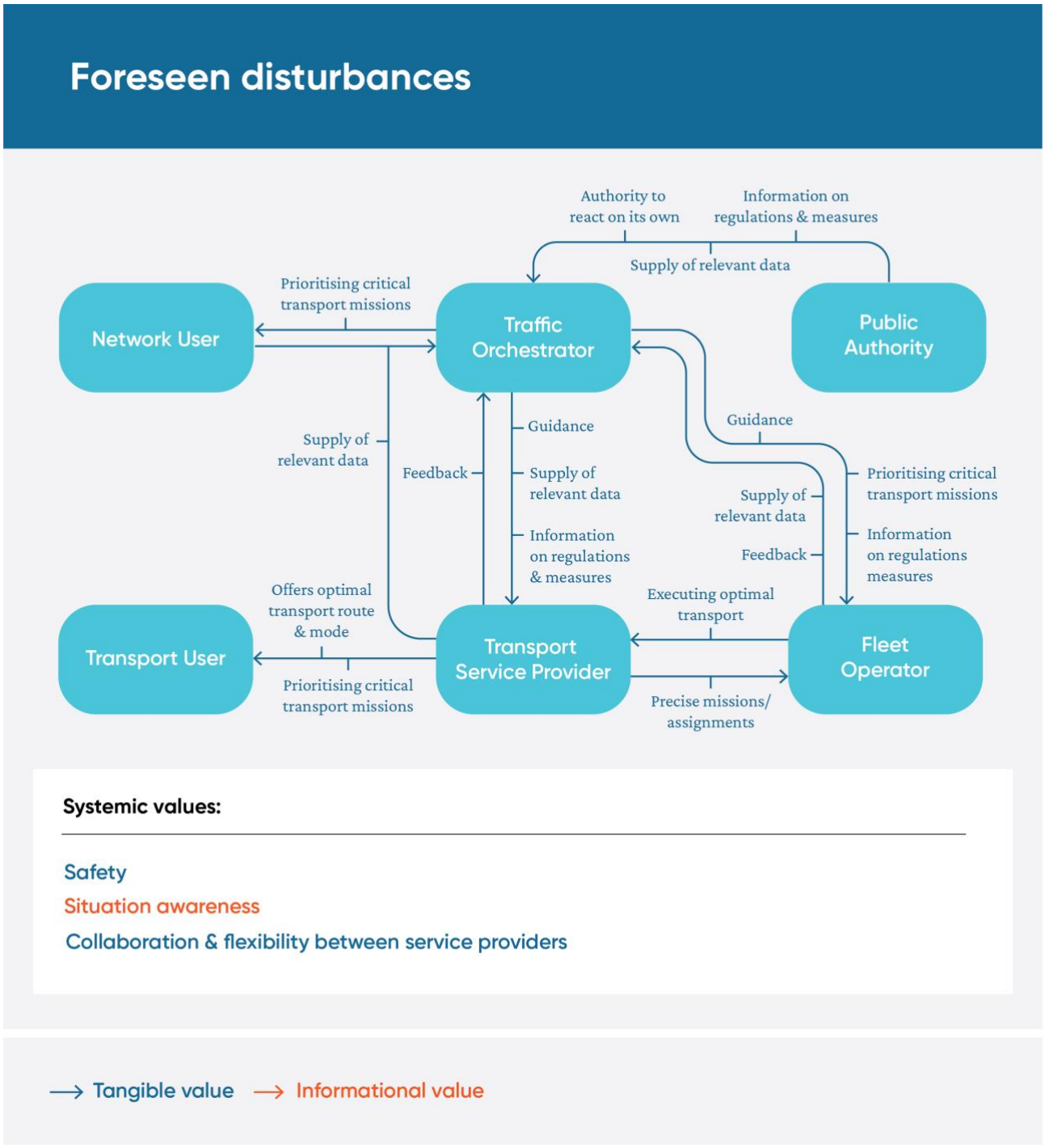

Figure 10 - Value Network Diagram - Foreseen Disturbances. Source: Own Depiction.

Handling foreseen disturbances in a MTM network requires the identification and mitigation of potential disruptions that may affect transportation networks. To achieve this, the ecosystem must support the stakeholders in making timely and informed decisions while maintaining safety and

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minimising the impact on network and TUs. Therefore, the most critical values in this scenario include the authority for the TO to react on its own, safety, supply of relevant data, executing optimal transport, guidance, information on regulations and measures, prioritising critical transport missions, precise missions and assignments, offering optimal transport routes and modes, feedback, collaboration, flexibility between service providers, and situation awareness.

The authority to react on its own is crucial for TOs as it enables them to make timely and appropriate decisions to mitigate the impact of foreseen disturbances and coordinate with other networks and modes. Safety is a primary value in transportation, and it is critical in ensuring the safety of all users, especially during potential disruptions. The supply of relevant data is essential in identifying potential situations and deciding how to address them through DCB and dynamic utilisation of transport mitigation actions. Guidance offered by the TO can help the transport actors to make informed decisions to minimise the impact of the foreseen disturbances. The FOs and TSPs must be kept updated with all real-time regulations and measures affecting their route, ensuring they can adjust their operations accordingly.

Executing optimal transport is critical in this scenario as it helps to anticipate the needs of the TSP and satisfy their demands across different transport networks, efficiently handling their transport needs. Precise missions and assignments can be achieved by utilising traffic orchestration services provided by the TO, allowing the selection of alternate routes, hence increasing efficiency of FO. By offering optimal transport routes and modes, the TSP can enhance its ability to cater to the needs of its TUs, providing sustainable transportation alternatives while minimising delays.

Collaboration and flexibility are crucial in managing foreseen and unforeseen disturbances in the transportation network, and TOs, TSPs, and FOs must adapt to changing circumstances and make quick decisions to minimise disruptions and ensure the safety of passengers, drivers, and cargo. In these situations, safety is prioritised over economic benefit to the stakeholders, and they are expected to collaborate to ensure that. This can include rerouting traffic, adjusting schedules, and coordinating with emergency services. Situation awareness, enabled by the data related to traffic provided to the TO, plays an important role in maintaining situational awareness of various events occurring within the transportation network, enhancing the ability to effectively manage traffic-related issues. Overall, the values outlined in the scenario are essential in managing foreseen disturbances in the MTM system, ensuring safe and efficient transportation.

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6.1.3 Scenario 3: Unforeseen disturbances

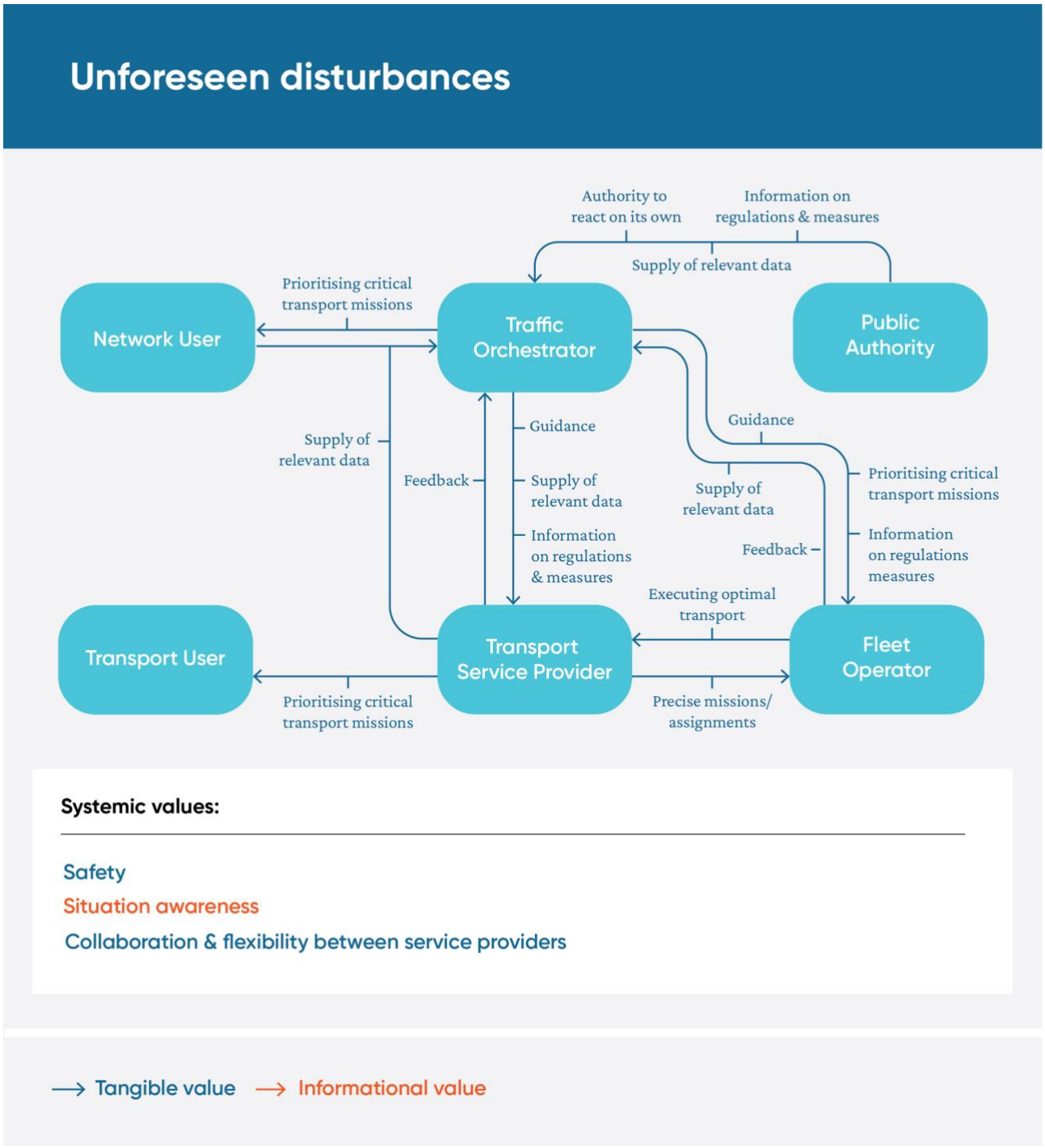

Figure 11 - Value Network Diagram - Unforeseen Disturbances. Source: Own Depiction.

Effective communication is a vital element in managing unforeseen disturbances. In situations where unexpected events occur, quick response and coordination are essential to minimise negative impacts on the transportation system. In unforeseen disturbances, it is essential to respond quickly

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and ensure efficient communication between relevant stakeholders. The VND presented here outlines similar priority values to those presented in the scenario of foreseen disturbances. However, unlike foreseen disturbances, future planning may not be feasible in unforeseen situations, and therefore the model's focus on offering an optimal route and mode from the TSP to the TU is removed. This is because the TSP may not have the opportunity to pre-plan TU journeys and immediately provide alternative options during such situations. Nevertheless, the priority values identified in the VND model can serve as a framework for stakeholders involved in unforeseen disturbances, guiding them to identify critical areas of focus.

