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ORCHESTRA Project Deliverable: D2.3

Initial scenarios for multimodal traffic management

Authors:

Ludovic Vaillant, Maire Douet, Chloé Eyssartier (CEREMA),

Marit K. Natvig (SINTEF),

Abdulghani Al Sabouni, Anne Freiberger (IKEM)

Nicola Cavagnetto (DBL)

Paria Amini (HES-SO)

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Deliverable Identification

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Release History

Version	Date	Internal Review Milestone Reached (if relevant)	Summary of main changes introduced in this version
0.1	2021-08-15	PCOS	Initial version
0.2	2021-09-27	PCOS Reviewed	Reviewer made major comments and suggestions
0.3	2021-12-23	PCOS approved	Updated document in accordance with reviewer comments
0.4	2022-03-30	Intermediate report proposed	Description of the design of the scenarios. MTM concepts and first target vision scenarios.
0.5	2022-04-01	Intermediate report approved	Updated document in accordance with reviewer comments
0.6	2022-04-26	External report proposed	Last target vision scenarios, Methodology and contains of the implementation scenario
0.7	2022-04-28	Released version proposed	Updated document in accordance with final reviewer comments
1.0	2022-04-30	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 freight and person transports across road, rail, water and air.

Legal disclaimer

For more information

Project Coordinator: Runar Søråsen, runar.sorasen@its-norway.no
Dissemination Manager (WP7 leader): Jenny Simonsen, jenny.simonsen@its-norway.no

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Executive Summary

This report provides the **initial scenarios for Multimodal Traffic Management** (MTM). It is a kind of bridge that allows to go from the target vision elaborated in deliverable D2.1 into its modelling (WP4) and gives the framework to the tests of use cases within the Living Labs (WP5). It provides a first alignment of vision, scenarios and uses cases of the ORCHESTRA project, as required by ORCEHSTRA's milestone MS2.

Traffic management is an activity that varies within all modes of transport. A review of the literature about the related work shows that the issues of the traffic management are common to all the modes of transport: safety, security, infrastructure capacity management, reduction of congestion, dissemination of real-time information to network users. However, each mode has developed its own system of traffic management, in which the dissemination of information in real time is at different stages of development and uses different technologies. Differences can also be pointed out between freight and passengers traffic management.

Nevertheless, traffic management can be conceptualized through two main concepts: the **"transport demand management" (TDM)** mainly used in road traffic regulation and the **"demand capacity balancing" (DCB)** which already founds the air transport system. These two concepts now ought to integrating the **automated driving** as a radical innovation that may affect the stakeholders' interactions and be relevant to policy and society.

These two key-concepts of traffic management feature some of the main archetypical stakeholders recently defined in D3.1 that are the **Transport Orchestrator,** the **Fleet Operator,** the **Transport Services Provider** and the **Network Users.** The transport Orchestrator is related to a **Governance Area** which is the area or space with respect to some authority and is the zone in which the traffic orchestration takes place.

The initial scenarios described in this report are composed of two different kinds of scenarios. First, the **target vision scenario** that is a description of how the MTM concepts function through previous stakeholders. It describes traffic management operations through the ORCHESTRA concepts assuming that all the MTM ecosystem barriers have been overcome, that all the gaps from the current context have been filled up. It provides a detailed description of the role of the main stakeholders-types and the nature of the information exchanged between them, in three different traffic management situations: **normal situation, foreseeable events,** and **unplanned events**. These situations may take place within a single governance area (that is a single network) or involve several adjoining governance areas, including hubs. It particularly explains how ORCHESTRA system can support the regular and exceptional operations of each stakeholder.

Second, the **implementation scenario** that deals with the needed requirements, the gaps to fill up, and the barriers to overcome, to reach the MTM target vision. It emphasizes:

- Policies and regulation, as the current legal framework both functions as a driver and a barrier in different aspects.
- Technical issues related to smart infrastructures and the integration of CAVs, for which a lot of investments and standards are still needed.
- Data governance and sharing, that deals with data access, data ethics, data quality, and ownership, as well as standardisation.

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- MTM functionality and the main steps to be taken, for a homogenous implementation of TDM and DCB as well, within each mode.
- The acceptance for traffic management operations and autonomy, that points out the Interest in participating in the MTME, and TO's acceptance.
- Operational practices and decision making, such as trails and business models.
- Business and organisational aspects.

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List of Abbreviations

Table 1: List of abbreviations

Abbreviation	Explanation
API	Application Programming Interface
CAM	Cooperative awareness message
CAV	Connected and Autonomous Vehicles
CoP	Community of Practitioners
DCB	Demand Capacity Balancing
DEMN	Decentralized environmental notification message
DoA	Description of Action
FO	Fleet operator
GA	Governance Area
GDPR	General Data Protection Regulation
GHG	Green House effect Gasses
IVI	In-vehicle information
KPA	Key Performance Area
KPI	Key Performance Indicator
MAP	Map Data
MaaS	Mobility as a Service
MTM	Multimodal Traffic Management
MTME	Multimodal Traffic Management Environment
MS	Milestone
NATS	National Air Traffic Services
NU	Network User
PMA	Polycentric Multimodal Architecture
OEM	Original Equipment Manufacturer
PI	Physical Internet
SPaT	Signal phase and timing
TEN-T	Trans-European Network - Transport
TO	Traffic Orchestrator

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Abbreviation	Explanation
TSP	Transport Service Provider
TDB	Transport Demand Balancing
VTS	Vessel Traffic Service
WP	Work Package
WS	Workshop

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List of Definitions

Table 2: List of definitions

Definition	Explanation
Mode	Road, sea, rail, or air. Within some of these, there might be sub-modes. In general, the traffic orchestrator address one mode, which may include sub-modes (e.g., bike, bus, car, etc. for road). If a sub-mode (e.g., light rail) is managed as a separate network, the sub-mode is considered as a mode.
Multimodal transport	The multimodal transport concept was first proposed by the United Nations in 1980, defined as "carriage of goods by at least two different modes of transport". (United Nations 1981). Multimodality now also addresses passengers.
Network	A transport network has a mode and the traffic in the network is managed in one or more governance areas.
Smart infrastructure	Ogie et al. (2017), on the basis of a literature review, introduce the concept of smart infrastructure as the result of "the irreversible marriage between digital technology and physical urban infrastructure". However, they pointed out that a common language to describe terms and processes is still missing. At the most basic level, they suggest that *"a smart infrastructure can be defined as an interconnected sensing network that provides real-time digital information about the state of the system (Morimoto, 2010). This definition of smart infrastructure focuses on the self-monitoring ability of the system through the combination of physical assets and digital technology (Balakrishna, 2012; Shahzadi et al., 2013; Stefansson and Lumsden, 2008). In this context, digital technologies are used to acquire data that are then processed, stored and delivered in the form of reliable and actionable information to aid infrastructure providers in making informed decisions about the management of their infrastructure assets (Hagen, 2011). Cambridge Centre for Smart Infrastructure and Construction (CSIC, 2016a: p. 2) defines smart infrastructure as 'the result of combining physical infrastructure with digital infrastructure, providing improved information to enable better decision making, faster and cheaper'"*.
Synchro-modality	Synchro-modality is defined as an "evolution of inter- and co-modal transport concepts, where stakeholders of the transport chain actively interact within a cooperative network to flexibly plan transport processes and to be able to switch in real-time between transport modes tailored to available resources" (Haller *et al.*, 2015).

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1 About this Deliverable

The D2.3 deliverable provides the target vision scenario for Multimodal Traffic Management (MTM) and describes the related ecosystem (MTME) that need to be implemented.

1.1 Why would I want to read this deliverable?

In the continuity of deliverables D2.1 and D2.2, D2.3 provides a first refined vision of how a MTM could function from the point of view of the stakeholders and what is needed for its implementation. It integrates the main results of the D3.1 *(Initial use cases for multimodal traffic management)* and the first results of D6.1 *(Evaluation handbook)*. Particularly, it describes in detail the role of the MTM stakeholders and the nature of the information exchanged between them, in various traffic management situations: normal situation, during foreseeable events, during unplanned events. It also provides the needed requirements, the gaps to fill up, the barriers to overcome, to reach the MTM target vision and its acceptance by the different stakeholders of freight and passengers traffic management.

D2.3 provides a first alignment of vision, scenarios and uses cases as required by milestone MS2.

These initial scenarios for MTM will constitute a basis for, the next Workshops and for the design of the final scenarios of MTM (D2.4).

1.2 Intended readership/users

This Deliverable is of interest for the European Commission, as well as beneficiaries of other H2020 projects interested by the vision of the future traffic management, and the inclusion of CAVs in the traffic. In particular, it provides the main avenues for implementing an environment (ecosystem) favourable to the development of MTM.

It is also of interest to all the ORCHESTRA project partners involved in:

- WP3 (polycentric traffic management design), as the scenarios are inputs to the work on the intermediate PMA for multimodal traffic management (D3.2).
- WP4 (Enabling toolkit, organization and business model), as the implementation scenario described in the D2.3 provides inputs to the business model's design.
- WP 5 (living labs, trials and simulations): further refinement of relevant part scenarios with details linked to the living labs and related simulations. The « selected and relevant parts of the scenarios will be simulated and tested in the living labs ». Therefore, the MTME scenarios and the use cases tested in the living lab must be aligned.
- and WP6 (evaluation and lessons learned), as the implementation scenario described in D2.3 gives relevant data to answer the research questions for some of the Key Performance Areas (KPAs).

1.3 Other project deliverables that may be of interest

In addition to this report, the reader is invited to read the other deliverables with which D2.3 is in connection.

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Inputs are used from:

- D2.1: *Initial target vision for multimodal traffic management*. It defines the initial target vision of a multimodal traffic management ecosystem within the 2030 and 2050 horizons.
- D2.2: *Pre-studies on environment analysis and drivers*. It defines the context in which multimodal traffic management will operate.
- D3.1: *Initial use cases for multimodal traffic management*. It defined multimodal traffic management concepts and concerns that the scenarios take into account.
- D6.1: *Evaluation handbook* (draft version). It defines the evaluation approach including the research questions, KPAs and KPIs as well as the data collection methods and plans for data analysis.

Outputs will be to:

- D2.4: Final scenario for multimodal traffic management.
- D2.5: White paper to policy makers.
- D4.1: Initial version of technical tools.
- D4.3: Handbook on organisational, business and market models.
- D4.4: Handbook on contractual and administrative implementation.
- D4.5: training modules.
- D6.2: Intermediate evaluation results from living labs.
- D6.5: Recommendations and lessons learned.

1.4 Involvement in work

Partners involved in this report are CEREMA, SINTEF, DBL, TUDELFT, IKEM, SEA, DBL, FST, HIP, ENAV, and HES-SO.

CEREMA has been leader of the work and the main author of the deliverable. SINTEF provided input regarding the related work, stakeholders' roles, the concepts of the MTM, target vision scenarios, and technology parts of the implementation scenarios, and the contributed with IKEM, FST, DBL and CEREMA to the contains of the target vision scenarios. IKEM provided input on the scenarios designing method, and they particularly contributed with CEREMA to the content on the implementation scenario. HES-SO (ROSAS) provided input on the training modules in the implementation scenario.

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2 Introduction

In the context of fully achieving the MTM target vision described in D2.1, transport modes are smartly used and combined. Synchro-modality is an enabler of greener traffic, seamless and user-centric, zero emission flows. An increased connectivity between different means of transport allows a more fluent multimodal experience for freight and passengers: it will be possible to anticipate solutions to disruption events thanks to well-performed data exchange system.

Nevertheless, D2.2 pointed out that this target vision relies on a radical socio-technical change. Indeed, this future vision of the MTM can only come about through a profound change in organisational and technical aspects throughout almost four different perspectives: legal and regulatory perspective, economic and market perspective, safety and security perspective, as well as psycho-sociological and acceptance perspective.

In the continuity of these two previous reports, D2.3 aims to refine the target vision through several detailed MTM scenarios. These scenarios describe the interactions – the data flows- between the main stakeholders of the MTM, considered as archetypes: the Traffic Orchestrator, the Fleet Operator, the Transport Service Provider and the Network User. After the reminder of the roles and concepts of the MTM as defined in D3.1, the report provides the scenarios regarding both people and freight transport in the context of three contrasted situations: normal situation, foreseeable events, and unforeseeable events. Those scenarios are fully detailed to be partly tested on the two Living Labs of the project (WP5).

The target vision scenarios are thus designed on a well-argued overall implementation scenario that gathers the most important requirements and enablers as pointed out by the MTME program theory (as presented in the D6.1): policies, governance and regulation, data governance and sharing, smart infrastructure, safety requirements. It also introduces the mechanism of change issues: acceptance, operational practices and decision-making, business policy aspects and organisational aspects.

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3 MTM: roles and concepts

This chapter gives the main definitions related to the MTM concepts. After a review of the literature about the related work within different modes of transport, it provides the conceptual definition as they are defined in D3.1. Those definitions focus on the MTM stakeholders who have an interest in the MTM scenario.

3.1 Related work

Traffic management is an activity within all modes of transport:

- Air transport: Eurocontrol's Network Manager Operations Centre (NMOC) optimise traffic flows by constantly balancing capacity supply and demand while ensuring the safe and efficient operation of flights going to and over Europe. In addition, each country organises their national and/or regional air traffic management (ATM).
- Sea transport: According to IMO, Vessel Traffic Services (VTS) are shore-side systems which range from the provision of simple information messages to ships to extensive management of traffic within a port or waterway. Ships entering a VTS area report to the authorities, usually by radio, and may be tracked by the VTS control centre. Vessels are tracked by AIS (Automatic Identification System).
- Inland Navigation: Harmonised information services support traffic and transport management in inland navigation. The River Information System (RIS) contributes to a safe and efficient transport process and helps utilise the inland waterways to their fullest extent.
- Road transport: Local, regional and national traffic information centres inform the general public about the conditions and traffic flow on roads and do traffic control both during normal situations and in case of incidents and accidents. There may also be traffic management for private networks or other networks with access restrictions, e.g. industry area and freight terminals.
- Rail transport: The European Rail Traffic Management System (ERTMS) is a single interoperable train control and command system, supporting cross-border interoperability and a seamless, EU-wide railway system. The individual railways (national, regional, local, private) usually have traffic control centres where the traffic is monitored and controlled.

This section provides an overview of related work of relevance to future traffic management and traffic orchestration.

3.1.1 Traffic management

According to van Balen et al (2019), traffic management systems traditionally were meant to support the traffic management operators in their work on managing the traffic. With smart infrastructures, intelligent systems, and connected automated vehicles/vessels this will change. New protocols and algorithms will facilitate a cooperative traffic management system.

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The ITS Directive (Directive 2010/40/EU) states that transport and traffic related data should be made available via national contact points. Data formats and exchange protocols are also standardised to ensure the exchange of data and information needed in traffic management, e.g.

- In road transport, Cooperative Intelligent Transport Systems (C-ITS) standards support communication with and between connected vehicle (see below). In addition, the DATEX II standards support the sharing of real-time traffic information.
- For the railways, train control standards (e.g. ETCS) and communication standards (e.g. GSM-R) for the European rail network to ensure an interoperable Automatic Train Protection (ATP).
- Air traffic management (ATM) information sharing is supported by SWIM (System Wide Information Management) standards.
- Sea traffic management (STM) information sharing is supported by SafeSeaNet, which fulfil the Vessel Traffic Monitoring & Information Systems (VTMIS) Directive (Directive 2002/59/EC and the amendment in Directive 2014/100/EU).

Guériau et al (2016) address the potential of C-ITS related to road traffic management through simulations of different levels of automation and different automation penetration rates. The simulations show that an approach with communication with roadside units is promising.

European Commission (2019) presents a set of business cases for rail transport showing how ERTMS can support a collaboration between the different stakeholders. The main benefits are for those that are managing the infrastructure (savings due to decrease in renewal costs and a more competitive market for components) and the railway undertakings (interoperability benefits - access to larger markets and increase in performance). Collaboration across borders and across corridors are also supported.

Rail Net Europe (https://rne.eu/) has activities targeting traffic management, among others:

- Estimated time of arrival (ETA) and forecast qualifier: The aims to improve the accuracy of ETA by taking different data sources into account and calculations of ETA by means of algorithm using artificial intelligence. Qualifiers will provide information on the assumed accuracy level.
- Data quality management: The data quality in Train Information Systems (TIS) and in the quality of data used by infrastructure managers and rail undertakers is addressed. A handbook on data quality issues is developed.
- Incident management: An International Contingency Management Handbook is developed and maintained. It describes how to allow "the continuation of traffic flows at the highest possible level despite an international disruption and to assure transparency of the status of the disruption and its impact on traffic flows for all relevant stakeholders across Europe". An online ‘TIS Incident Management tool’ is also developed to "help dispatchers to identify the trains directly affected by the interruption". It also supports online communication with affected infrastructure managers.

van Westrenen and Praetorius (2014) address sea traffic management and the collaboration and coordination between the stakeholders involved. The current Vessel Traffic Services (VTS) are distributed solutions monitoring the traffic and providing guidance, but no control. These solutions are not sufficiently complete and systematic. Vessels and VTS must be more integrated to arrange

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for more optimal solutions. In addition to the distributed VTS solutions, there is a need for more centralised planning to support mutual adjustments.

Work on further development of Air Traffic Management (ATM) is mainly handled by the Single European Sky ATM Research (SESAR) Programme. The programme includes exploratory research projects dealing with:

- START (Stable and resilient ATM by integrating Robust airline operations into the network): The project is about automated updates of trajectories in reaction to developing uncertainties and optimisation algorithms for robust airline operations. Uncertainties are modelled at micro and macro levels, and artificial intelligence is used to generate pan-European robust trajectories.
- CORUS (Concept of Operations for EuRopean UTM Systems): A set of services for the integration of drones in the airspace is defined to support UTM (Unmanned aircraft Traffic Management). It includes use-cases for nominal scenarios such as contingencies and emergencies.
- ECHO (European Concept of Higher airspace Operations): The use of the higher airspace (between the airspace normally used by aircraft and the beginning of space) is addressed. This is an environment that can become an incubator for future ATM.

Lind et al (2018) describes how the European MONALISA 2.0 project, inspired by the SESAR initiative in air transport, has developed the sea traffic management (STM) concept. "STM enables interoperable, standardised and harmonised services allowing a ship to operate in a safe and efficient manner from port to port with a minimal impact on the [marine] environment. Of high concern for STM is to minimise the use of energy fuel/bunkers to steam between two ports and to maximise the utilisation of facilities in ports. "The need for a holistic approach with collaboration and information sharing between the actors involved is emphasized. STM will lead to improvements in situational awareness, predictability of arrivals and departures, just in time operations, and innovation capacity.

3.1.2 Transport demand management

The term "transport demand management" (TDM) is known from road traffic management.

Broaddus et al (2009) provides a training document on TDM where aspects and examples of the concept are defined and discussed in an urban context with a focus on the transport of people. They define TDM as "a strategy which aims to maximize the efficiency of the urban traffic system by discouraging unnecessary private vehicle use and promoting more effective, healthy and environmental-friendly modes of transport, in general being public transport and non-motorised transport".

Dowling et al (2011) describes a methodology for predicting the impacts of active transportation and demand management (ATDM) measures on highway performance. They state that "*Active transportation and demand management* (ATDM) is a comprehensive approach to facility management and operation that seeks to increase facility productivity by *proactively balancing supply and demand to avoid or delay facility breakdown*. Examples of ATDM measures include: adaptive ramp metering, congestion pricing, speed harmonization, traveller information systems, and adaptive traffic signal control systems. Incident management and work zone management programs may employ one or more of these ATDM measures".

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3.1.3 Demand capacity balancing

The term "demand capacity balancing" (DCB) is known from air traffic management.

Xu, Prats & Delahaye (2020) introduce a *synchronised collaborative DCB model* where the *demand* is the number of flights (and trajectories) and the *capacity* is the airport/airspace accommodation. The effort to achieve DCB is known as air traffic flow management (ATFM). The paper explores the potential of synchronising the traffic flow optimisation and airspace configuring scheduling. Four model variants are presented of SC-DCM.

Xu, Dalmau et al (2020) states that the main reasons for delays and congestion in air transport are a high number of flights (*demand*), limited airspace *capacity*, peaks caused by holiday seasons and large events, weather conditions, airspace restrictions, and overloaded airports. The balancing of demand and capacity (known as Air Traffic Flow Management) must follow fair criteria (e.g., first scheduled, first served policy). The airspace users should also participate in the decisions through collaborative decision-making mechanisms. Important aspects are information exchange, procedural improvements, tool development, and common situational awareness. A collaborative air traffic flow management (ATFM) framework is proposed. The framework architecture consists of four modules, each representing the tasks that are conducted by either the airspace users or the Network Manager, as follows:

- Initial planning of user-preferred trajectories, initially scheduled by airspace users.
- Detection of demand and capacity imbalance. Network Manager (i.e. the traffic orchestrator) detects time-varying hotspots.
- Submission of trajectory options and pre-tactical delay preferences. Hotspot information is shared back to the airspace users, who plan alternative trajectory options to avoid crossing these congested airspace volumes, as well as providing to the Network Manager (i.e. the traffic orchestrator) different pre-tactical delay management preferences.
- System-wide optimisation to balance demand and capacity. The best trajectory selections and the optimal distribution of delay assignments are computed, such that the cost deviation from the initial status (all the user-preferred trajectories) is minimized.

In addition to the scientific literature listed above, there is also several products targeting DCB in air traffic management. The documentation of these products provides examples of DCB functionality:

- NATS[1] (https://www.nats.aero/wp-content/uploads/2020/02/Demand-Capacity-Balancing.pdf), providing solutions deployed at Heathrow Airport, states that DCB "minimises disruption and optimises operations using powerful, accurate forecasting that balances demand with capacity allowing the airport to anticipate and mitigate disruption". The DCB solution uses d*emand predictions* to calculate arrival times days in advance, *operational foresight* to arrange for better punctuality and passenger connectivity, and *scenarios* to support more diverse and accurate planning. When a problem is identified, updated arrival times that corrects the imbalance are generated, and this has an effect on the demand on the airport.