6.2 Organisational model

In the following, the organisational model will be created according to the model creation explained in chapter 4.5.2. The focus in this context lies on the TO, as it represents the new element in the context of MTM and the other players primarily benefit from its role. For this purpose, an overview of the current organisation of traffic management and the conceivable options to integrate the TO as new central element will first be given. The first challenge to create an organisational model concerns the integration of the TO into the current system of traffic management. Generally, the TO can be conceived as an externalised service provider or be directly integrated into existing traffic management structures. The analysis of the two options to design the TO are followed by an examination of the potential constraints to the TO's operations and how these can be overcome by means of a resilient organisational design. It is assumed that the responsible TOs can handle the challenges described in scenarios 1-3, such as foreseen and unforeseen network capacity drops, as long as they are operational. In this respect, the organisational model particularly considers cases in which the TO's operational capability is limited or negated. Finally, the model is assessed and examined from the perspective of NIE.

6.2.1 Status quo: Current traffic management

In the following, the sector of road traffic management in Germany will serve as an example to explain the status quo of current traffic management responsibilities. In general, traffic management responsibilities in road transport can be distinguished into national and local authorities. Both local and national authorities will be examined in detail for this purpose. To this end, the responsibilities for various subject areas and road types will be outlined. As can be seen in Table 6, German roads are divided into motorways, roads of special importance, federal roads, national roads, and county roads. Road traffic management lies with the respective municipalities of various sizes, the counties, and the independent cities, while motorways and roads of special importance are managed by Autobahn Ltd. These are superordinated by the Ministry of Transport of the respective federal state.

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Table 6 - Responsibilities in the local road traffic sector based on the example of the German federal state of Hesse. Source: Hessen Mobil[68,69].

Local/Federal state road traffic management								
Administrative Authorities	Hessian Ministry for economic affairs, energy, transport planning	Autobahn Ltd. Road and Traffic Management	Regional Council	Cities without districts	Countries	Municipalities >50.000 inhabitants	Municipalities 7.500 to 50.000 inhabitants	Municipalities < 7.500
Supreme Road Authority	■							
Higher Road Authority		■	■					
Road Traffic Authority		■		■	■	■	■	■
Responsible entity				Head Mayor	District administator	Head Mayor	Mayor	Mayor
Road network in Hesse	Hessian Ministry for economic affairs, energy, transport planning	Autobahn Ltd. Road and Traffic Management	Regional Council	Cities without districts	Countries	Municipalities >50.000 inhabitants	Municipalities 7.500 to 50.000 inhabitants	Municipalities < 7.500
Motorways		■						
Roads of special importance	■	■						
Federal roads	■		■	■	■	■		
National roads	■		■	■	■	■	■	
County roads	■		■	■		■	■	■

At the national level, the 16 ministries of transport of the federal states and the Autobahn Ltd. Are responsible for road traffic monitoring and management and for the infrastructure, as can be seen in Table 7. These in turn are subordinate to the national Ministry of Transport, which formulates the overarching national road policy. Vehicles are regulated by the KBA and enforcement is carried out by the police.

[68] Hessen Mobil, 'Straßenverkehrsbehördliche Zuständigkeiten Hessen', 2022, https://mobil.hessen.de/sites/mobil.hessen.de/files/2021-12/Stra%C3%9Fenverkehrsbeh%C3%B6rdliche%20Zust%C3%A4ndigkeiten%20in%20Hessen.pdf.

[69] Hessen Mobil, 'Wer ist zuständig im Verkehr?', mobil. hessen.de, accessed 6 April 2023, https://mobil.hessen.de/verkehr/zustaendigkeiten-im-verkehr.

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Table 7 - Responsibilities in the national road traffic sector based on the example of Germany. Sources: European Commission[70], Hessen Mobil[71], Autobahn Ltd.[72]

National road traffic management						
Administrative Authorities	Traffic Ministry BMDV	Federal Highway research institute	Autobahn Ltd	Ministries/ Road authorities of 16 federal states	Federal motor transport authority (KBA)	Police/ Highway patrol
National Road Policy formulation	■					
Traffic Monitoring & Management			■	■		
Infrastructure maintenance & improvement		■	■	■		
Vehicle regulation					■	
Enforcement						■

Other relevant actors:

Vehicle manufacturers/ OEMs	Road user association	Trade / Insurance association	Police trade union	Automobile club	Municipal umbrella organisation

Relevant communication channels would therefore have to be set up between the TO and all entities that operate road traffic management. These include the municipalities, counties, cities without districts and the Autobahn Ltd. Information on the condition, maintenance and improvements of the infrastructure should also be transmitted between these stakeholders. Furthermore, a communication channel between the TO and the police and emergency services can be considered purposeful in order to be informed about the exact time of changes in foreseen and unforeseen disturbances.

Other relevant stakeholders include the OEMs, various associations such as road users, trade and insurance, the automobile club, the police trade union and the municipal umbrella organisation. These should be involved particularly in the establishment of the system to assess further requirements and necessities from their perspective. Further research in this field is necessary. At the international level, it is important to facilitate seamless cooperation between TOs in GAs close to the border. Corresponding, ideally standardised contracts for the exchange of relevant data between the TOs should be drawn up and signed accordingly to enable a European standard in

[70] European Commission, 'European Road Safety Observatory National Road Safety Profile - Germany', 2021, 20, https://road-safety.transport.ec.europa.eu/system/files/2021-09/erso-country-overview-2021-germany_en.pdf.
[71] Hessen Mobil, 'Wer ist zuständig im Verkehr?'
[72] 'Verkehrsmanagement, Betrieb und Verkehr', Die Autobahn GmbH des Bundes, accessed 7 April 2023, https://www.autobahn.de/ueber-uns/verkehrsmanagement-betrieb-und-verkehr.

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traffic orchestration. This example refers to road traffic management in Germany. However, the approach of identifying the currently relevant traffic management entities and outlining the possible future interconnection with the TO is transferable to other traffic modes and countries. For implementation, a case-by-case assessment of the relevant stakeholders, their responsibilities, and their relationship to the TO should be carried out in each case.

6.2.2 Integration of the Traffic Orchestrator

In general, two options for integrating the TO into the current traffic management can be distinguished. As an

- **Internalised entity**, the TO would be directly integrated as a new part of the structures that currently operate traffic management in their respective traffic modes. This is shown in Figure 12.
- **Externalised entity**, the TO is integrated as a new stakeholder that enters into data exchange with the relevant entities of the current traffic management system. This is illustrated in Figure 13.

These two options will be examined in more detail in the following.

Internalised entity: An internalised TO would be integrated as part of the existing national and international traffic management entities. One TO would manage one GA in the respective traffic modes of air, waterways, road, and rail, as can be seen in Figure 12. These GAs are tailored to the specific requirements of the different transport modes and thus generally differ in size and shape, as a road GA could be a tunnel and an air GA a section of the air traffic network.[73] The TOs also enable intercommunication between silos and can execute DCB in order to optimise network utilisation.

[73] Mairt Natvig et al., 'Intermediate PMA for Multimodal Traffic Management', 2022, 36, https://orchestra2020.eu/wp-content/uploads/2021/07/D3.2-Intermediate-PMA-for-multimodal-traffic-management.pdf.

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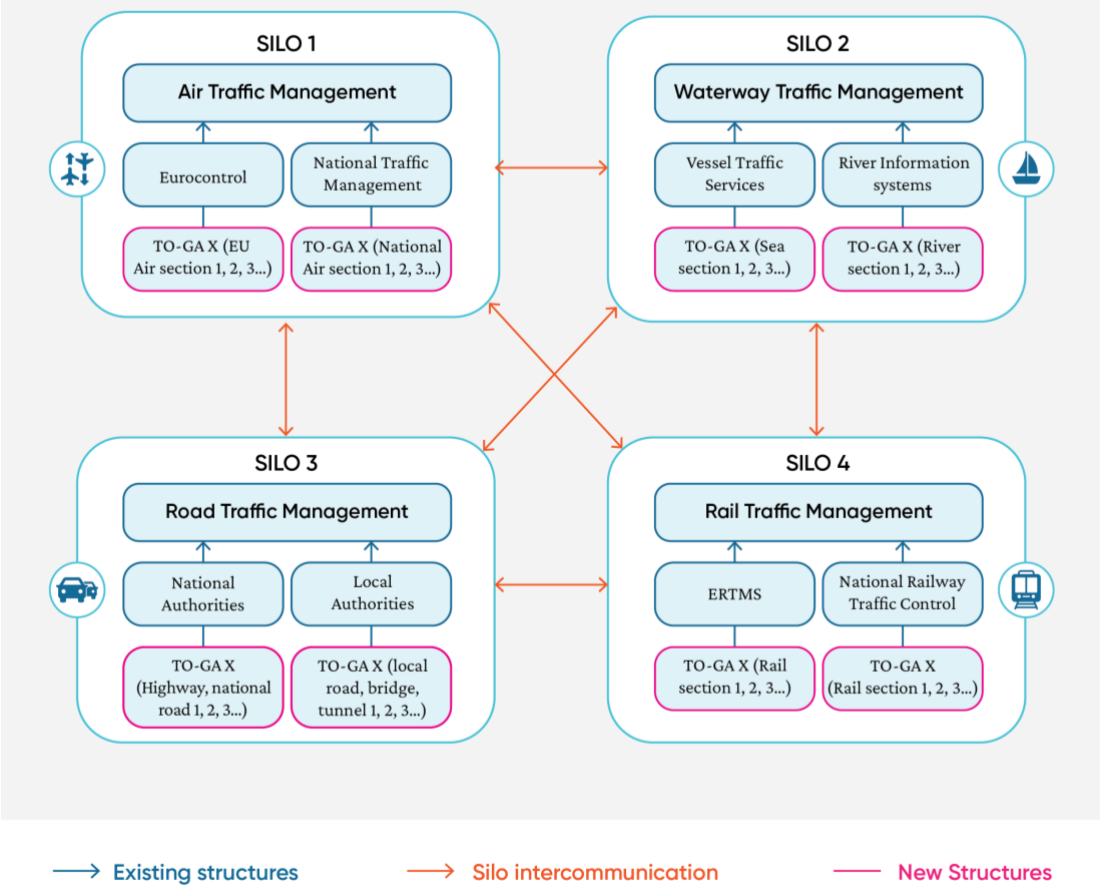

Figure 12 - Traffic Orchestrators as internalised part of current traffic management structures. Source: Own Depiction, based on information from Vaillant et al. [74]

As this option allows for an expansion of the competences of the traffic managers, it can be assumed that there will be no resistance to the solution from their side. A decentralised solution with many small TOs is also less prone to disruption, as the potential shutdown of small TOs does not have a similarly big effect as the shutdown of large centralised TOs.

However, in the context of costs, an internalised TO can cause increased expenses. Provided that each transport mode-specific GA has a TO with corresponding personnel, it can be assumed that there is a broad personnel pool necessary to fulfil the tasks with corresponding costs. Since the tasks to be fulfilled by the TOs are often mode-specific, it can also be assumed that different companies with different specialisations fulfil these tasks within the framework of a PPP (see chapter Market Model). This requires corresponding administrative resources for the respective tendering processes and for quality controls. In order to reduce such potential costs, outsourcing tasks that do not fall into the core field of expertise of the current traffic manager's responsibilities can offer noteworthy advantages. While the TO responsibilities described in the PMA, such as traffic monitoring or

[74] Ludovic Vaillant et al., 'Initial Scenarios for Multimodal Traffic Management', 2022, 16, https://orchestra2020.eu/wp-content/uploads/2021/07/D2.3-Initial-scenarios-for-multimodal-traffic-management.pdf.