[1] NATS (National Air Traffic Services) provides Air Traffic Control (ATC) services to aircraft flying in airspace over the UK and the eastern part of the North Atlantic, and at 13 UK airports. It also provides other ATC and related services to customers in the UK and overseas.

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- Airport suppliers (https://www.airport-suppliers.com/product/demand-capacity-balancer-dcb/) collaborates with NATS at Heathrow airport. Their DCB solution automatically *processes various types of data* (meteorological forecasts, flight schedules, real-time information, historical data, airport constraints, etc.) *to predict demand and capacity* and to create and continuously update an overview of arrivals and departure on a short and long term. Based on this insight, *what-if scenarios that can be built* to support plans on how to handle different situations. The benefits are more efficient allocation of resources, fewer cancellations in case of disruptions, correct prioritization of flights, and more optimal use of capacity, runway, and airport infrastructure.
- L3HARRIS (https://www.l3harris.com/sites/default/files/2020-07/as_mn_datasheet_harris-demand-capacity-balancing-dcb-es.pdf) is a solution provided by NATS. It extends the airport's operational look-ahead time from minutes to months. A "*rolling airport operations plan (AOP)* and bridges the gap between pre-tactical and tactical planning so an airport can have the best possible performance". The DCB uses *simulations and data analytics to predict impacts* on the airport performance. The solution forecasts demand and balances it with available capacity to improve operational readiness supports the creation of plans that minimize negative impacts.

3.1.4 Automated driving

Milakis et al (2017) address road transport and present a literature review addressing *potential effects of automated driving* that are relevant to policy and society are explored. The review identifies:

- First-order implications like traffic, travel cost, and travel choices are expected to have a positive effect on road capacity, fuel efficiency, emissions, and accidents risk. The effects are likely to increase with the level of automation and cooperation and with the penetration rate of such systems. Synergies can multiply these benefits.
- Second-order implications like vehicle ownership and sharing, location choices and land use, and transport infrastructure. Automated vehicles can induce additional *travel demand* because of more and longer vehicle trips.
- Third-order implications like energy consumption, air pollution, safety, social equity, economy, and public health. These effects are so far unclear.

Botte et al (2019) provides an overview on automated driving on roads supported by Cooperative Intelligent Transport Systems (C-ITS) and presents the implementation status of V2V (vehicle to vehicle), V2I (vehicle to Infrastructure), and V2P (vehicle to pedestrian) services in the European Union and related policies, standardisation, and practices. The aim is to set up a reference framework for Cooperative, Connected, and Automated Mobility (CCAM) policies. The services are listed in Table 3. The service type they represent, the standardised messages and communication channels used when they are implemented, and the type of network (urban/ motorway) targeted are provided as well as an indication on whether they are safety critical or not.

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Table 3 C-ITS services and related information (based on Botte et al (2019))

Category	C-ITS services	Type	Message[2]	Communi-cation	Where	Safety critical
Hazardous location notifications	EBL: electronic brake light	V2V	DENM	ETSI-G5	Urban, Motorway	Yes
	EVA: emergency vehicle approaching	V2V	CAM, DENM	ETSI-G5	Urban, Motorway	Yes
	SSV: slow or stationary vehicle	V2V	CAM, DENM	ETSI-G5	Urban, Motorway	Yes
	TJW: traffic jam warning	V2V	DENM	3G/4G	Motorway	Yes
	RWW: road works warning	V2I	DENM	3G/4G	Urban, Motorway	Yes
	WTC: weather condition	V2I, V2V	DENM	3G/4G	Urban, Motorway	Yes
	CCRW: cooperative collision risk warning	V2I, V2V	CAM, DENM	ETSI-G5	Urban, Motorway	Yes
	MCA: motorcycle approaching	V2V	CAM	ETSI-G5	Urban, Motorway	Yes
	WWD: wrong way driving	V2I	DENM	ETSI-G5	Urban, Motorway	Yes
Signage applications	VSGN: in-vehicle signage	V2I	IVI	ETSI-G5	Urban, Motorway	Yes
	VSPD: in-vehicle speed	V2I	CAM, IVI	ETSI-G5	Urban, Motorway	Yes
	PVD: probe vehicle data	V2I	CAM	ETSI-G5	Urban, Motorway	No
	SWD: shockwave damping	V2I	IVI	ETSI-G5	Urban, Motorway	No
	GLOSA: green light optimal speed advisory	V2I	CAM, SPaT, MAP	ETSI-G5	Urban	NO
	SigV: signal violation/intersection safety	V2I	SPaT, MAP	ETSI-G5	Urban	Yes
	TSP: traffic signal priority	V2I	SPaT, MAP	ETSI-G5	Urban	No
Others	Info: Infotainment, traffic Information, and smart routing	V2I	CAM	3G/4G	Urban, Motorway	No
	LZM: loading zone management	V2I	CAM	ETSI-G5, 3G/4G	Urban	No
	ZAC: zone access control	V2I	CAM	3G/4G	Urban	No
	VRU: Vulnerable road user	V2P	CAM	ETSI-G5, 3G/4G	Urban	Yes
	CCN: connected and cooperative navigation	V2I	Not yet described			

Carreras et al (2018) address the capabilities of road infrastructures to support automated vehicles, and a classification scheme for such infrastructures is provided. The classification scheme is based on results from the European INFRAMIX project and has five level (A – E) of Infrastructure Support for Automated Driving (ISA Levels):

A. Digital infrastructure supporting cooperative driving. Real-time information on vehicle movements is used to guide groups of vehicles and single vehicles in order to optimise the overall traffic flow.
B. Digital infrastructure supporting cooperative perception. Microscopic traffic situation can be detected, and information can be provided to automated vehicles in real-time.
C. Digital infrastructure with provision of all types of static and dynamic, digital information.
D. Conventional infrastructures with provision of digital map data as well as static road information (e.g. signs).
E. Conventional infrastructures with no support for automated vehicles.

[2] DENM: decentralized environmental notification message; CAM: cooperative awareness message; SPaT: signal phase and timing; MAP: map data; IVI: in-vehicle information.

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Franco et al (2019) provides a suggestion for a train-to-ground communication architecture for self-driving trains where the application layer is adaptable to different communication technologies, e.g. 5G and beyond.

3.2 The MTM Ecosystem

Ecosystem of Interest as described in 4.1.1 of D3.1: **System of Interest in MTME**

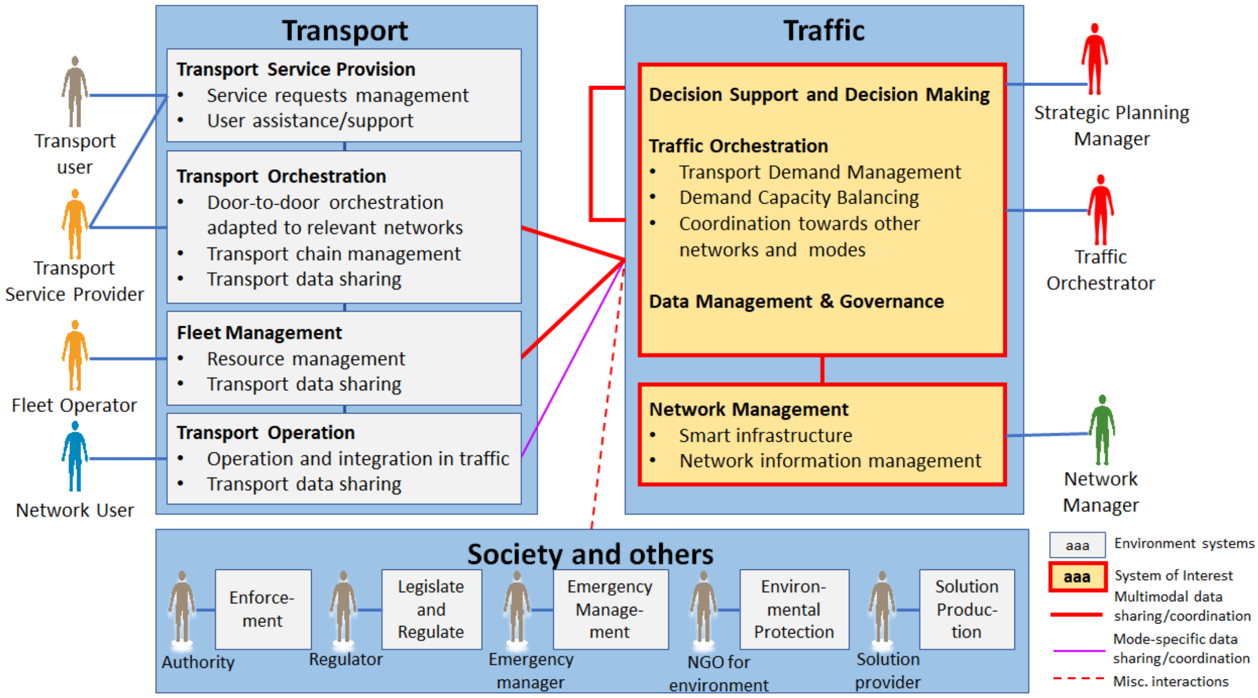

Figure 1: Multimodal Traffic Management Ecosystem (MTME) with System of Interest in its environment (Source: D3.1)

Figure 1 provides an overview of the MTME. The System of Interest is the boxes with red boarders in the traffic part of the ecosystem and the red and purple links towards the transport part. The other parts of the MTME constitute the environment in which the System of Interest operates.

As shown in Figure 1, the **ecosystem** is divided into three areas with activities, described below: (1) Transport, (2) Traffic, and (3) Society and others. There may be many system instances for each activity. Many of them will have a defined governance area that will encompass one network and one mode. The areas will however interact to arrange for a more optimal transport system as a whole.

The **stakeholder** types depicted in the figure are further described in section 3.3. It is important to notice that one actor may cover several stakeholder types. A freight forwarder being a Transport Service Provider may for example also be a Fleet Operator operating own vehicles/vessels. A Mobility as a Service (MaaS) provider is a Transport Service Provider but may for example also be a Fleet Operator for a fleet delivering public transport.

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3.3 Stakeholder types

The description of the target vision scenario is enlightened in chapter 5 of the current report from the perspective of the following core transport and traffic stakeholder types as described in Chapter 5.1 of ORCHESTRA deliverable D3.1. These stakeholder types are the Transport Orchestrator (TO), the Transport Service Provider (TSP), the Fleet Operator (FO), and the Network User (NU). Indeed, in the continuity of D3.1, these four stakeholder types are directly related to the System of Interest within the MTME.

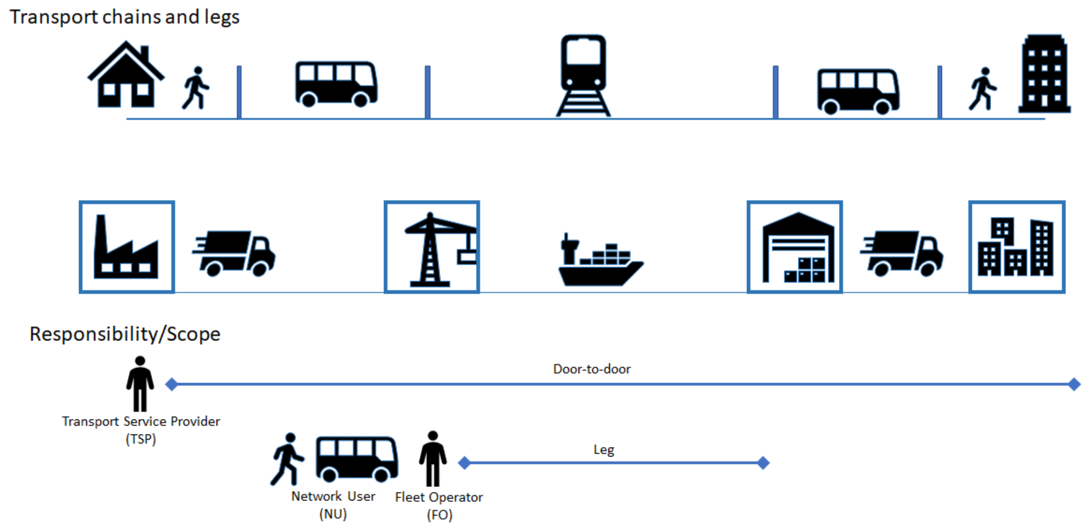

Figure 2: Responsibility/Scope of the transport actors: TSPs, FOs, and NUs

3.3.1 Traffic Orchestrator (TO)

The term "orchestration" is defined to be "an arrangement of events that attempts to achieve a maximum effect" (https://www.thefreedictionary.com). Dhanaraj and Parkhe (2006) address orchestration in the context of networks consisting of loosely coupled and autonomous firms, where a hub "orchestrate network activities to ensure the creation and extraction of value, without the benefit of hierarchical authority".

Based on the above definitions, **we define traffic orchestration to be informed decisions and actions that affect the traffic flows in a way that is optimal to the society. The traffic orchestration is done by a hub, represented by the Traffic Orchestrator (TO), based on a holistic picture of the current and upcoming traffic situation**. The network affected by the traffic orchestration is the multimodal traffic management ecosystem (MTME), and the traffic orchestration will allow all the actors in the ecosystem to "play together" to accomplish overall goals.

As stated by D3.1, the TO aims to arrange for sustainable transport from an environmental, economic/socio-economic, and societal point of view according to the directions of the Strategic Planning Manager as well as operational laws and regulations. This is done through:

- Traffic management. The traffic flow and the movement of vessels/vehicles/pedestrians is guided or controlled to arrange for safety, efficiency, and optimal utilisation of the network. This includes

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interactions with Network Users related to transport demand management, capacity demand balancing, access control, traffic control/guidance, information sharing, etc.

- Transport network resource management. The access to and use of limited resources like parking spaces, loading bays, waiting areas, etc. is managed.
- Coordination towards other modes, networks, and governance areas. Information is exchanged and decisions and actions are coordinated to contribute to a more optimal transport system as a whole.

3.3.2 Transport Service Provider (TSP)

The TSP provides transport services to the Transport User, and the scope of responsibility is the whole transport chain provided to the user, as illustrated in Figure 2. This includes customer support and information, decisions how the service is to be provided, and the follow up. In person transport, Transport User usually will influence the decisions (e.g., select the modes and routes to be used). In freight transport, the TSP quite often takes decisions on behalf of the Transport User. The decisions will affect which Fleet Operators to use. One or more Fleet Operators may be needed to cover the desired transport chain. The actual transport operations will be managed by the Fleet Operator.

3.3.3 Fleet operator (FO)

The FO manages transport operations, and the scope of responsibility is the limited to the transport legs covered by these transport operations, as illustrated in Figure 2. One transport operation may carry passengers and/or cargo from several transport chains. The FO manages resources like personnel, vehicles/vessels, space in vehicles/vessels, and load units. Time schedules are planned, resources are allocated, and operations are followed up to ensure that they are carried out according to rules, regulations, and agreements. The use of resources is planned to be as optimal as possible. Optimal routes and possibilities for return loads are considered. When relevant, the TSPs are informed about the progress. The vessels/vehicles managed by the FO are Network Users.

3.3.4 Network Users (NU)

The NU accomplishes a transport operation on one transport leg and may be a person (e.g., a pedestrian), a person supported by systems (vehicle/vessel with driver/operator, micro mobility included), or a system (e.g. a Connected and Automated Vehicle - CAV). As stated by D3.1, the NU is responsible for an integration into the traffic in compliance with laws and regulations and for safety issues related to behaviour and operation of the vehicle/vessel. The NU may be a person, a person supported by systems, or a system (e.g. a Connected and Automated Vehicle - CAV).

3.4 MTM concepts

3.4.1 Governance area (GA)

"A governance area defines the area or space with respect to some authority and is the zone in which the traffic orchestration takes place" (D3.1). A GA is related to a single network and a single mode of transport, and the traffic within the GA is managed by one Traffic Orchestrator. The organisation and geographical size of a GA depends on the mode, the network segment(s) in need for monitoring and control, and its institutional perimeter of control. GAs may vary in size. For road networks, a GA may for example cover a bridge, a tunnel, or a segment of road, or it may cover all roads within an

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area, e.g. a region or a municipality. Thus, the structuring of GAs may follow different patterns to fulfil different needs. Some examples are provided below:

- GAs may vary in size. For road networks, a GA may for example cover a bridge, a tunnel, ore a segment of road, or it may cover all roads within an area, e.g. a region or a municipality.
- GAs may be structured as non-overlapping areas. In sea transport, the coast of a national state may for example be divided into VTS areas. GAs may be structured in a hierarchy. In air transport, the GA of EuroControl covers the whole European air space, and it is superior to the GAs covering regions.

3.4.2 Traffic orchestration

The Traffic Orchestrator (TO) is responsible for the traffic orchestrations within a governance area (GA). The traffic orchestration goes beyond the traditional traffic management to mitigate and handle current and upcoming traffic situations. This also includes coordination with other networks and modes, and the measures taken are anchored in well-defined policies and strategies on how the traffic is to be managed with respect to (see further definitions below):

1. Transport demand management
2. Demand capacity balancing.

3.4.3 Transport demand management (TDM)

TDM is a part of the transport orchestration. The aim is to maximize the sustainability (efficiency, climate neutrality, inclusivity, profitability in coherence/balance/relation) of the transport system by discouraging/restricting unnecessary vehicle use and promoting/enabling more effective, profitable, healthy and environmentally friendly transport across all modes and infrastructure owners/Transport Networks.

TDM may include different measures, e.g. measures for access control, priority, information dissemination, traffic calming, payment, etc. The measures are carried out according to well defined measure conditions and with connected vessels/vehicles, the measures can to a large extend be automated.

3.4.4 Demand Capacity Balancing (DCB)

DCB is a part of the transport orchestration. The aim is to cope with a current or upcoming situation with imbalance between the transport demand and the capacity of the network. Measures are taken to re-establish the balance. DCB may include:

- Measures taken towards individual Network Users. They may for example be asked to wait, slow down, or to take another route.
- Measures taken to adapt the network capacity to the need. They may for example redefine the use of parts of the infrastructure, open/close parts of the infrastructure, etc.
- Use of transport demand management measures (see above), for example access control and priority to balance the capacity.
- Coordination with other modes and networks. In case of problems in one network, traffic may be transferred to other networks with available capacities.

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3.4.5 Arbitration model

The model used in the traffic orchestration to support decisions where a trade-off between different optimisation goals is needed. The arbitration model defines decision rules on how goals that are in conflict should be balanced and handled.

3.4.6 Transfer node

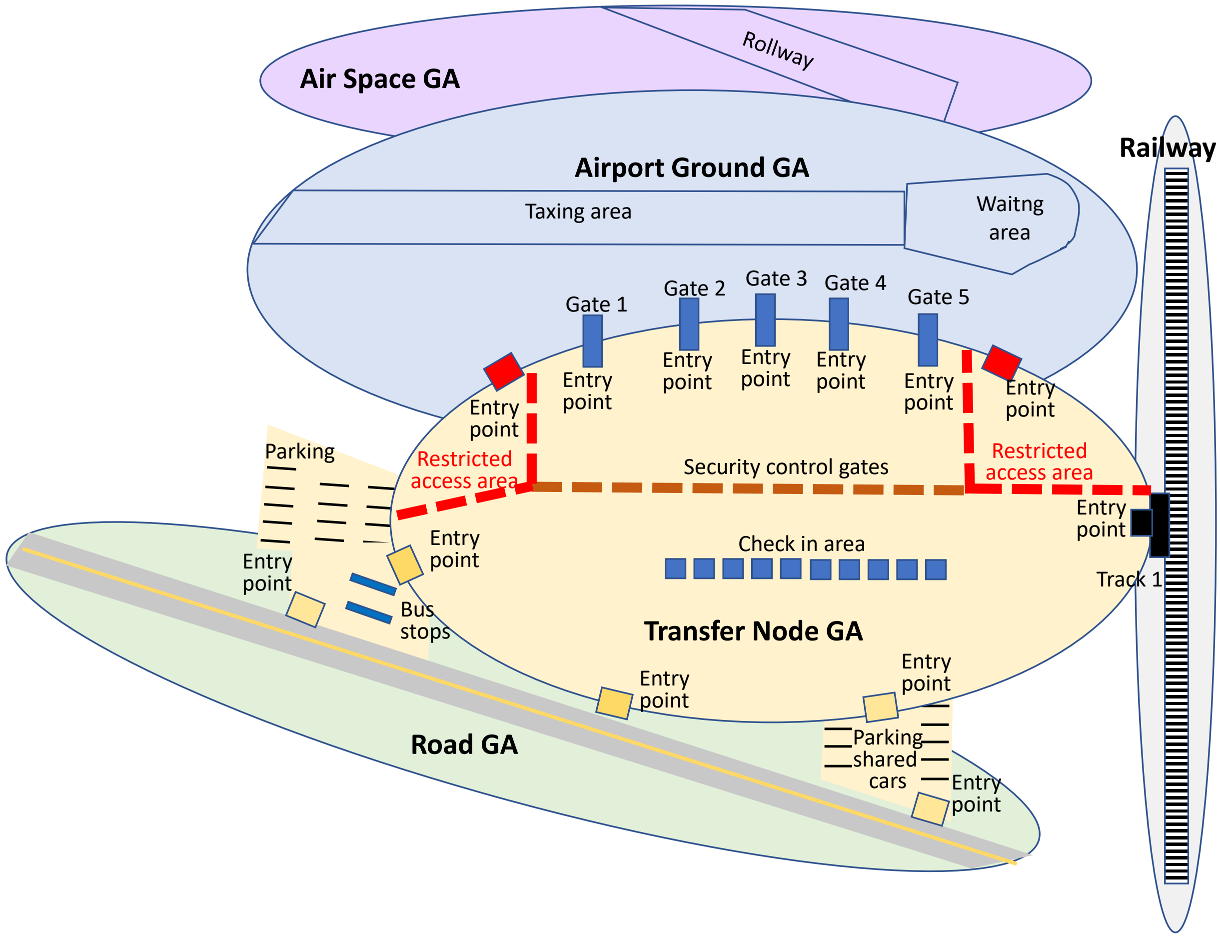

Figure 3: Airport transfer node example - governance area connecting many different modes

A transfer node is a geographical location where transport users can switch between transport means within one or between several modes. Transfer nodes come in many sizes and complexity levels. Some covers just one transport mode (e.g., a bus stop). Others connect several modes and cover a larger area like the example provided in Figure 3.