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communication with NUs[75], should remain within existing traffic management structures, as it is their core field of expertise, outsourcing of data processing should be considered as an option, especially where IT expertise is limited.

So, while the internalised TO offers some advantages, such as fitting into existing systems and increased resilience through a decentralised approach, this model also requires the creation of many small TOs with corresponding personnel and, in the case of PPPs, a high number of tenders, which are not insignificant cost points. One option to reduce costs is to outsource business fields that do not correspond to the core field of expertise of the existing traffic management, such as data processing.

Externalised entity: Another option is the externalised TO. It can be conceived as a single entity that communicates with the respective traffic managers of the different traffic modes in a governance area, as can be seen in Figure 13.

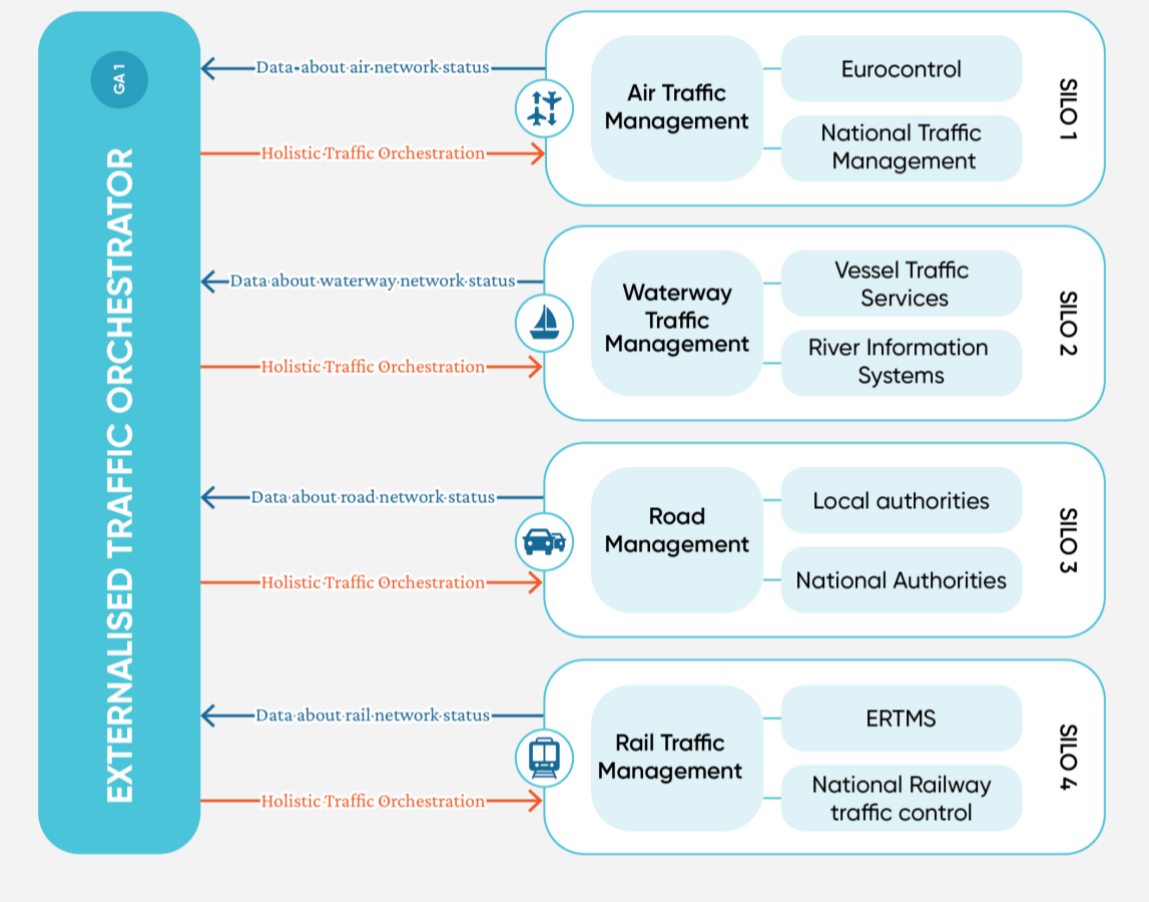

Figure 13 - Simplified representation of the current traffic management system in cooperation with the externalised TO. Source: Own Depiction, based on information from Vaillant et al.[76]

[75] Natvig et al., 'Intermediate PMA for Multimodal Traffic Management', 94.
[76] Vaillant et al., 'Initial Scenarios for Multimodal Traffic Management', 16.

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One issue with this approach, however, is that the governance areas of the different traffic modes may not overlap. In this respect, an adaptation of the GA shape would be necessary, in order to include tunnels, highways, railways, air and sea sectors into one GA. A TO would also have to be created as stakeholder outside the existing traffic management. If the TO were to take over competences of the existing traffic management, restructuring costs would occur. In addition, a lack of acceptance of previous traffic managers could be expected. A disadvantage would also arise insofar as a relatively smaller number of TOs and thus greater centralisation would create more vulnerability in the event of disruptions.

However, a more centralised approach with fewer TOs is likely to come with lower personnel costs and reduce the number of necessary tenders and quality controls. Moreover, a restructuring of GAs, although different from the current modus operandi, is conceivable, as local areas of responsibility can also be reallocated. A redistribution of responsibilities that are already being carried out, such as traffic monitoring or communication with NUs, should be avoided, as the restructuring of a functioning, existing system is not necessary and would cause further costs.

In summary, the option of an externalised multimodal TO poses a number of challenges. First of all, an externalisation of the designated competences of a TO[77] is only beneficial for newly added competences, i.e. in particular for the automated processing and handling of data. The cost savings resulting from a lower number of required personnel and fewer tenders are contrasted by the necessary restructuring of the GAs as well as the higher susceptibility to disruption of a centralised solution.

With regard to the integration into existing structures and increased resilience, the internalised TO is arguably advantageous. Provided that solutions are found that avoid a personnel-intensive multitude of small-scale TOs and associated tenders, **the internalised TO can be considered the preferred option**. An overview of the advantages and disadvantages of an internalised and externalised solution can be found in Table 8**Error! Reference source not found.**.

Table 8 - Advantages and disadvantages of internalised and externalised TOs. Source: own depiction.

Category	Internalised TO	Externalised TO
Governance Areas	In line with existing Traffic Management structures	A single TO for different traffic modes can lead to non-overlapping GAs
Complexity	Builds on existing management structures, requires several smaller TOs	Would need to be established as a new central stakeholder

[77] Natvig et al., 'Intermediate PMA for Multimodal Traffic Management', 94.

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Costs	A high number of TOs can cause additional personnel and transaction cost	Outsourcing data processing to a central entity/company specialising in this can increase the efficiency of the process
Acceptance	Unlikely to meet opposition, as competencies of existing entities are extended	Could encounter opposition if competences of the existing traffic management are to be transferred to new entities
Resilience	A decentralised solution is potentially less prone to disruption, as the failure of small TOs does not have a similarly large effect as the failure of large TOs	A centralised solution with fewer TOs can pose problems in the event of disruption of one more TOs.

6.2.3 Disruption or dysfunctionality of the Traffic Orchestrator

This chapter deals with constraints to TO functionality. This is based on the assumption that functioning TOs can cope with the challenges described in scenarios 1-3[78], but that the system will only achieve a high degree of resilience if the TOs are operational without interruption. In this context, traffic orchestration is possible only to a limited degree or impossible if

- **Case 1:** The TO(s) are not operational.
- **Case 2:** The communication channels between the stakeholders are not functional.
- **Case 3:** The transmitted data is not complete or incorrect.

This is not the case in scenarios 1 and 2, as all stakeholders can work regularly as depicted in Figure 14**Error! Reference source not found.**. Unforeseen disturbances can, however, limit holistic traffic orchestration. This will be discussed in the following.

Case 1: Various causes can lead to temporary inoperability of the TO in one or more Gas. The inoperability of the TO in one GA leads to a lack of traffic orchestration in that area. Furthermore, this is accompanied by unpredictability for the TOs in adjacent Gas and possibly beyond, which further complicates their work. Consequently, it is important to avoid this case. Accordingly, measures should be taken to mitigate the likelihood of inoperability of individual Tos, such as contingency plans in case of power or technical system failure. Should inoperability still occur, further backup mechanisms are needed.

Taking into account the restrictions from Chapter 5.1.5, in particular that:

- Data is not stored centrally but only exchanged between stakeholders who need access to it.
- Only data that is needed for the current work steps and those that will be needed in the near future is exchanged.
- Data is not stored for a long period of time.

[78] Vaillant et al., 'Initial Scenarios for Multimodal Traffic Management', 32–47.

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This can be achieved, if the individual data providers send their data to the TO in charge and also to adjacent TOs. This way, even if one or several TOs are inoperable, there are always several others to provide holistic traffic orchestration, while only few stakeholders have access to the data. This requires, at least for the temporary period of inoperability, corresponding back-up resources in terms of both personnel and technology. Here, too, it can be assumed that corresponding costs for the provision of such capacities will decrease considerably with increasing automation. The result is a data path as shown in Figure 14. This way, the resilience and flexibility of the system is guaranteed. Consequently, traffic orchestration is only impossible in the case of comprehensive inoperability of all adjacent TOs.

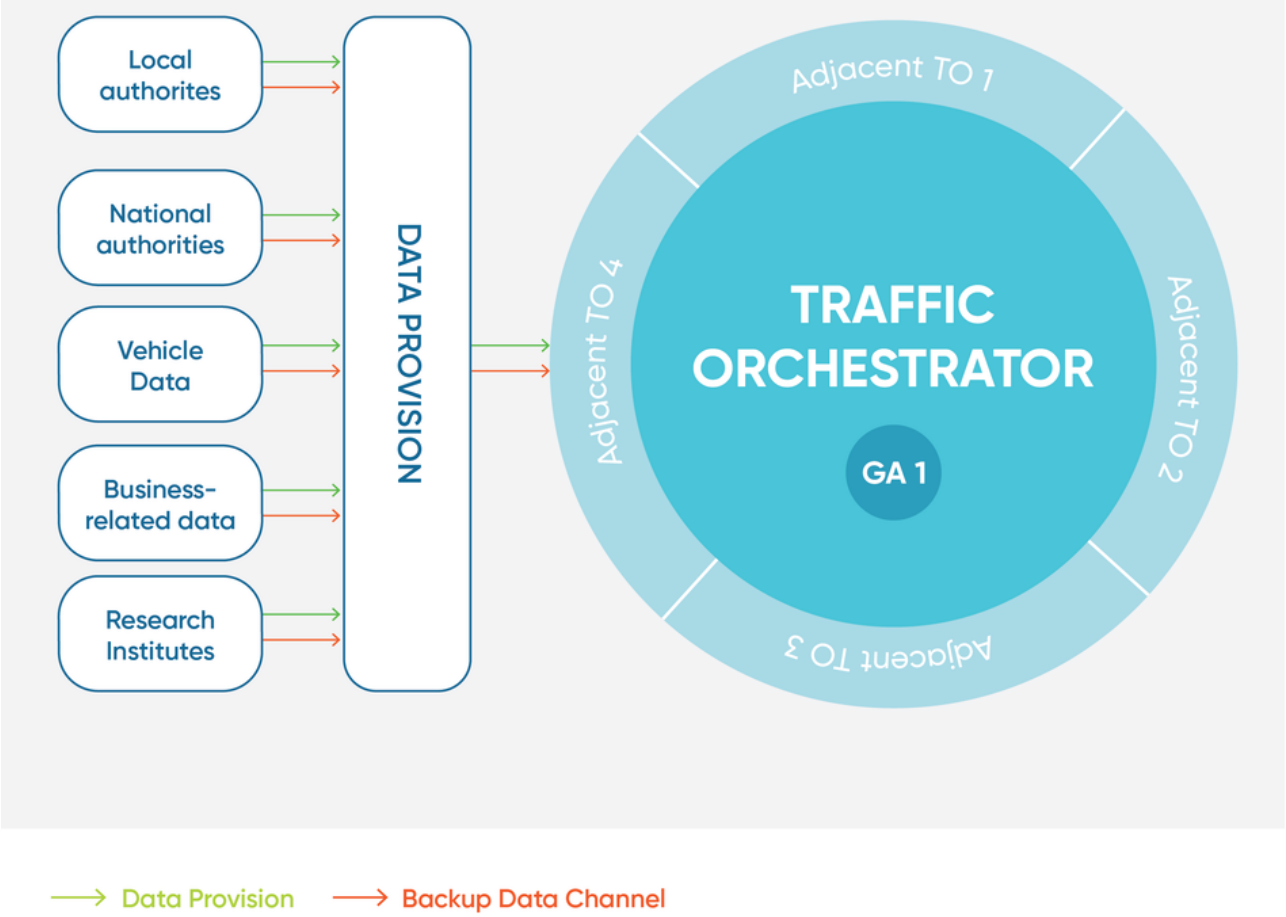

Figure 14 – Data path. Source: Own depiction.