Complex transfer nodes like the one in in Figure 3 may also be defined as a governance area (see definition above) where the flow of people inside the transfer node is managed and supported. In such cases, the people (pedestrians) and vehicles (those entering and operating inside the transfer node area) are network users. The airport transfer node (yellow area) example in Figure 3 has with entry points towards other modes and governance areas (air, railway, and road) and between different parts of the transfer node (e.g. between parking spaces/bus stops and airport check in area).

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4 Scenarios definition approach

The scenarios within the context of this deliverable are hypothetical or anticipation scenarios. They are the result of two distinctive and correlated approaches (see Figure 4):

1. **The MTM target vision scenarios:** The first approach describes target visions of the multimodal traffic management (MTM). Thus, these target visions give useful inputs for WP 3, 4 and 5.
2. **The Implementation scenarios:** The second approach intends to describe the implementation scenarios, i.e., the requirements, the gaps to fill, the barriers to overcome to reach the former target visions.

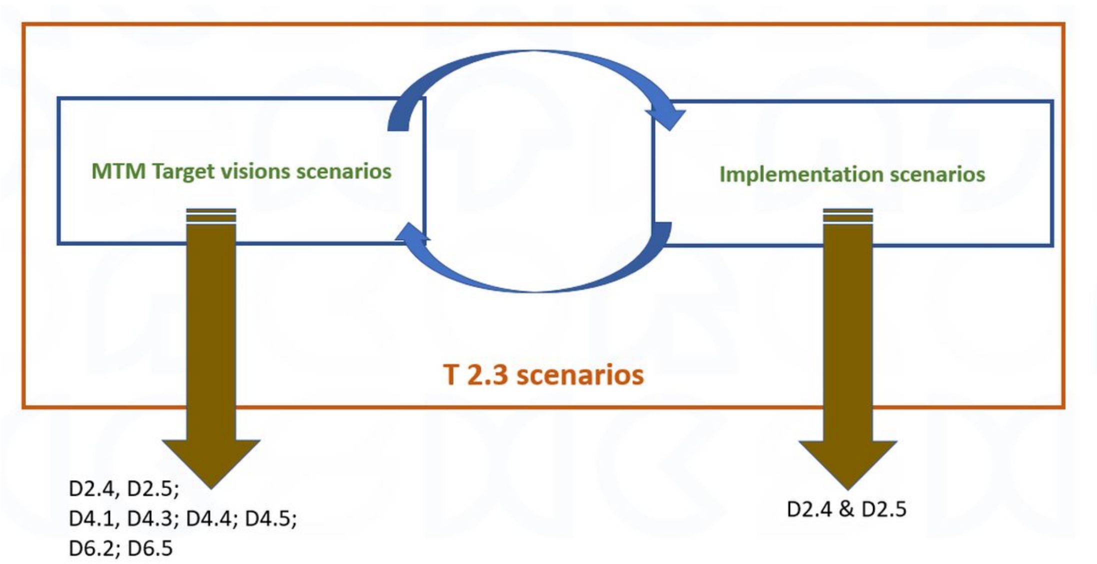

Figure 4: The D2.3 scenarios are composed of MTM target vision scenarios and implementation scenarios

Their respective definitions differ, from a large extend, from the definition of scenarios it the context of the other WPs. Thus, they are not LivingLab scenarios or use cases (D5.2 & D5.3). The target vision scenarios are more generic than these scenarios (see Figure 5).

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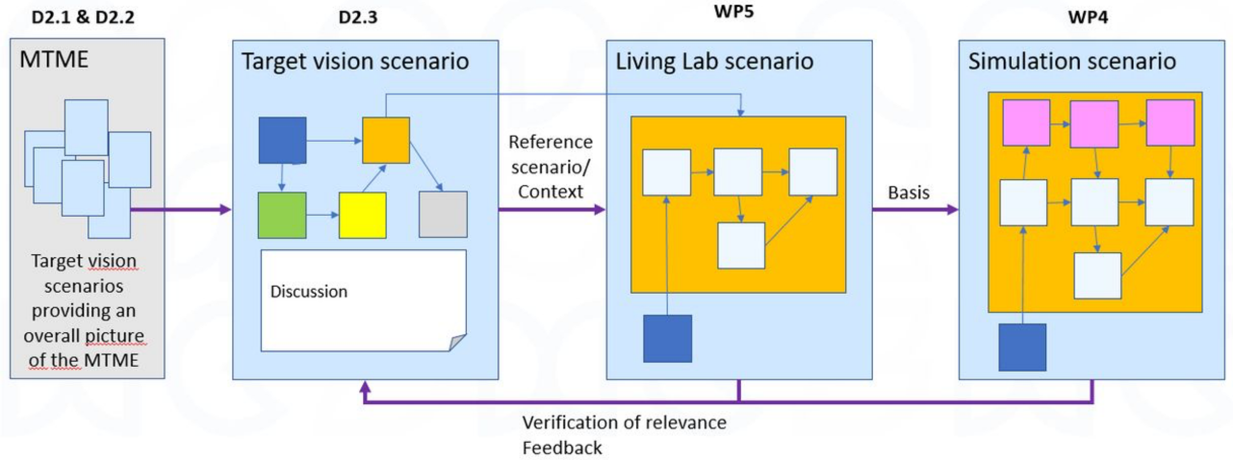

Figure 5: Relation between the scenario-types though the different WPs

4.1 MTM Target visions scenarios

4.1.1 Generic approach

ORCHESTRA project addresses technical solutions for MTM. Therefore, the target visions scenarios describe functional solutions of the MTM and how they work. Thus, the target visions scenarios describe a narrative and generic overall approach addressing:

- Three generic situations of traffic management regarding both people and freight transport: normal situation, foreseeable events, and unforeseeable events.
- Each of the four stakeholder archetypes (Traffic Orchestrator, Fleet Operator, Transport Service Provider and Network User).
- How this stakeholder uses and is supported by the functionality provided by the systems and tools involved, and the effects or value achieved.

The D2.3 scenarios do not describe transport services solutions (such as MaaS), but how MTM will support such transport services

4.1.2 Assumptions made

A target vision describes situations that assume that all the MTM ecosystem barriers have been removed, that all the gaps have been overcome. Thus, scenarios are somewhat “successful”, “ideal” MTM visions. The identification of the needed requirements and enablers are detailed in the implementation scenario. They deal with policies and regulation, technical issues related to infrastructures and data sharing, and the mechanisms of change.

4.1.3 Template followed

After the description of the overall environment in a story-telling way, the target vision scenarios follow the same canvas for the three situations of traffic management:

- An expressive title which mentions the situation which is considered;
- A short description of the situation in a story-telling way;

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- The list of the stakeholder types involved;
- The issues addressed (information exchange between *xxx*, use of decision support, transport demand management for *xxx*, coordination across network/modes, …);
- The scenario description itself, from the perspective of each stakeholder.

4.2 Implementation scenario approach

4.2.1 Definition and objectives

The implementation scenario is a deductive scenario enlightening the challenges to cope with to reach the ideal target visions described in the former approach. It aims to detail the assumption that found the target visions scenario, and addresses:

- The gaps to fill up from the current situation to the target scenarios.
- Issues that must be handled and, if possible, how they should be handled.
- Foreseen barriers and risks.

4.2.2 Design method

The implementation scenario takes into account the different key-parameters and hypothesis among the MTM eco-system components. These parameters are gathered around the relevant research questions defined by the program theory in D6.1 (draft available when this deliverable is published). It identifies relevant issues and challenges, and gives a few snippets of answers to the research questions. The inputs are mainly based on D2.1 and D2.2 results. Nevertheless, some new topics were added, as the work between the project partners raised up new issues.

This scenario particularly deals with three KPAs of the program theory:

1. The requirements and enablers.
2. The MTM Functionality
3. The mechanisms of change.

The other KPAs are not relevant for the implementation scenarios as they deal with the assessment's topics: “effects” and “impacts”. Figure 6 details the sub-sections of the two KPAs selected (see red boxes), that structures the implementation scenario description.

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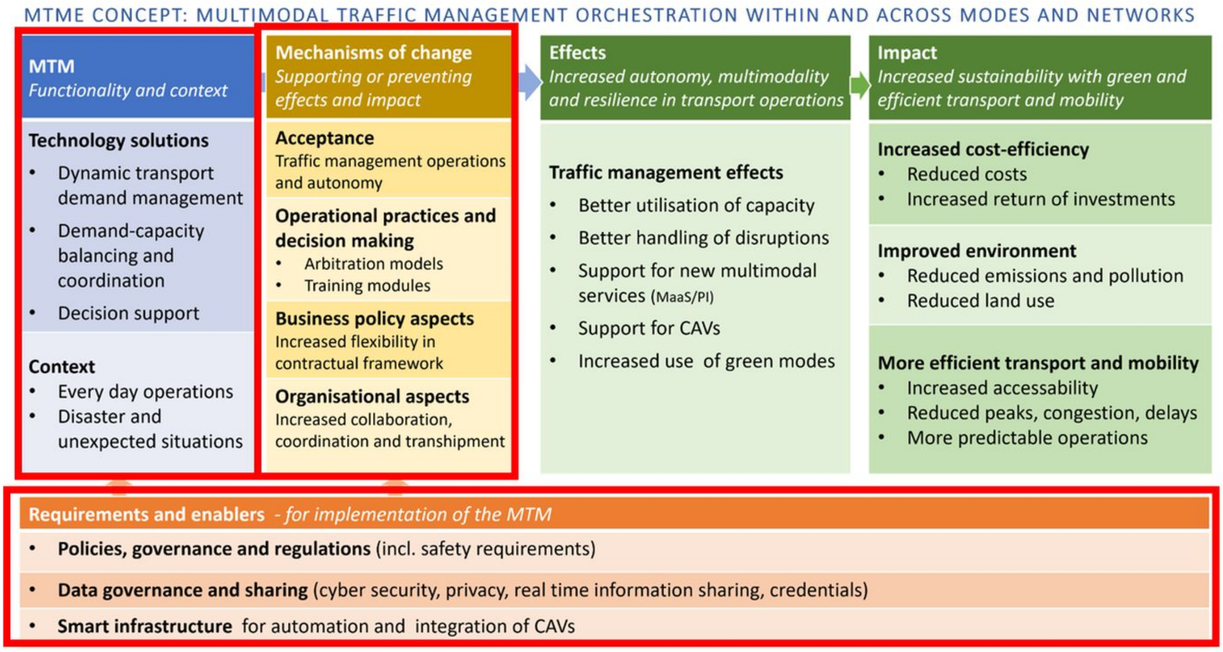

Figure 6: The selected KPAs from the MTME program theory that structures the implementation scenario (Source: D6.1)

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5 MTM target vision scenarios

5.1 The overall context

In a future time, around the year 2050, sustainable mobility is at the fingertips of EU's inhabitants. Public transport is reliable and safe – as cities grew and densified, the transport and digital infrastructure as well as the network followed. A mix of attractive and diversified Mobility-as-a-Service (MaaS) offerings adorns the city. MaaS has reduced the desire for car ownership, which over the years drastically lowered the number of private vehicles on the road. Travellers can choose from several door-to-door MaaS options: hailing a ride in an autonomous shuttle connecting suburban parts of the city, reserving a private autonomous vehicle for a faster, more exclusive ride, or the cheaper car-sharing. Almost all commercial vehicles and many private ones are electric CAVs, the rest is a rapidly shrinking mix of old technology. Other sustainable modes flourish, as bike-highways and parks had overtaken the diminishing parking spots. Logistics also reached the 4.0 paradigm that had been promoted for decades. Logistics, from global to urban, is now founded on a global open system of systems enabling assets and resources in logistics networks to be interconnected, facilitating their use to the maximum capacity and productivity while increasing agility and resilience of supply chains. Door-to-door logistics are now well spread all over Europe offering the shippers reliable, secure, and sustainable services using from a large extend connected and autonomous vehicles/vessels.

Strong environmental policies and strict vehicle standards are established and in place. Industrial policy delivered a 21st century innovation economy, as tech giants and OEMs compete for clicks and customer data. At the same time, incentivising them to share data in a mobility traffic data ecosystem through legal requirements and economies of scale and scope. Urban dwellers as well as shippers rely on vast, integrated networks of high-quality mobility services and logistics. They switch modes at will. Travellers take an e-scooter to hop on the metro to then hail a ride to their final destination. Numerous ride-hailing offers make it easy to embrace autonomous technology. Logisticians shape their transport plans based on multimodal chains interconnected according to the principles of the physical internet. Smart infrastructures and connected vehicles/vessels provide real-time monitoring of the traffic. The traffic data shared between the stakeholders in the MTM ecosystem. The multimodal traffic orchestration has substantially reduced traffic congestion and the overall commuting time, while increasing energy efficiency, safety, productivity, and a pleasant mobility experience across the city.

In this context, the following target vision scenarios address three different MTM situations:

- Situation 1: The traffic management of normal operations
- Situation 2: The handling of foreseeable events
- Situation 3: The management of unforeseen events

Figure 7 shows in a generic approach, the data flows between the MTM stakeholder types. These flows are detailed through the following description of the three situations.

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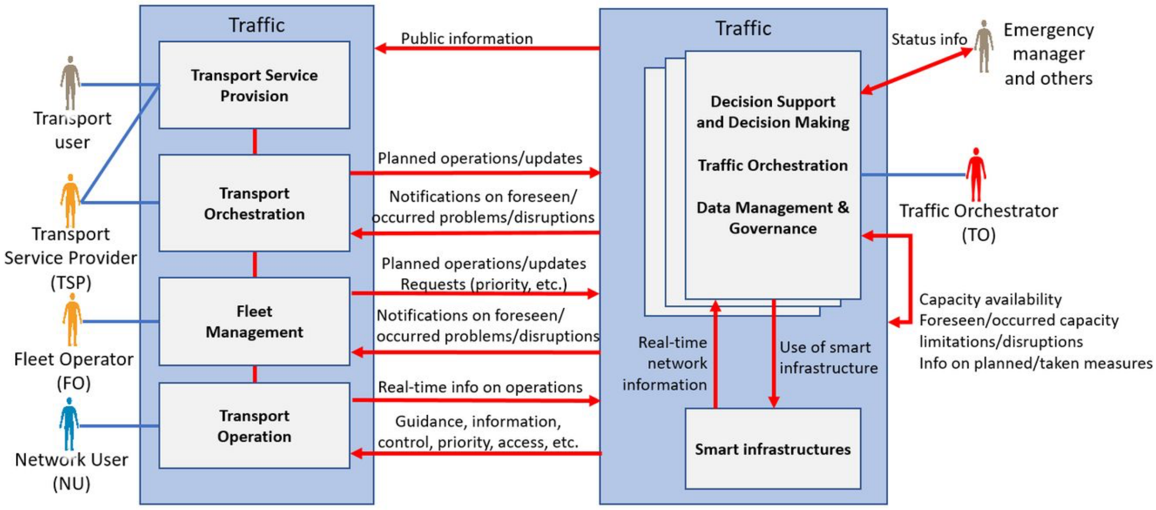

Figure 7: Generic *data flows between the MTM stakeholder types*

5.2 Situation 1: The traffic management of normal operations

The management of normal MTM operations (e.g. a more fluid intermodal transport), including minor incidents that can be handled without much effects on the traffic (e.g. limited infrastructure works, weather conditions, minor incidents, a delay on the arrival/departure on the previous/next transport mean of a multimodal chain). Overpassing the old silo-chapped organisation of transport modes makes possible a seamless transport through networks, and through different modes. Also including the information and data exchange linked to normal operations.

5.2.1 Information exchange with and between TOs

This scenario is relevant because it describes the normal situation and normal procedures, data collection, and data exchange that goes on is such a situation. This is the bases for more or less all the other scenarios.

Situation:

- Traffic flows with minor incidents and events that can be handled without considerable effects on the traffic flow.
- There is no need for transfer of traffic to other networks/modes.

Stakeholders involved:

- Traffic orchestrator (TO) in governance area (GA) focused by the scenario.
- TOs in neighbouring governance areas.
- Transport service providers (TSPs) and Fleet Operators (FOs) with transport operations in the GA.
- Network Users (NUs) in the GA.

Issues addressed:

- Traffic monitoring

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- Data collection to establish awareness and a basis for detection of situations and decisions
- Predictions to detect upcoming situations
- Detection of situations
- Traffic management/control under normal circumstances
- General support to transport actors

Detailed scenario description:

1. TO systems continuously receives input from different actors and sources on planned and ongoing use of the transport network, the conditions in the traffic network, and the traffic situation.
    a. Input on planned transports is received from TSPs. This is information about planned use of the network in the governance area (overall information on time schedule, type of transport, etc.)
    b. Input on planned and ongoing transport operations is received from FOs, e.g., type of operation (freight transport, passenger transport, emergency operation, …), start, route, destination, time schedule, type of load (dangerous cargo, etc.), load factor/capacity used/free capacity, etc.
    c. Real time information is received from NUs on their use of the network. This is for example location and updates of the information from the FO (e.g. time schedule)
    d. The TO is also supported by the smart infrastructure. It collects information on network conditions and traffic situations.
    e. The TO is also updated by the traffic orchestration in neighbouring modes and network. They report about their current and foreseen capacities as will on the status of the traffic in their networks.
2. The TO uses tools that by means of the available data continuously monitor and support awareness regarding the current and upcoming situations.
    a. TO can see a picture of the current situation based on real-time data
    b. Plans and historical information support predictions
3. TO systems use the awareness about the current and upcoming situations to inform other actors:
    a. Information is provided via open information channels
    b. Selected information is communicated to TSPs and FOs that subscribe to information of relevance to certain transport operations or for certain part of the network.
    c. Relevant information is communicated to TOs in neighbouring network
4. The TO's systems do as far as possible control the traffic in an automated way according to predefined rules.
    a. Transport demand management measures are taken. The speed may for example be regulated, and just electric utility vehicles and emergency vehicles are allowed to enter the green areas of the city. The NUs adapt to the measures.
    b. When abnormalities that cannot be handled by the system are detected or predicted, the system notifies the TO to trigger manual actions.
5. The TO uses decision support tools to decide how to handle situations in the best possible way.

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   a. The tools are aware of the situation, and they suggest alternative ways to handle the situation.
   b. The TO chooses the measures to be taken based on awareness about the situation and the solution alternatives.
   c. The systems effectuate decisions in an automatic way whenever this is possible. Transport demand management measures for road payment and access control are taken based on predefined rules. Speed limits are adjusted to a level that supports optimal traffic flows.
6. When this is required, the TO handles situations manually.
   a. Manual measures are taken towards individual NUs. They are guided or controlled to contribute to the best possible traffic flow.
   b. New transport demand management measures like temporary access restrictions are introduced to avoid congestions related to a public event.

5.2.2 Support to TSPs under normal conditions

Situation:

- The TSP plans and re-plans the transport chains to fulfil the requirements of the Network users.

Stakeholders involved:

- Traffic orchestrator (TO) in governance area (GA) focused by the scenario.
- Transport Service Provider (TSP) having transport chains with legs that depends on the network in the GA.

Issues addressed:

- Transport chain planning and follow up supported with information from the TO

Detailed scenario description

1. The TSP subscribes to information from the TOs with relevant networks and network segments. Thus, the TSP receives notifications on foreseen and occurred issues in these networks
2. The TSP uses tools to plan the transport chains according to the shippers' wishes and requirements.
   a. The notifications received from the TOs are used when the use of modes and legs are selected. Networks where problems are expected are avoided.
   b. The planned legs are reported to the respective TOs. In that way, the TSP can also receive more detailed information of the traffic of relevance to the planned chains.
3. Due to the above, TSP receives details about problems or expected problems in all networks of relevance. In case of problems:
   c. Affected transport chains and legs not yet stared are re-planned.
   d. Affected, ongoing legs are monitored carefully (via the relevant FOs). Mitigating actions are considered and planned in collaboration with the relevant FOs.
   e. If the subsequent legs are affected (e.g. due to late arrival), these legs are also re-planned.

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5.2.3 Support to FOs under normal conditions

Situation:

- FO plans and re-plans the transport operations
- FO follows up ongoing transport operations

Stakeholders involved:

- Traffic orchestrators (TOs) in governance areas (GAs) focused by the scenario
- Fleet Operator (FO) with transport operations in the GA

Issues addressed:

- Transport operation planning and follow up supported with information from the TO

Detailed scenario description:

1. The FO subscribes to information from the TOs of the relevant networks. Thus
   a. The FO receives notifications on foreseen and occurred issues in these networks
   b. Information on network conditions, etc. collected by the smart infrastructure
2. The FO plans/re-plans the use of resources and the transport operations.
   a. The notifications received from the TOs are used when the operations are planned/re-planned. Network segments where problems are expected are as far as possible avoided.
3. Planned/re-planned operations are reported to the respective TOs
   a. By default, the following is reported/updated: start, route, destination, schedule, type of load (passengers, type of cargo, hazardous cargo, etc.), load factor/used capacity/free capacity, etc.).
   b. If needed, the FO may request priority. Priority may for example be requested if the cargo transported is crucial for the load factor of the next leg. In that way, the TO may take priority measures towards this transport operations.
4. Thanks to the reporting to the TO, the FO receives details about problems or expected problems in the network of relevance, and
   a. Affected transport operations not yet stared are re-planned
   b. Affected, ongoing operations are monitored carefully. Mitigating actions are considered and planned in collaboration with the relevant TSPs.