Case 2: If the communication channel between the stakeholders is disrupted, holistic traffic orchestration is no longer possible, as the TO either partially or completely lacks the data for processing. Accordingly, the data transmission should be highly secured on the one hand, and on the other hand, alternative channels for data transmission should be set up as a backup in order to ensure data transmission even in the event of a failure of one communication channel.

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Case 3: Incomplete or incorrect data can be a serious challenge for the system. Incomplete data decreases the quality of traffic orchestration. An exponential effect can be assumed here. For example, if data is missing to a significant degradation of a certain part of the infrastructure, accidents and other disruptions in that region can be favoured, which in turn affects the traffic orchestration in other Gas. If this occurs multiple times and in overlapping periods, the quality of traffic orchestration is significantly reduced. If, on the other hand, such cases are known, it is possible to plan ahead. It is therefore important to examine to what extent the data of individual data providers was complete in the past and where systems can be further improved. If it can be determined that there is a long-term incompleteness of data from certain data providers and that there is no improvement perspective, this should be factored into the traffic orchestration models as an uncertainty parameter.

Incorrect data is potentially an even greater challenge than incomplete data. For example, if a region is restricted for traffic as a result of a flood warning and appropriate diversions and shifts in traffic modes are put in place, but the flood occurs elsewhere, this can have devastating consequences. In this respect, it is important to obtain data from as many different reliable sources as possible, to compare and to assess their validity. Here, too, Ais can presumably provide considerable support in the future.

6.2.4 Model examination from NIE perspective

In this chapter, the organisational design of MTM will be examined for transaction cost advantages with the help of the NIE theories described in chapter 3.3.2. In the context of the **property rights theory**, this applies in particular with regard to data processing and the rights to data. As discussed earlier, data should only be usable to the extent it is needed and by the stakeholders who need it. Their rights to the data must be contractually determined in order to create a stable and secure legal framework. This becomes particularly relevant when the system is concretised. That means when large-scale tests and pilot projects have been carried out and it is clear who exactly needs which data for which tasks. Then, the rights to the respective data can be legally specified. This stage has not yet been reached in the current state of research, and thus remains subject of future research.

In the context of **principal-agent theory**, there are different constellations of contractual partners to be distinguished. As the TO is the new, central element added to existing traffic management, three constellations in particular are examined that are central to the TO's work. These include:

- TO (Agent) - TSP (Principal)
- TO (Agent) - FO (Principal)
- Private Partner (Agent) - TO (Principal)

Since the constellations TO-TSP and TO-FO are quite similar, as both profit from traffic orchestration provided by the TO, they will be considered together in the following.

Constellation TO – TSP & TO - FO:

As a provider of information on optimal traffic flow, the TO has an information advantage over both the FO and the TSP who use his services. This information advantage cannot be compensated by the FO or TSP for reasons of data protection, as much of the data processed is legally protected (private data, business data, etc.). As far as monitoring and control costs are concerned, it is possible for FOs and TSPs to conduct before-and-after comparisons as well as comparisons with the competition if the latter does not (yet) use the TO's services. Signalling allows the TO as agent to

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clarify which services and performances are to be expected from his service. If he can point to positive performance, e.g. through successful pilot projects or tests, his system looks attractive to potential customers. If he describes the advantages and disadvantages of his service as well as the factors that determine it in a transparent and freely accessible way, he is executing effective signalling and saves the principal expensive screening work.

Overall, it can be said for this constellation of actors that the TO's mode of operation is largely a black box for the principals (FO/TSP) that is difficult to comprehend. The agent can counteract this if it can provide concrete examples of positive performance and the relevant factors for functioning in a transparent and freely accessible manner. Transaction costs are low when relevant information on the TO's work can be accessed without barriers. The system is successful if this information can convince the principals of the offer.

Constellation Private Partner – TO

This constellation describes the outsourced business area(s) of the TO. If this concerns data processing, the private partner has the information advantage about the algorithm that evaluates the provided data and processes it into recommendations in the transport sector. In this case, monitoring and control costs as well as signalling and guarantee costs are reflected in the tender process leading to the signing of the contract. In addition to the financial criterion of the lowest cost bid, the TO must set quality standards and monitor them, while the bidding companies must present and guarantee that they meet them at optimal cost. The complications involved are described in detail in Chapter 6.3.2.

Transaction costs are low if the quality standards defined reflect the relevant factors for the successful work of the private partner, if quality controls become necessary only to a limited extent, if tenders are not repeated (very) frequently, and if there are generally no more tender processes than necessary.

Regarding transaction cost theory, the primary factors that determine the level of transaction costs are the frequency of transaction, factor specificity and the uncertainty of actors. In general, data is transferred from the data providers to the TO, which in turn provides traffic orchestration for stakeholders in traffic.

The *frequency of the transaction* can be considered high, as data is exchanged continuously. Provided that the transaction leads to satisfactory results on both sides, this can lead to enhanced trust and thus to lower control and adjustment costs.

Factor specificity refers to the reallocation potential of investments. The lower the reallocation potential, the more one partner is dependent on the compliance of the other partner, which represents a high potential for exploiting the dependent relationship. If there is a legal obligation to share data, reallocation is impossible. For data that does not have to be shared but is still critical to the TOs work, however, there is a dependency of the TO for a database that is as complete as possible. A certain reallocation potential to alternative data may exist in some cases, e.g. if certain logistics companies cannot or do not want to share their data, the TO can switch to others. However, if a significant proportion of the movement data of vehicles is missing, the analysis and forecasting capability of the TO is dramatically limited. Therefore, there is potential for reallocation in individual cases, but as soon as a critical mass of data is missing, there is a strong dependence on the compliance of the data providers. A contractual framework to determine the value or compensation for data to be shared voluntarily can be helpful in this regard. Provided that a

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mutually acceptable value is determined and transparently recorded in the contract, it can be assumed that there are few incentives for reallocation.

With respect to the *uncertainty of actors*, the TO is dependent on the quality and completeness of the data from the data providers. As such, initiation and control costs to check the data occur. However, through the multitude of different data sources and the historical analysis of the past quality of the data of individual sources on a topic and the comparison of that data, the system can be enabled to automatically find anomalies, identify faulty data and handle errors. This way, initiation and settlement costs can be minimised, and information asymmetries reduced.

For all stakeholders who benefit directly or indirectly from traffic orchestration, the question arises to what extent the TOs recommendations provide improvements. Analysing this implies further transaction costs. This can be minimised through empirical testing and transparent provision of information about the systems qualities once it has been sufficiently tested to reduce initiation costs. Furthermore, data providers may be critical of the handling of their personal or business-related data, which in turn raises initiation and control costs. In general, and especially in the context of voluntarily provided data, a credible framework for data protection needs to be developed for this purpose, which creates security and trust between participants and minimises transaction costs related to such information asymmetries as much as possible.

In summary, transaction costs are low when there is a clear, transparent legal framework on the value and compensation of data to be shared voluntarily, when the TO has set up automated data verification/algorithms for the validity of submitted data, when a comprehensive legal framework has been established for handling sensitive data, and when there is comprehensive, easily accessible, positive information on the performance of MTM in test, pilot and large-scale applications.

6.3 Market model

A market model is generally conceived as a basic economic representation of supply and demand. While it can be assumed that traffic orchestration affects the market structure of all players who come into contact with it, the market model of the TO itself is particularly relevant. As for the market model of other stakeholders, it can be assumed that companies in the logistics sector generally emit fewer emissions through successful traffic orchestration and operate more cost-efficiently, as the transport networks are utilised optimally. Thus, they can offer their services more cheaply, which is likely to have a positive effect on the demand for their services compared to markets or competitors without traffic orchestration. As a new, central element in multimodal traffic management, however, the newly created market for TOs is particularly relevant. Therefore, this chapter will focus on the relevant factors for the supply and demand of TO services.

In the specific case of MTM, two cases can be distinguished:

1. TO operation on public or predominantly public transport routes. This concerns the vast majority of the transport routes under consideration.
2. TO operation in private systems. An example of this could be the HIP.

In order to classify the market models in the two cases, the relevant variables that determine supply and demand will first be identified. Furthermore, criteria for MTM as critical infrastructure and market requirements will be identified. Finally, the supply and demand structure is analysed in order to classify both cases in the context of a market model.

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Furthermore, it is important to note that the target state of Traffic Orchestration with MTM is considered in the following. There will be a market ramp-up phase between the current state and the target state. During this phase, it is particularly important to generate broad acceptance among the population and to demonstrate the advantages of the system early and transparently. This can be achieved in particular through successful and transparent tests and pilot projects with the involvement of relevant stakeholders such as OEMs, unions, and associations, as well as early broad data availability. The latter can be realised in particular with regard to voluntarily shared data without legal compulsion if special incentives such as tax breaks, temporary, degressive subsidies or soft incentives are used.

6.3.1 Demand

On the demand side, the primary factors are the price of traffic orchestration, the quality of traffic orchestration, and potential risk factors for customers. This applies to both private and public TOs. However, it must be noted that price reactions may be different for public institutions than for private ones. This depends primarily on the availability and management of taxpayers' money. The quality of traffic orchestration depends primarily on the data type (quality), data availability (quantity) and the data processing, which in technical processing mainly refers to the algorithm used. The data type relates to the kind of data transmitted. On the vehicle side, this comprises among others real-time location data, transported cargo, and planned route. PAs and traffic and infrastructure managers can provide data about upcoming events, current and historical data about the state of the infrastructure and traffic conditions, while research institutes provide data on weather, geological activities, and so on.