5.2.4 Control of/guidance to NUs under normal conditions

Situation:

- Transport operation is carried out.

Stakeholders involved:

- Traffic orchestrator (TO) in governance areas (GA) focused by the scenario.
- Network User (NU) with transport operation in the GA.

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Issues addressed:

- Transport operation in network

Detailed scenario description:

The NU communicates with the TO and the digital network infrastructure through the built-in systems of the connected vehicle. The communication is automated, and the response to traffic management measures are also to a large extend automated.

1. On entrance to the GA, the NU identifies itself and provides information about the transport operation, e.g. type of engine, type of transport operation, and destination.
2. It is ensured that the NU can operate according to the rules and regulations of the GA and that the NU is aware of important issues.
    a. On entrance to the GA and in case of updates, the NU (e.g. the systems of the connected vehicle/vessel) receives details on the current, and dynamic traffic management rules and regulations that apply in the governance area.
    b. The NU receives information that may be useful, e.g. information on travel times, parking availability, charging availability, and information about the traffic situation.
3. The NU continuously provides relevant data and information to the smart infrastructure and the TO
    a. The sensors of the NU (e.g. the sensors of the connected vehicle/vessel) share data with the smart infrastructure.
    b. NU provides real-time information about the transport operation to the TO, for example position, heading, speed, energy type used, and charging level.
    c. When relevant, the NU sends updated information about the transport operation to the TO, e.g. information about the load factor and the destination.
4. The NU is indirectly and directly controlled by the TO.
    a. The NU adapts to the rules and regulations of the governance area. Areas with access restrictions are avoided, and speed regulations are followed.
    b. The NU provides the information requested. The use of the network and network resources like queys and parking slots is for example reported in a way that supports billing.
    c. The NU is dynamically controlled on an individual basis when this is needed.
    d. The NU interacts with other NUs according to the rules applied in the GA.
5. In case of smaller incidents, the NU will be supported in a way that ensures optimal traffic flows:
    e. NU receives new rules and regulations with updated speed limits and new guidelines on use of lanes.
    f. NU receives a priority adapted to the type of transport operation that facilitate use of specific lanes.

5.3 Situation 2: The handling of foreseen events

The handling of foreseen disturbances includes the discovery of the upcoming situation, decisions on how to handle the situation through demand capacity balancing (DCB), dynamic use of transport mitigating actions to limit the effects – e.g. dynamic use of transport demand management (TDM)

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measures. This includes support to the transport actors, and coordination with other network and modes to ensure that they are prepared.

Foreseen disturbances in a network may for example be scheduled maintenance operations, public works, weather conditions, seasonal or daily peaks of traffic (those are well documented in data), road or underground congestion risks linked to a specific event (for example a football match, a political or social demonstration, a carnival, and so on). Such situations may cause one or more of the following situations:

- A reduced capacity in the concerned network(s).
- An increase in traffic in other (neighbouring) networks.
- The use of a variety of mobility solutions (micro mobility, car sharing, ride hailing, e-scooter, CAVs, and others).

The scenario described below address a foreseen flooding in the underground, detected based on a forecasted weather situation. This is an example of the way the situation is monitored, the issues are considered, the given support to ongoing transports that are affected, the immediate coordination and response with other networks and modes, and how the recovery from a foreseen disturbance can be achieved.

5.3.1 TO handling foreseen events

Situation:

- The systems of TO of the underground metros monitors many data, weather data included, and detects an extreme weather forecast that may cause a flooding in parts of the underground. With such a flooding, some the metro lines will be disturbed.
- The situation will probably not happen until the next day, the handling can be planned and prepared in advance.
- The ability to direct the affected traffic to alternative transport networks is high due to the anticipated measures, and hence the overground urban networks can be utilised.

Stakeholders involved:

- Transport orchestrator TO_{road} in the relevant road traffic governance areas.
- Transport orchestrator TO_{rail} in the relevant underground/overground rail traffic governance areas.
- Transport orchestrator TO_{air} in the relevant air traffic governance areas.
- Transport orchestrator TO_{sea} in the relevant sea traffic governance areas.
- TSPs that are or may be affected by the situation.
- FOs planning and managing traffic operations that are or may be affected by the situation.
- NUs in the transport networks that are affected by the situation.

Issues addressed:

- Situation anticipation and preventive measures.
- Coordination between TOs, TSPs and FOs of the relevant governance areas.

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- Priority requests and priority handling.
- Decision support.
- Effectuation, configuration, and deployment of traffic orchestration measures.

Detailed scenario description:

1. TO_{rail} detects the extreme weather forecast and foresee a flooding the next day, and the flooding is expected to last the whole day.
2. TO_{rail} immediately begins to inform, coordination and synchronisation with other TOs.
   a. To coordinate with TO_{road} of the relevant governance zones to manage the extra traffic demand by offering other mobility solutions in different transport networks, especially during peak hours. This is achieved through synchronisation with the available TSPs and their respective FOs.
   b. To coordinate with TO_{sea} and TO_{air} of the relevant governance zones and ensure passengers or freight shifting to the road network are re-routed away from the disturbed areas.
3. All TOs involved inform the affected TSPs and FOs according to information subscriptions and reported transports. The TOs also provides generic information to the public on the situation to influence transport decisions.
4. The TSPs and FOs start to re-plan and report their re-planned chains and operations to the respective TOs.
   a. They report to the TOroad of the relevant governance zones to arrange for a planning of how to handle the extra traffic demand.
   b. The TSPs informs their consumers and suggest alternative routes and transport means.
   c. TSPs and FO agree on how to mitigate the problems, and they report to the relevant TOs.
5. The TOs monitor the situation based on the information received.
   a. They continuously calculate and manage the demand within the given areas most impacted by the disturbance.
   b. They forecast the traffic in the disturbed areas.
6. The affected TOs plan how to do demand capacity balancing
   a. They plan transport demand management measures to handle the situation (priority measures, access control, etc.). Public transport such as buses, trams, overground trains, utility vehicles, ride hailing, and carsharing will get a high priority. Private vehicles will get a lower priority.
7. TOs share information on the foreseen capacities and negotiates on how to distribute the traffic across different networks and modes
8. The TOs provides generic information to the public on the situation to influence transport decisions. This occurs throughout the whole duration of the disturbance.
   a. Open data sources used by other systems are updated to reflect the current situation as well as the traffic management decisions taken. In this way, navigation systems can inform NUs and re-route NUs approaching the area.
   b. Generic traffic messages are broadcasted to create awareness about the situation, to cause caution, and to influence transport plans under establishment.

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   c. TSPs and their respective FOs can clearly see which transport networks are over/under served in the disturbed areas and adapt a strategy to utilise their fleet efficiently. This is achieved through the Orchestra platform and is transparent to the relevant stakeholders.
   d. Limitation of road speeds if required along with other relevant safety measures.

9. TO systems receive priority requests regarding transport operations from some FOs. TO_{road} defines priority groups supported by standardised procedures.
   a. Emergency vehicles, freight vehicles transporting critical equipment/goods, and other response units get the highest priority.
   b. Public transport operations get the second highest priority since it guarantees high transport volumes and is accessible to the masses.
   c. Private MaaS transport options in the area are given third priority level.
10. TO systems provide decision support to the NUs regarding how to handle the situation.
    a. Predictions and simulations explore the possible development of the situation when different measure alternatives are taken. Historical data is used as well as predefined arbitration models and rules.
    b. Alternatives and potential effects are presented to support manual decisions.
    c. TO systems explore re-routing and transfer of ongoing transport to neighbouring networks.
    d. TO systems identify concerns regarding NUs characteristics and give recommendations based on their usual decision-making criteria.

5.3.2 Support to TSPs and FOs under foreseen events:

Situation:

- Some of the underground metro lines will have a limited capacity.
- The transport operations of the FOs may be affected due to more traffic in other networks.
- FOs may utilise the need for more transport due to problems in the metro.

Stakeholders involved:

- Transport orchestrators ($TO_{s)}$ of affected networks.
- TSPs that are or may be affected by the situation.
- FOs planning and managing traffic operations that are or may be affected by the situation.

Issues addressed:

- Coordination between TOs, TSPs and FOs.
- Priority requests.

Detailed scenario description

1. The TSPs and FOs operating in the affected transport networks are informed according to their subscription for information from the TOs. In that way:
   a. Those that can handle the travellers not able to take the metro may prepare to handle a higher demand. They can allocate more resources, introduce more vehicles from their respective fleets, and have increased frequencies to match the demand.

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   b. Those that have transports that may be affected by foreseen congestions may re-plan their transport chains, and their transport operations. They may for example take unusual routes to avoid further traffic congestion
   c. Those that have transport operations that are entitled to priorities may plan and prepare priority requests.
   d. TOs may recommend when transport operations should be carried out to contribute to a better traffic flow.
2. TSPs can inform their customers (e.g. travellers) and suggest the use of alternative services and modes.

5.3.3 Support to NUs under foreseen events:

Situation:

- Due to the foreseen flooding in the underground, tis expected to be more dense than usual.
- The NUs in the road network are affected.

Stakeholders involved:

- Transport orchestrators (TOs) of affected networks.
- NUs in the transport networks that are affected by the situation.

Issues addressed:

- Situation anticipation and preventive measures.
- Priority requests

Detailed scenario description

1. Through open data, potential NUs are informed through navigation systems of the situation digitally along with the congestions and speed limitations across different transport networks in real-time.
   a. NUs are offered alternative overground transport services and transport routes.
2. NUs may ask for priority
3. Some NUs and/or logistics/freight vehicles might choose to postpone their trips and reduce their lost time due to traffic, hence increasing productivity.

5.4 Situation 3: Managing a sudden reduction in network capacity

Unforeseen situations in a network may for example be accidents, sudden obstructions (vehicles blocking the network, avalanche, landslide, sudden floodings, etc.), and technical problems causing limited capacity (e.g. reduced ability to control CAVs), etc. Such situations may cause one or more of the following situations

- A considerable reduced capacity in the network
- A sudden outage of the traffic orchestration with one governance area
- The traffic flow in one network may be heavily affected by problems in another network due to re-routing of passengers and freight.

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The scenarios described below provide examples of how the situation is detected, issues to be considered, support to ongoing transports that are affected, immediate coordination with other networks and modes, and recovery from the situation.

5.4.1 Significant reduction in network capacity

Situation:

- Large accidents in a main highway with high traffic volumes.
- After a short period with full stop in the traffic flow, some traffic is allowed to pass. The capacity is however reduced to less than 20 % of full capacity
- The ability to re-direct the affected traffic to alternative route is limited. Private roads in a neighbouring network can be used as a short detour if the owner allows this but cannot be used by large trucks due to a low subway. Other detours will take up till 2 hours extra.
  - All relevant information is shared and managed as described in section 5.2.1

Stakeholders involved:

- Transport orchestrator TO_{road} in main road governance area where the accident happens.
- Transport orchestrator $TO_{private}$ in private road governance area providing a possible short detour
- TSPs organising transport chains that are or may be affected by the situation.
- FOs planning and managing traffic operations that are or will be affected by the situation.
- NUs in the network that are or will be affected by the situation.