The more data is included in the forecast model, the more precise the results. Data availability refers to the quantity of data provided. For example, if only half of the road users provide their traffic-related data, the movement profile of the participants processed in Traffic Orchestration will be incomplete and recommendations for optimal traffic flow can only be provided sub-optimally. If business-related data is included that is not subject to a legal obligation for data sharing, incentives such as tax cuts are an option to obtain business-related data. However, from a business perspective, this trade-off is directly related to risk management. If a potential data leak containing business-related data could cause more damage than the benefit of the incentive from the company’s perspective is worth, the company will not engage in such data sharing. The more data is utilized in the system, the better the traffic orchestration, and thus the higher the potential demand for the product.

Finally, the processing of the input data is essential. Humans can hardly process such a vast amount of data, which is why the algorithms that translate the input data into traffic models and recommendations are particularly crucial. In this context, the TO will primarily be responsible for the data processing/algorithm, while the data type and data availability will depend on state regulations and laws.

In addition to data quality, potential risk factors such as data loss, hacks or comparable events also play a role. In particular, the loss of sensitive business data can cause high financial damage. Where non-state market actors are involved, these risks must be credibly hedged, otherwise market entry may not take place. In this respect, it is important to minimise risks as far as possible and to communicate this transparently to market participants. Conceivable ways of minimizing risk include not saving data for a long period, only transmitting data between stakeholders that are

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concerned, anonymising data before it is sent and cybersecurity certification as a prerequisite for participation in the system. If the risk has been sufficiently reduced, a business case can be created for insurance companies to compensate for the loss. A government framework can also provide security for market participants. A clear political commitment to the technology and a credible assurance of the advantages and security of the approach can have a positive effect on public perception and reduce uncertainty. Lastly, the price of the service also plays an important role. The variables that influence demand are shown graphically in Figure 15.

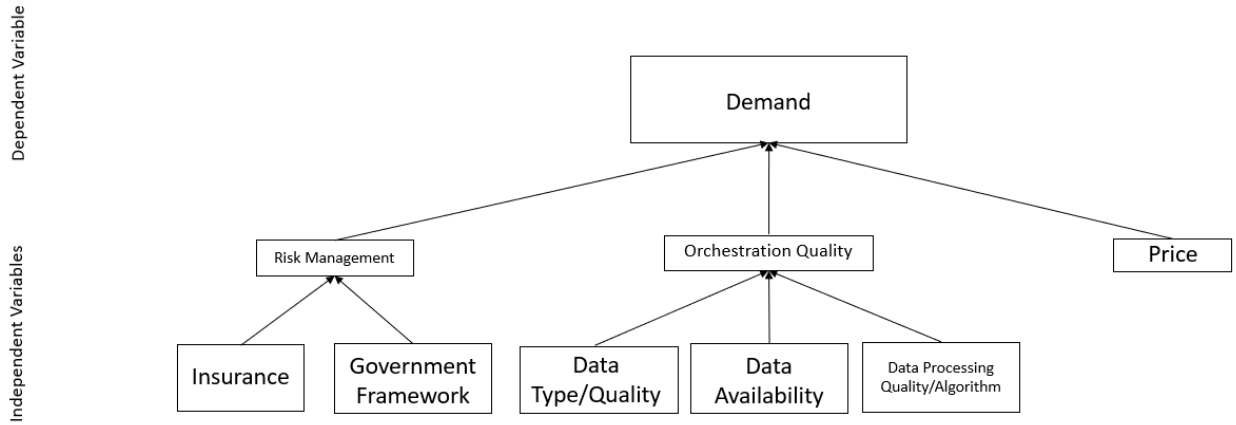

Figure 15 – Variables that influence demand for Traffic Orchestration. Source: Own depiction.

6.3.2 Supply

Besides the demand side, the supply side plays a central role. Particularly for the **TO operation regarding public transport routes**, MTM can be classified as critical infrastructure, which makes some regulations for the field necessary. Additionally, there are also some requirements for the market characteristics of the system. These include:

Table 9 - Requirements for the TO on public transport routes. Source: Own depiction, based on information from ORCHESTRA D2.2[79] and D3.1[80].

Critical Infrastructure Requirements	Market Requirements
Constant Functionality: Ensuring that a TO is always operational for each GA (no market exit due to market shocks).	**Business neutrality**: Accessibility for new players, no market-barriers (capital requirements, licenses, network effects).

[79] Benjamin Grosse et al., 'D2.2', 34.
[80] Marit Natvig et al., 'Orchestra - Initial Use Cases for Multimodal Traffic Management', 2022, https://orchestra2020.eu/wp-content/uploads/2021/07/D3.1-Initial-use-cases-for-multimodal-traffic-management.pdf.

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Backup: The ability to compensate for technical system failures must be always ensured.	**Cost efficiency**: Extensive, unnecessary spending must be avoided.
Standardisation: Data processing must be standardised and uniform to allow flexibility and avoid transaction costs.	**Innovation**: The field of MTM is dynamic and characterized by technological innovations. Market players have to cope with this in order to ensure that the system is up to date and functional. This can be guaranteed by competition.
Data processing: systems must function synergistically or at least interoperably with each other.	
Interconnection of TOs: All GAs must be connected, as events in one GA potentially affects several other GAs in other places.	**Compatibility**: Must seamlessly connect to and extend current Traffic Orchestration system.

Overall, this results in a field of tension between necessary, rigid state regulations and the need for keeping up with technological innovation and adaptability, which can only be ensured through competition. The requirements described here clearly limit the possibility of a private market model. As part of the critical infrastructure, the operational capability of the TO must be ensured at all times, which also makes it necessary to operate at (temporary) financial loss, if necessary, without exiting the market. Standardisation, uniform data formats and the interconnection of TOs limit the possibility of independent innovative development of new systems. At the same time, MTM is also subject to strong technological change and thus requires innovation, which can only be ensured through competition and accessibility for new players. In this context, the question arises as to how the TO can be integrated appropriately into the existing traffic management structures.

There are mainly two options for this: Building up the necessary competences within the authorities that execute traffic management and hiring fitting personnel, so-called insourcing. Or outsourcing the competences to a specialised service provider.

The advantages of outsourcing include primarily:

- Optimised resource allocation: specialised service provider and outsourcing organisation can each focus on their core tasks and fulfil them efficiently.
- Reduced costs: Costs for hiring and training personnel and materials can be avoided for the outsourcing organisation, thus reducing set-up costs, operational and recruitment costs.

The disadvantages of outsourcing include primarily:

- Risk: Possibility of exposing confidential data and technology.
- Suboptimal partner choice: partners with lack of expertise can produce low quality output, changing partners can imply further problems and costs.[81]

As insourcing within PA structures does not enable competition and accessibility for new players, relevant market requirements would not be fulfilled. Outsourcing the task and allowing for

[81] Somjai Sudawan, 'Advantages and Disadvantages of Outsourcing', 2017, 3–4, https://cberuk.com/cdn/conference_proceedings/conference_21121.pdf.

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competition in the selection process of the partner is a viable option to fulfil the requirements. This can be done by a tender process within the framework of a PPP. The risk of exposing confidential data and technology can be mitigated by appropriate contractual relations. As for the partner choice, a tendering process is likely to present a fitting tool. As part of this, the state can set certain specifications about the quality of the requested product and ask for bids from companies that want to offer it. However, if specific quality characteristics are prescribed, these must also be controlled frequently, which can lead to considerable transaction costs. The company that can deliver it at the lowest cost is awarded the contract. Competition is ensured by a regular repetition of the tender, usually for a few years, so that the company in question has a certain temporal security to engage in business, but at the same time competitive pressure is exerted again soon. However, in order for tenders as a tool that substitutes real competition to lead to welfare-optimised results, some conditions must be met. According to Borrmann[82], these are:

1. the existence of a homogeneous good.
2. a sufficient number of applicants.
3. non-preferential treatment - bidders are treated equally by the tendering authority.
4. absence of cartels - bidders do not collude with each other.
5. static market - demand function and cost function are constant during the award period.
6. information completeness - demand function of consumers and cost function of producers are known.

While 1. is most likely to apply, as data and systems are supposed to be standardised and 2.-4. are conceivable, 5. and 6. can be problematic. Generally, very few markets are static. The electricity market, for example, was dominated by coal for a long time, then supplemented by nuclear power and is currently facing a highly dynamic change with challenges related to renewable energies, energy storage solutions and sector coupling.[83] However, it must be noted that the demand for traffic orchestration with a constant number of GAs still has an important, static constant. With increasing automation, the type of traffic orchestration is changing, from human-controlled data processing to autonomous, self-learning systems. In this respect, the traffic orchestration market can be assumed to be a dynamic market with static elements.

Examples of the uncertainties of future cost developments include a change in the interest rate for capital, market demand or factor prices for inputs. These circumstances often lead to a phenomenon that can be called the "winner's curse". According to this, the winner is often the bidder who underestimates his own cost function and future risks the most and offers the correspondingly lowest price. If the cost or demand function then change to their disadvantage during the operational period, they are likely to enter the deficit zone. Furthermore, quality standards formulated by the state can act as a minimum requirement. However, the price of a product and its quality usually correlate with each other.[84] If the state selects the cheapest provider for traffic orchestration within

[82] Jörg Borrmann, 'Die Ausschreibung von Monopolstellungen — Probleme Und Lösungsansätze', *Zeitschrift Für Öffentliche Und Gemeinwirtschaftliche Unternehmen: ZögU / Journal for Public and Nonprofit Services* 22, no. 3 (1999): 256–72.

[83] Alexander Neubaur, 'Die Energiewende Und Smart Energy', 2022, https://www.researchgate.net/profile/Alexander-Neubaur/publication/362125250_Die_Energiewende_und_Smart_Energy/links/62d7a2d8441ed55f843cf486/Die-Energiewende-und-Smart-Energy.pdf.

[84] Borrmann, 'Die Ausschreibung von Monopolstellungen — Probleme Und Lösungsansätze'.

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the framework of the tender, this can also have negative effects on the data processing quality and thus on the quality of traffic orchestration in general.

Overall, a PPP for TO operation on public or predominantly public transport routes can therefore be described as a viable method to ensure traffic orchestration within the given framework. So, while tenders generally deliver less optimal results than free competition, most of the conditions to achieve welfare-optimal results relating to tenders are fulfilled or can be fulfilled. In the field of tension between critical infrastructure requirements and market requirements, PPPs thus present a suitable form of market organisation for TOs in the public sector. However, it is also associated with the challenges described above, which should be sufficiently considered when implementing the system.

With regard to **TO operation in private systems**, there are several points to consider. If a company has a large property, for example, on which many different vehicles operate and need to be coordinated, a TO can be a suitable solution. Unlike the public TO, however, no state guarantee for constant functionality or backups can be assumed here; rather, it is the entrepreneurial risk of the company to ensure that the processes function smoothly. If they do not, this may have a negative impact on the company's performance. A legally unified data standard would enable advantages in data exchange and interconnection between public and private TOs. However, it could also restrict private companies in their choice of preferred systems, for example if they prefer a system with a different data format. It is not yet foreseeable to what extent this will be legally regulated. In this respect, public TOs differ from those that operate in private systems. Depending on legal regulation, a comparably free, competitive market for companies offering traffic orchestration in private systems is conceivable. A regulated market is also conceivable, in which competition generally prevails, but the companies must fulfil certain conditions regarding the data standard and their communication with public TOs.

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7 Conclusions

This chapter summarises and interprets the presented results in this handbook. In the following, the limitations of the research and recommendations for further research will be discussed. Finally, the contribution to the main objects of the project and the impact on other parts of the project will be discussed.

The VNDs developed, based on the synthesis of VNA, TBL, and NIE, offer a holistic vision of the entire MTME network and give readers an overview on the critical business transactions that are necessary for ideal MTME functionality. Stakeholder-specific values can highlight the distinct value exchanges companies would perform when aligning themselves with MTME. By considering the value exchanges occurring among the stakeholders, companies can proactively adapt their existing business models. This approach allows companies to benefit from their association with MTME while minimising the need for major alterations to their existing business models. Systemic values arise from the interactions among multiple stakeholders simultaneously occurring within MTME. Moreover, systemic values further include societal benefits derived from these value exchanges. Values such as transport safety, reduction in emissions, reduction in traffic congestion, and avoidance of unnecessary expansion of transport infrastructure are advantageous to both MTME stakeholders and society in general. An efficient and optimised MTME can offer significant benefits to society.

The utilisation of VNDs must also be taken into consideration. From the point of view of policymakers and authorities, VNDs can help in efficient transport management across all modes. In contrast, from a company/private sector perspective, it can help improve existing businesses and products/services and generate new revenue streams. VNDs can be used as baseline information for creating new business models or extensions of existing ones. The stakeholder value interactions and systemic benefits that are realised for the entire ecosystem can be used as foundation for new, more defined business models. For instance, a TSP can consider VNDs of BAU, foreseen and unforeseen disturbances, and make changes to their existing business model accordingly to better execute transport services. Furthermore, the VNDs can assist stakeholders in identifying the needs of their contemporaries and formulate partnerships and collaborations within the ecosystem. Overall, VNDs helps in facilitating the development of sustainable business models and strategies that cater to the needs of all stakeholders while contributing to meeting the climate and emission goals set by the EU.

Following and building on current traffic management and data protection concerns, the TO has been integrated into the organisation of traffic management. The detailed example of road traffic management in Germany has illustrated the organisational structure and can serve as a blueprint for the further organisational connection of traffic management in the respective traffic networks with the TO. Furthermore, the organisational structure was examined with regard to cases that limit traffic orchestration. These occur especially when the TO(s) can only operate to a limited degree or not at all, when the communication path is disrupted, or the input data is incorrect. This can be prevented in particular if backup mechanisms prevent TO malfunctions and if malfunctioning TOs can be replaced by adjacent TOs in emergencies. Communication channels, especially for data to be transferred, need one or more backup channels in case of malfunction. Incomplete or incorrect data must be subject to a continuous evaluation process so that insufficiencies are noticed early and can be factored in by the system. Versatile data sources for individual topics (e.g. weather) are also

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recommended in order to be able to quickly recognise, analyse and classify strongly deviating data sources. By identifying, classifying, and proposing solutions to these challenges, the organisational model can be designed to be more flexible and resilient.

As part of the work on the market model, the variables and requirements that determine supply and demand could be identified. In the context of demand, these are primarily risk management, orchestration quality and price. The requirements for suppliers operate in the field of tension between critical infrastructure requirements and market requirements. In particular, a compromise must be found between security, standardisation, and uniformity of the system on the one hand as well as flexibility, innovative strength, and fair market access conditions for all players on the other. In this context, the model of PPP provides a suitable option, but comes with some potential challenges related to cost structure and orchestration quality. In contrast to the requirements for TOs operating in the public space, TOs in private entities are expected to operate in a comparatively free market environment. However, this depends in particular on the future legal requirements for data uniformity and data exchange between private TOs and public entities.

In conclusion, the research question "How can organisational, market, and business models be designed to optimally facilitate MTME, promote collaboration between relevant stakeholders and achieve economic, social, and ecologic benefits?" can be answered as follows: The organisational model builds on the existing traffic management system and introduces several options to integrating the TO and creating a framework of backup mechanisms to ensure the system's operability and links these to data security concerns. The market model analyses the relevant variables affecting supply and demand for TOs operating in the public and private space and presents a solution to the field of tension for requirements from the market side and the critical infrastructure side. The VNA analyses and presents the benefits of collaboration as well as economic, social, and environmental benefits in the respective scenarios, and further serves as a roadmap to emerging and future business models that could be a part of the MTM network. These models provide a framework that contributes to the facilitation of MTME, enables collaboration and generates benefits on an economic, social, and environmental level. Overall, MTM presents a promising opportunity to make optimal use of existing resources and thus progress towards the macroeconomic ideal of the Pareto optimum.

The limitations of this handbook include the novelty of the system under study and the corresponding scarcity of data and sources, especially regarding quantitative information. This limits the research in this handbook to qualitative methods such as expert interviews, workshops, and literature review. Moreover, due to constraints regarding the length of the paper, it was outside the scope of the handbook to conduct detailed case-by-case reviews for concrete organisational models of the different transport modes in the different EU Member States. Further research is required in the context of elaborating the specific organisational structure of different transport modes and their organisational relationship with the TO. Furthermore, a concrete, quantitative examination of the costs associated with MTM as well as the financial benefits is interesting for future research in order to quantify the advantages of the system. As soon as such quantitative data exists, an examination of business models including cost structure and profitability can be concretised. The PPP model described in the market model chapter and the challenges it poses for TOs and PAs also presents viable opportunities for future research. In addition to analysing external VNDs, exploring the internal value exchanges within the TO can be valuable. Such an analysis can provide insights into enhancing the functionality of the TO and offer readers information on the

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internal operations and functionality of the TO. By examining the internal value exchanges, readers can better understand how value is created, transferred, and transformed within the TO. This approach can aid in identifying areas where value creation can be improved, or inefficiencies can be eliminated.

The outcomes of this handbook have the potential to be utilised by the Living Labs, aiding in the development of guidelines and administrative procedures within the MTME. Useful insights can be drawn to have an effective deployment of the toolkits, as well as in the allocation of roles and responsibilities among the various actors and organisations involved. Additionally, the findings of this study provide valuable insights for establishing a secure data-sharing framework and a data monetisation system.

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8 Appendix

A.1 Summary of interviews

Motivation and aim of the interview.

The ORCHESTRA project aims to conduct comprehensive research on processes related to MTM. The long-term goal is to create a data exchange digital reference architecture that ensures the effective exchange of information between key stakeholders such as infrastructure managers, logistics companies, IT companies and other private sector companies. This would enable participating stakeholders to regulate access to the various infrastructures according to their capacity, optimise vehicle movements, and generally promote the efficient utilisation of mass transportation. The aim of the interviews within the context of Task 4.2 is to **identify applicable business, market, and organisational models to facilitate MTME with special regard not only to economic benefits, but also social and ecological ones**. Furthermore, special attention shall be given to factors that increase the overall macroeconomic benefit of the system and promote collaboration among the primary stakeholders.

Suppose the interviewee is also interested in further participation in the project. In that case, they will be able to follow the current state of research as a member of the CoP. Furthermore, the interview will encourage CoP members to contribute their practical knowledge to the research process and serve as an additional pillar of information in validating the outcomes and results throughout the project and beyond.

Methodology and research questions

After a brief round of introductions, the first part of this interview will be a general section asked of all interview participants. This is followed by specific questions adapted to the knowledge of the interviewee. The interview is designed to last 1 hour. However, discussion questions are still possible at the end should the interviewee have additional time to spare. The main research question is:

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- How can organisational, market and business models be designed to optimally facilitate MTME, promote collaboration between relevant stakeholders and achieve economic, social, and ecologic benefits?

The following guide comprises four sections; while the first and last sections are common to all the interviewees, section 2 is designed to contain specific expert questions. Further details on individual questions can be found in the comments below.

Section 0: Addressing and personifying the interview partner/general introduction to the interview partner (open part)

Introductory Statement	0 Questions	Answers
• Introduction of the interviewer • Usage of the findings (We would like to record) • Topic presentation • Structure of the interview	0.1 None	Presentation of the project and person of the interviewer.
• Introduction of the interviewee partner • Introduction of the company/institution. • Status of the company/institution. • Field of expertise of the company/institution.	0.2 To begin, could you please briefly introduce yourself? 0.3 What is the name of your organisation or company? 0.4 Are you a subsidiary of a group? 0.5 What is your status: public, private, or private-public partnership? 0.6 What is your field of competence?	• (Individual answers)

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Section 1: General questions

This section contains general questions about the properties of business models of MTM.

Introductory Statement	1 Questions	Answers
• Business models are often characterised by specific attributes. Since MTMEs are a multi-layered construct, it is important to identify these accurately.	1.1 What aspects/structures does a business/organisational model need to possess to facilitate MTM?	• Business models should **focus on economic, social, and environmental benefits**. • Business models must **focus on long-term benefits and not highlight short-term** and individual benefits. • **Data monetisation** can make the services of MTME more appealing to private businesses. • Government must have oversight when imposing monetisation and penalties mechanisms. Information flows must be controlled by the government. • **Infrastructure/Platform** must be built in **an open environment and** open to all. It might need financial support until a sound business model is established.
• Apart from certain attributes, it is important to find a comprehensive business model/organisational model that matches the requirements of MTM.	1.2 Can you think of a business or organisational model that is suitable in facilitating MTM from an economic, social, and ecologic perspective?	• **Small and medium-level enterprises** should get **financial incentives** to keep running their **daily operations**. • There is no scientific way to measure social aspects, so we must figure out how to **ethically model social elements**.
• An insight into your previous experiences related to the topic can also be valuable for us.	1.3 Have you encountered comparable approaches for business models in MTM? If so, what kind of business models were those? Did they have distinctive features?	• **Port of Los Angeles** has a system called "**Marine Exchange**", which is a non-profit entity formed by member companies which guide vessels and vehicles by offering timeslots for entering the port over time; companies have learned to trust this system and abide by the suggestions given by "Marine Exchange". • **Software accessibility** was given much focus in EU Mobility Dataspace. It was free and open source. Users could sign up for free and exchange their data. It would be best if you kept the entry level for MTME low **to allow a maximum number of individuals to participate**.

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Section 2 Economic focus

Introductory Statement	2 Questions	Answers
• In a multimodal transport journey, several stakeholders are involved such as the TSP, FO, NU, and TU. To identify the value propositions taking place between these stakeholders, we've used the VND method. It focuses on mapping economic, informational, and intangible transactions and interactions that produce value in each ecosystem (external), or within an organisation (internal).	2.1 Based on your experience and expertise how would you evaluate our approach of utilizing value network methodology? 2.2 Within your company's business ecosystem, how do you ensure to deliver values to key stakeholders?	• VND is a good starting point. It **shows stakeholders different benefits**, gives a big picture, and is used in other projects. • We deliver critical values through contacts, resources, and knowledge. It is essential to communicate with stakeholders, and this process of providing values should be transparent.
• The TBL approach suggests that businesses must lay equal importance to economic, social, and environmental aspects to be sustainable.	2.3 In your organisation, how important is it for a product/service offering to produce social and ecologic benefits as well as economic ones? 2.4 From your experience, would it be realistic to assume that this is possible? Or would they be given second priority?	• For public entities, it is possible to focus on social and ecological aspects rather than financial incentives. • For large businesses can focus on social and ecological aspects and initially let go of financial incentives. • For medium and small businesses, can create sustainable business strategies and focus on social and ecological aspects. To do so, they will need subsidies to take care of their finances.
• Our initial research shows that MTM might be a service dominant business which is inclined to improve the social standard and build a resilient transport ecosystem.	2.5 Would your organisation be willing to invest in MTM services that promise a reduction in energy consumption and overall travel time, as well as improved safety, without being able to directly give a quantifiable figure on the economic benefits?	• In the Mobility dataspace research project, many companies were inclined to be a part of it. They made investments initially because they **wanted to improve their sustainability and reap the rewards of data sharing**. • We can attract more companies by offering **priority services** if companies are willing to pay more. • Private companies might need to be motivated to engage with MTME for a **long duration**. Public entities must be **regulated and mandated** to cooperate on a multimodal level.
• To achieve a more resilient transport ecosystem in the future, TSPs and FOs must increase their collaboration,	2.6 Within your company's relevant business ecosystem, what steps has your company taken with other TSPs or FOs to achieve a more	• Private companies are willing to change their business models temporarily to receive financial incentives. They need to be convinced that their data remains safe. **Public entities** are easy to convince to collaborate since they

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which requires their existing business models to be changed accordingly.	collaborative relationship? 2.7 What are the challenges that arise when trying to achieve this?	**have overarching goals** of serving people/society. • Companies are willing to collaborate if their **product offering is improved eventually**. • To improve collaboration, all the parties must be willing to collaborate and have overarching goals.
• MTME proposes to create a collaborative business environment among its stakeholders. So that in case of disruption/accident there are minimum congestions, emissions, downtime.	2.8 In case of disruption/accident what kind of collaboration would you expect between TO and other stakeholders such as authority, TSP, FO, NU, TU?	• In case of disruption, the TO should estimate **"how long the disruption is going to last"**, and the second step would be to provide suggestions and not orders **on "how to behave"**. In the case of a private orchestrator, these suggestions should be precise and accurate, or private companies can sue orchestrators, which might be legal challenges. • TO must be a public entity with certain rights and authority in the event of a disruption. A dedicated **risk analysis for each scenario**, clear **protocols for each situation** and follow guidelines in case of disruption.
• The companies have less flexibility due to the current business models. For instance, one business relies on just one TSP/FO for the duration of their shipment. In the event of disruptions, this results in an increase in overall travel time, and the corporation must deal with the economic effects of the delay.	2.9 Do you feel confident in dealing with a single TSP/FO for the duration of your transportation? If yes, what precautions/steps have you taken to achieve this level of confidence? 2.10 What were the unfavourable incidents/impacts caused because of dependency on a single TSP/FO, based on your experience?	• We've got one common TSP for the entire HIP, and they've gained the trust over the period. • From an end-user perspective, one point of contact is preferable. It might become problematic if one needs to interact with ten other organisations, creating obstacles and legal challenges. However, if you solely rely on one party for the entire transport and if they go offline during disruption, it can cause trouble. So, TO must be well **equipped with backup** in case of disruption.
• MTME proposes to have flexibility in selecting the contractors for the transportation. For instance, a NU can quickly switch their TSP or FO with the help of the TO in the event of an interruption or accident so that they can avoid traffic and	2.11 What steps/parameters should the TO take into consideration to achieve this degree of flexibility within MTME? 2.12 What general steps/parameters should be taken into consideration to achieve this degree of flexibility between stakeholders like authorities, tech companies, TSP, FO, NU, TU?	• TO must have an overview of the **cost of changing the operator**. This should be taken into consideration by TO before giving out the suggestion of changing service providers. • TO must be aware of the content of the goods transported and should have a **priority list** that specifies who should be given precedence in the event of a disruption. • In air traffic management, all entities know the route, origin, destination, and **contingency plan**. A similar approach could be followed in MTME.

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finish their route on schedule.		• In case of disruptions, TO will have resources which can immediately kick in and resume operations. But in everyday scenarios, such resources remain idle and unsuitable for the ecosystem. • To encourage greater collaboration, tech businesses should comply with open data exchange standards.
• To have seamless traffic orchestration in multimodal transportation. It is mandatory to have real time traffic data being exchanged between relevant stakeholders. So that accurate and precise traffic orchestration can be achieved.	2.13 What kind of data exchange practices do you use within the business ecosystem of your organisation to obtain accurate and precise traffic and transport information? 2.14 What are your concerns and reservations when it comes to sharing traffic related data/information with the relevant stakeholders of your ecosystem?	• The **real-time location, vehicle capacity, and desired route**. These are three basic things which an orchestrator might need. • **Trust** is an important aspect when we are talking about MTME. • A PA responsible for storing and managing the data may help gain stakeholders' trust. If TO can hold such extensive data from different stakeholders, they are prone to **cyberattacks** and should consider having appropriate data storage security. • **GDPR** would be a significant concern for private companies.
• TO is required to have real time traffic data from TSP, FO, NU, TU to deliver accurate and precise traffic orchestration. However, not all traffic related data is required to be shared with TO. The right category of data is sufficient for traffic orchestration.	2.15 Think about your business joining MTME. What would assure your organisation in feeling secure and confident in sharing this data with the MTM ecosystem?	• **Trust** would be an important factor. From a private entity perspective, they would like to have financial incentives. • **Data protection** and storage. • PA looking over all the data. • There should be **clear list of advantages** when one joins MTME. Government should play active role in bringing big players into MTME.
• Transport authorities/municipal corporations play a critical role in forming transport policy, implementing regulations, measures regarding cost reductions.	2.16 From your experience, what would be the most significant changes that an authority could make to improve the transport ecosystem? 2.17 TO can be expected to have a PPP model at an administrative level. What level of involvement would you expect between the authority and the TO?	• While applying for licenses, companies must showcase their **contingency plan for disruption**. Furthermore, when there is a significant accident/disruption, they must participate in solving the problem for the better good of all. • Authorities can create effective regulations. They can **upgrade the necessary infrastructure** required. • **Data standardisation** is essential so that various data formats can be used in MTME. • Authorities must be proactive. It is better if local governments join MTME because they've got more benefits than national authorities. TO must make decisions quickly; government entities often do not take decisions rapidly. Hence daily

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		operations should be done by a private entity. • PPP contracts should **clearly distinguish the roles** of PAs and private entities. Because private entities tend to find loopholes in the contract and exploit PAs.

Section 3 Discussion Questions

Introductory Statement	3 Questions	Answers
	3.1 ORCHESTRA provides a reference architecture which can act as an extension to existing traffic and transport management solutions. Would you consider using a similar architecture in your organisation's daily operations? If not, what are your reasons?	• It would help TSP, FO a lot and make it easy for them to move around different modes of transports. It needs to provide appropriate incentives to private companies. We have a similar architecture planned to be implemented at HIP but just on a smaller case.
	3.2 What doubts or worries do you have about not getting engaged in MTME?	• Some concerns include: Who oversees the platform? Are there any platforms like ORCHESTRA that are rivals? Is the data trustworthy for use in routine tasks? Companies would expect a certain level of quality to improve their products. • If the companies don't see the results, gains, and reputational benefits coming in 2-5 years, they will start reconsidering their association with MTME.
	3.3 Do you think MTME will become a reality soon, given your knowledge and experience? If not, how well can MTME accomplish its goals?	• Yes, I believe MTME will be a reality but not soon. • Application cases for MTM-like scenarios are growing. • There will be several advancements next year, but there is no reason to believe that the status quo will shift until a significant disruption, such as an energy crisis or a major conflict.

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Final analysis and contextualisation of the results

In the following, the results of the interviews held as part of ORCHESTRA Task 4.2 are analysed. In total, four economic semi-structured qualitative interviews were conducted with representatives of ITS Norway, Technical University of Berlin, HIP, Lernende Systeme/ACATECH.

Section 1 revolves around general questions on MTM. The section contains information about a general understanding of the business of MTM and how experts perceive it. The experts agreed that business models must focus on social and ecological aspects along with economic aspects and particularly on long term benefits. Data monetization could be particularly interesting for private companies, as it represents an additional source of revenue within their business model. Some interviewees highlighted that PAs should create and regulate a possible future data sharing platform to ensure optimal use and security of the data. Since the completeness and quality of the data is important for the system's full functionality, establishing an incentive system can be a viable option. Furthermore, it could be advantageous if MTME was open to all and created in an open-source environment to increase its reach. Establishing an ecosystem of this kind will require initial financial support during the market ramp-up phase, especially for small and medium-sized companies.

A comparable project that successfully followed a similar approach is the Port of Los Angeles "Marine Exchange" system. It is a non-profit entity created by member companies which guide vessels and vehicles by offering timeslots for entering the port. Many companies have overcome their initial scepticism and are now highlighting its benefits. Software accessibility was prioritised when working on the "Mobility Dataspace" research project. This platform was developed in an open-source format; all companies could sign up for free and exchange their data. A similar approach with low entry barriers could also be beneficial for MTME. However, some social and ethical aspects are difficult to assess from today's perspective and thus require further research.

Section 2 revolves around the economic focus. This forms the main section of the interviews. In total, 17 questions were asked, and each set of questions was focused on different topics such as the value network method, TBL approach, flexibility and collaborative business models, data exchange practices and the role of authorities. All experts agree that a value network methodology is a valuable tool for MTME. It highlights benefits for all stakeholders in the ecosystem, especially on a macro level. They believe that public entities can focus on social and ecologic aspects, since their goals revolve around serving the people. Large companies with corresponding financial resources usually also have the option of taking social and environmental aspects into account. However, small businesses with fewer financial resources would presumably be more likely to do so with financial support. It is essential to understand the willingness of private and public entities to invest in MTME. In the "Mobility Dataspace" research project, it was observed that companies were motivated and investing in the project to improve their sustainability and reap the benefits of data sharing. TOs could consider having priority services/value-added services as a premium feature, which might generate an additional revenue stream. One of the experts suggested offering priority services/value added services on top of essential traffic management services. This might motivate companies to pay for premium/exclusive services. According to the interviewees, the long-term

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participation of many companies in the system is essential. To achieve this, creating corresponding incentives or regulatory measures is conceivable. In both cases, the security of the data provided must be guaranteed and ensured.

The interviewees recommend establishing the TO as a state entity rather than a private company to provide the necessary rights and powers. In the event of a disruption, the TO can then provide assessments of the traffic situation and recommendations for optimal handling. To do so, risk analyses or protocols for different disruption scenarios could be created. As for the customer perspective, interviewees highlighted that a single point of contact system makes the most sense, as communication with different contacts often becomes difficult. Thus, if only one party is responsible for an area and acts as a single point of contact, they need to provide backup options in case communication or technical problems arise. In addition, an overview of any cost changes, e.g., due to a shift in transport mode due to a disruption, should also be available quickly and communicated transparently.

Open data standards can improve collaboration among stakeholders of the ecosystem. However, trust will play an important role in achieving open data standards. The holder of an extensive mobility data pool, including real-time location, capacity, and desired route of vehicles, can quickly become a target of cyberattacks. Therefore, it is recommended that PAs are given the responsibility to store and manage the data along with a legal and insurance framework that protects private companies in case of damage and does not disadvantage them so that their business model is not adversely affected. In this context, particular consideration should be given to the General Data Protection Regulation.

Authorities also play a key role in other areas, such as licensing, contingency plans, and accident resolution. According to the interviewees, it therefore makes sense to integrate MTME firmly into the network of various authorities that deal with mobility as well as local governing entities. A PPP can also make sense in this context. If the legal and organizational framework is organized and provided by PAs, the operational activities can be outsourced to a private company (e.g., to optimise costs).

Section 3 consists of discussion-based topics. Here the interviewees were asked some open-ended questions and their perspectives on implementing MTME. Interviewees did come across similar application cases/projects related to MTME. Hence, they acknowledge that much work is being done in this domain. Unfortunately, they disagree that MTME could be a reality soon. Being part of MTME can benefit the TSPs and FOs. However, there were some concerns/worries that interviewees had regarding MTME:

- Who oversees the platform?
- Is the data trustworthy for use in routine tasks?
- To what extent will the quality of the product/service be improved by being part of the MTME?
- What kind of incentives will private companies get by joining MTME?
- If the benefits are not realised in 2-5 years, companies will reconsider their association with MTME.

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In conclusion the interviews provided detailed insights from the economic, social, as well as ecological aspects of MTME. It is necessary that both private companies and public entities must have willingness and common goals to achieve maximum results for MTME.

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A.2 Second workshop: Organisational models and business aspects.

GROUPS 1 & 2 – LEGAL CLASSIFICATION OF DATA SHARING

The source material collected reveals some challenges in establishing MTM. Some of these challenges require case decisions. These include:

THE TYPE OF DATA SHARED

Comprehensive, time-accurate individual data such as the real-time location of vehicles, the planned route, and the transported cargo allow optimal traffic orchestration since it is then possible to react flexibly. However, this requires legal compliance with data rights such as the GDPR.

Historical data is comparatively uncritical because it does not interfere with the data rights of individual stakeholders. However, precise personal data on cargo and real-time location are more accurate. Historical data could accordingly lead to inferior results in traffic orchestration. In this context, the question arises about how this conflicting issue can be resolved.

Question: To what extent does data protection law allow the collection and processing of individual and time-accurate data? Is it possible to combine relatively uncritical personal and time-accurate data together with historical data? Or must the pure use of historical data be resorted to?

Group 1: Real-time data is very difficult to share according to current laws. Personal, age, and especially healthcare data is very sensitive (handicap data etc.). It can be possible if you restrict it to a specific trip (individual agreement per trip) – use temporary data (no more historical data).

Is it NOT possible to combine relatively uncritical personal and time-accurate data together with historical data? Data aggregation is a challenge.

Historical data are easier to anonymise.

Group 2:

- Historical data is problematic (competition)
- (Type of data) depends on whom you share your data with.
- Within a GA, you might only share the data relevant to the TO in charge.
- Historical data is not to be shared with some stakeholders. (Not everyone can have historical data, apart from TO)
- Question of “open data”.
- What about something like flight radar for trucks? (i.e., where you can see where they are coming from, where they’re going to) e.g. you don’t want to show the truck transporting gold.
- Position cargo should generally be shared weight, height, width (measures), time–criticality (e.g. The latest time the goods should arrive), receiver, and constraint in general (including weather, predictions should be used for this), information about the change of plans.
- Trucker could, e.g. share information about time and, as a benefit, find free space to rest/avoid queues.

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THE DATA-SHARING MECHANISM

The idea of MTM is based on the benefits of additional, comprehensive information that can be provided regarding traffic. This data is collected by companies, such as transportation companies, and institutions, such as weather research institutes or government agencies, and processed by an institution, such as the TO. This data has value, may include trade secrets, and is often protected by data protection laws.

In this respect, the question of the data-sharing mechanism arises. It is conceivable to create a legal basis according to which there is an **obligation to share data** with a protected institution such as the TO. This would have the advantage that extensive data would be available for processing already at the start of the system. Accordingly, the system could make precise calculations and provide qualitative results. But it needs to be clarified to what extent the creation of such an obligation conflicts with existing data protection law.

Another option is an **incentive system for data sharing**, i.e., data monetisation. In this case, the data provided by companies are paid for with financial resources. In return, data processing and optimal calculating routes or optimal network utilisation would also require payment from companies that use MTM. In this case, there is a possibility that the quality of the system is compromised. If only some companies join the system, processing sufficient data will lead to low-quality results from the system, which will also disincentive for already participating companies to remain in the system. A negative snowball effect, in which customers leave the system due to low-quality data and the quality continues to drop further, causing more customers to give up, would be imaginable in this scenario.

Question: To what extent does a legal obligation to share data conflict with current data law?

Group 1: Very difficult but might be easier with temporary data. GDPR, healthcare HIPAA, specific laws for age/income/etc.

Group 2:

- Legal obligation is at least very beneficial; this is a basis. It would be best if you get monetary compensation for further data you share.
- Depends on whether private cars or commercial trucks. Because for personal vehicles, google has so much information about traffic already.
- Public companies already (in many countries) must share their data.
- For passengers, it could be an option to share their data; they would get the benefits of being considered in case of a delay etc.
- Incentives can be significant (consider the truck example mentioned earlier).
- Do users want to share the same data with all TOs? Or different types of data for different TOs?
- There should be rewards but not punishments.
- Money as compensation might not work because they might not recognise the inherent value of sharing data.
- Incentive systems should be easy to handle and not cause an administrative burden.

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GROUPS 3 & 4 – FINANCIAL & HEDGING FRAMEWORKS

The source material collected reveals some challenges in establishing MTM. Some of these challenges require case decisions. These include:

THE SYSTEM LAUNCH

The system is exceptionally qualitatively functional if as much traffic-related data as possible is supplied. Therefore, data monetisation is likely if a legal obligation to share data is not chosen or proves impossible. In this scenario, companies would sell their traffic-related data to the TO and pay for the traffic orchestration service. If this offer reaches enough potential customers in the initial phase, the traffic data received, and the quality of traffic orchestration will be high.

So here the question arises about the measures to make the system attractive from the beginning. For example, financial benefits such as an attractive fixed price for data packages for a limited period, degressive (i.e., decreasing over time) subsidies for participating companies, tax breaks, and similar measures would be feasible. At the same time, it must be remembered that government incentives are paid for by taxpayers' money and are thus limited. Non-financial incentives are also possible.

In this respect, the aim is to collect ideas and advantages and disadvantages of specific incentives for the system launch. In the case of financial incentives, potential costs should be weighed up against the level of motivation.

Question: What is the most cost-efficient way to incentivise early participation in the system?

Group 3 & 4:

- Preferred treatment for the sharing data (tweaked optimisation algorithm) zero cost.
- Compile data-sharing into existing “green efforts” that lead to tax breaks (sharing data for greener…)
- Living labs /Demonstration that show that the system work (give trust to other stakeholders)
- Temporary tax break
- Bonus point system
- Temporary subsidies
- Soft incentives (e.g. using bus lanes)
- Trust (long-term) must be created.
- Involve companies in pilots.
- Prepare and involve OEMs.

THE HEDGING MECHANISM

Companies make themselves vulnerable by providing various business-related data, such as the exact cargo of delivery, the planned route, and the real-time location. Financial damage can be severe if such data is shared, hacked, or leaked. In this respect, it is essential, on the one hand, to credibly insure against potential data leaks and, on the other hand, to protect against the event of damage. However, this is not the case; companies do not weigh their data safely or are not protected

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against damage. In that case, there is an increased risk due to joining the system, which can have a deterrent effect and make the system unattractive.

In this respect, it is essential to consider the extent to which government stakeholders can provide related securities and how an insurance concept could be designed.

Question: How can PAs ensure the safety of the system? How can an insurance framework be designed that is both secure and affordable?

Group 3 & 4:

- Data should be anonymised (Risk minimisation).
- Companies should anonymise their data before sending it.
- Convincing government framework and political will are required (Risk minimisation).
- Calculating/assessing the value of data is challenging. There needs to be a standardised method to avoid a legal clash.
- Business cases for insurance companies must exist if they cannot cover their costs; no business case exists.
- Certification for cybersecurity (Risk minimisation).

GROUPS 5 & 6 – STAKEHOLDER DESIGN

The source material collected reveals some challenges in establishing MTM. Some of these challenges require case decisions. These include:

THE ORGANISATIONAL FORM OF THE TO

For the TO, it has yet to be determined which role it will appear. This mainly concerns the organisational form. The TO will be a private-sector, state or mixed stakeholder, a so-called private-public-partnership. In addition, given the rapidly advancing development of AI, the question arises as to whether the task would be performed by humans or not primarily or entirely by AI.

In this respect, it is essential to discuss the effects of the organisational form of the TO. A business model including revenue sources and profit must be designed if it is privately owned. Its responsibilities, rights, and duties must be defined if it is state-run. Finally, if the TO acts as an AI, special consideration must be given to the additional risks that arise and how they can be hedged.

Question: What needs to be considered for these different organisational forms? Which organisational form is preferable under which situation?

Group 5: Private TO: the goal is to get money. But who is going to pay? The users who are ready to pay to get the service. The rule is: priority to the one who pays. Auctions could be implemented in a private network but not in a public one.

Public TO: the goal is to reach collective issues (climate, pollution, security, safety...). for instance, HIP provide common safety-related services. HIP can be paid for this mission. This can be extended to traffic regulation. The rules are defined in advance for all users.

PPP TO: the PA is the one who orders. The Private operates on behalf of the PA. The PA order the goals and the means they use to reach these goals!

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Consideration related to AI: AI will handle most situations. AI can help Automation. But we need time to use the data set to make it practical iterative development. To get confidence in AI, we need human control of the results the AI provides.

Group 6:

- AI – mainly discussion support
- Common regulation and standardisation
- EU/NPRA can regulate and standardise and make it mandatory for other actors to share data on infrastructure.
- AI – effectiveness of the actual possibility of learning
- What is the difference between a public and a private actor doing the TO based on a common policy, regulation, and standardisations? Responsibility must be alike.
- Clear understanding of hierarchy – many prefer public actors at the top of the hierarchy (depending on the country)
- Regulations and standardisation need to be understood and built on trust – and accepted policies.

THE ROLE OF PA

Another critical question is to what extent PAs would be involved. On the one hand, cooperation with PAs helps inform about occurring events, which can also have traffic consequences. On the other hand, the question arises to what extent PAs could be involved in the administration of MTM and form a regulatory framework. PAs can force companies to collaborate, especially during disruptions. Interview results have revealed some aspects where the PA's role could benefit the system. For instance, the presence of PA will enable trust among the stakeholders in MTME. It will be assured to the stakeholders if a PA oversees data storage and monetisation facilities. In addition, PAs can use their political influence and attract big tech companies to participate in MTME. On the contrary, experts also suggested that the system would be more beneficial if the local transport authority were associated with MTME. Since local transport authorities are aware of local bottlenecks, they can take a proactive approach to fix disruptions and congestion compared to regional authorities. However, if a PA is involved in MTME, they must be regulated and mandated to cooperate on a multimodal level.

Question: It is important to establish and understand the role of PAs and their integration and tasks in the system. What tasks do PAs perform in MTM?

Group 5:

- Data should be collected at the national level, not at a local level.
- The PA (or a private body on behalf of the PA) should be the Data intermediate service provider, I.e., the trusty third party.
- The states should define the rule that the TO should follow (e.g. data that infrastructure managers ought to share with NU).
- The national access point has defined several Catalogues of metadata.

Group 6: TO, Authority, Regulator- Many tasks – regulations, standardisation, and policy.

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