Issues addressed:

- Situation detection
- Coordination with and support to emergency and other response units
- Coordination between governance areas and stakeholders
- Priority requests and priority handling
- Decision support
- Effectuation, configuration, and deployment of traffic orchestration measures

Detailed scenario description:

1. TO systems detects that the traffic flow stops and notifies TO_{road} about an unnormal situation. At the same time, the situation is reported by several NUs, both digitally and manually
2. TO systems take safety measures. The speed of NUs approaching the area is controlled to avoid chain collisions, and NUs are informed about the situation.
3. TO_{road} takes actions to get more information about the situation.
   a. A dashboard showing the real-time traffic situation is used
   b. Data and videos of affected locations are observed
4. TO_{road} establishes a communication channel towards emergency units and other response units that will help to handle the situation. This contact goes on continuously as long there is a need.
   a. The status with respect to response operations is exchanged

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5. The TO's systems provide updated information about the situation to support the units
6. TO systems take actions to limit the consequences through communication with systems and actors. Information on the current and foreseen situation is shared as well as information on measures taken to handle the situation. This goes on as long as there is a need.
    a. Open data sources used by other systems are updated to reflect the current situation as well as the traffic management decisions taken. In this way, navigation systems can inform NUs and re-route NUs approaching the area.
    b. Generic traffic messages are broadcasted to create awareness about the situation, to cause caution, and to influence transport plans under establishment.
    c. TSPs/FOs are informed individually if they subscribe to information about affected network segments or if they subscribe to information of relevance to planned and ongoing transport operations in the network.
    d. The TOs of governance areas that might be affected are informed, $TO_{private}$ included. This in particular includes information about measures planned or taken that may affect the traffic in the other governance area.
7. TO systems receive certified priority requests regarding transport operations from some FOs and NUs. TO_{road} defines priority groups supported by standardised procedures:
    a. Emergency vehicles and other response units get the highest priority
    b. Public transport operations get the second highest priority
    c. Transport operations with a next leg with certain characteristics get the third highest priority level. These operations have a necessity for reaching the next leg in time (e.g. due to the type of cargo or the societal effects of not catching the next leg).
    d. Transport operations with no specific needs get the lowest priority
8. An efficient emergency response will limit the consequences of the accident. TO_{road} and TO systems offer support to the emergency units:
    a. These NUs have the highest priority and get privileges. They can use close road segments and override light signals and speed regulations.
    b. The NUs are supported in getting to the location. They get dedicated access one lane.
    c. Conflicts with other NUs are solved. The others are told to move away from the dedicated lane. They are guided to use the hard shoulder of the road.
    d. A network segment close to the accident is reserved for use by the response units.
9. TO systems provides decisions support regarding how to handle the situation.
    a. Predictions and simulations explore the possible development of the situation when different measure alternatives are taken. Historical data are used as well as predefined arbitration models and rules. Alternatives and potential effects are presented to support manual decisions.
    b. As soon as the emergency response has control, TO_{road} decides to open the road with 20 % capacity
    c. TO systems explores re-routing and transfer of ongoing transport to neighbouring networks. $TO_{private}$ is asked and approves a transfer. This is included in the plan. Longer detour alternatives within the network of TO_{road} are identified.

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   d. TO systems identifies concerns regarding NUs characteristics (hight and weight) for the re-routing alternatives.
   e. The use of the priorities is defined. Those with the three highest levels can use the remaining 20 % of the capacity in the network. The next level can take the short detour unless they have hight and weight constraints. If so, they may also use the main road. The remaining NUs are divided among longer detours.

10. The measures selected in point 8 are made operational by the TO systems. Network regulations are updated and applied on the smart infrastructure:
    a. The passage through the main road gets access restriction for all but those with the right priorities.
    b. The exit to the roads managed by $TO_{private}$ get access restrictions ensuring that just those with a sufficient priority level and limited vehicle dimensions get access.

5.4.2 Sudden outage of traffic orchestration in governance area

Situation:

- The traffic orchestrator in a road network cannot operate as planned due to an outage for technical reasons. In such situations there are two options:
- A backup solution exists, and there is no need to close the network or operate with a very limited capacity.
- The traffic orchestrator of another governance area in the same network takes over the responsibility of the affected area.
- All relevant information is collected and managed as described in section 5.2.1.

Stakeholders involved:

- Transport orchestrator TO_{outage} in the TO in the road governance area that cannot operate due to a technical outage.
- Transport orchestrator $TO_{takeover}$ in the TO in the road governance area that takes over the responsibility for the GA originally managed by the $TO_{outage.}$
- Transport orchestrator $TO_{superior}$ in the TO road governance area that is superior to TO_{outage} and $TO_{takeover.}$ $TO_{superior}$ is may for example be on a national level and is responsible for the coordination of the takeover.

Issues addressed:

- Situation detection
- Identification of alternative TO
- Handover

Detailed scenario description:

1. $TO_{superior}$ detects that TO_{outage} is not responding due to a technical problem.
2. As an immediate response, $TO_{superior}$ takes over the governance area of TO_{outage}. This is possible since $TO_{superior}$ already has access to all data and has the systems needed for a takeover.

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3. $TO_{superior}$ is not supposed to continue to do operative traffic orchestration within subordinate governance areas. Since the traffic situation is normal and can be handled automatically at the moment, $TO_{superior}$ starts to work on the handover of the responsibility to another subordinate governance area.
    a. Relevant governance areas are identified. In general, neighbouring governance areas within the same network are preferred. The traffic orchestrators of the area must also have the skills needed.
    b. $TO_{superior}$ contacts $TO_{takeover}$, which is the most relevant candidate, and $TO_{takeover}$ approves a handover.
4. $TO_{takeover}$ take measures to increase the traffic orchestration capacity. Extra personnel are called.
5. $TO_{superior}$ takes the formal actions needed to facilitate the handover to $TO_{takeover}$. $TO_{takeover}$ is approved and gets access to all relevant data and systems. The handover is completed.
6. $TO_{takeover}$ now has the responsibility for the governance area of TO_{outage} as long as this is needed. The NUs, the TSPs, and the FOs will not be affected and may not know about the handover.

5.4.3 Transfer node/passenger transport - Sudden capacity reduction in neighbouring network

Situation:

- The traffic flows within a large transfer node (an airport) are managed and coordinated with the traffic flows in neighbouring networks. See the illustration of the transfer node (TN) in Figure 3.
- Sudden, unforeseen technical problem in the rail network causes a stop in all rail transport to the airport.
- The travellers in the trains are picked up by busses for further transport to the airport. Travellers not yet in the train must find other solutions, and they are supported by their TSP. Since this is just before a weekend, the roads are already quite congested.
- After a silent period, with no arrivals to the airport from the rail network, very many passengers start arriving via the road network. This may have consequences for the check in, the security control, and the boarding. If the boarding is delayed, the planes will have to leave with too few passengers.
- Those that arrive late to the airport are in a hurry and may not reach their airplane in time.
- All relevant information is collected and manged by the TO, as described in section 5.2.1.

Stakeholders involved:

The traffic orchestrators (TOs) listed below are linked to the transfer node example and governance areas provided in Figure 3.

- TO_{rail} - Transport orchestrator for the rail governance area. This also includes the railway station at the airport (e.g. ticketing areas and waiting areas)
- TO_{road} - Transport orchestrator for the road governance area.
- TO_{TN} - Transport orchestrator for the airport transfer node governance area. TO_{TN} manages the traffic in the airport transfer node. This is 1) the flow of people (travellers, crew, and airport workers) through entry points to/from parking areas for cars (shared cars and private cars), bus stops, railway tracks, and gates from airplanes; 2) the flow of crew and airport workers through

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dedicated entry points and areas with access restrictions; and 3) the low of travellers, crew, and airport workers in terminal areas. This includes the flow through check in desks, luggage drop-off points, security gates, and gates to airplanes.

- TO_{air} - Transport orchestrator for the air space governance area, the space used for landings and departures included.
- TO_{ground} - Transport orchestrator for governance area covering the land side of the airport. This includes the ground infrastructure with taxing and waiting areas, as well as the gate areas used by the airplanes and the rollway. It also covers the roads used by vehicles supporting the airplanes and the passengers.

Issues addressed:

- TSP supporting transport to airport
- Airport preparing for and handling delayed arrivals
- Support to travellers in airport

Detailed scenario description:

1. TO_{rail} detects that a train has stopped, and after a dialogue with the train operator, it is clear that the train cannot operate as planned. Thus, TO_{rail} informs other stakeholders about the problems with the train and that this will affect the traffic. The stakeholders informed are: Neighbouring TOs (TO_{TN} and TO_{road}), TSPs and FOs subscribing to such information. Based on this information:
2. TSPs will as a response to the information received from TO_{rail} stop using the train as a transport alternative to the airport.
   a. The FO operating the train will order busses for transport of passengers to the airport.
   b. Other FOs will as a response to the information received from TO_{rail} offer alternatives to rail transport and TO share data on these new/extended transport alternatives are with TSPs and others. The alternatives may for example be: New/more bus departures and adapted routes (to avoid possible road congestions) are organised, and shared cars and cars that can be hired are moved to relevant locations for use by travellers to the airport.
3. The TSPs' systems will find the open information about the new/extended transport alternatives, and the systems will support the travellers in finding these alternatives.
4. TO_{road} will as a response to the information received from TO_{rail} start preparing for an increased traffic volumes in the road network.
   a. Information about the situation (expected travel times, etc.) is shared with TSPs, FOs and NUs.
   b. FOs are asked to postpose unnecessary tours if this is possible.
   c. The busses to the airport get priority
   d. Selected NU_{road} groups have to take a detour to avoid congestions in known bottlenecks.
5. TO_{TN} will as a response to the information received from TO_{rail} foresee late arrival of many passengers.

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   a. As a response, TO_{TN} informs the service providers operating in the airport (those handling the check in, the boarding, the luggage, the security control, etc.). They are asked to increase the capacity at the estimated peak time.
   b. TO_{TN} receives, as a part of the normal reporting, information from TSPs, FOs and NUs on planned arrivals to the airport (bus stops, parking areas, etc.). Thus, TO_{TN} also knows about the planned arrivals of the extra busses and cars, and the expected number of passengers.
   c. TO_{TN} takes measure to control and guide the NU_{TN} in the airport.

6. On arrival, a NU_{TN} provides check in information or other information to the TO_{TN}.
   a. Each NU_{TN} is categorized (traveller, crew, airport worker, etc.), and for travellers, the TO_{TN} knows the time schedule and destination gate in the airport.
   b. Crew members and airport worker get access to specific entry points and areas.
   c. Travellers get support and they are guided whenever this is needed to ensure the best possible flow through the airport and to ensure arrive at the destination gate in time. The support is adapted to both needs and situation. Some travellers already have a priority. Other get a priority due to the delay, and they are guided through the critical parts of the airport.

5.4.4 Transfer node/freight transport - Sudden capacity reduction in neighbouring network

Situation:

- Sudden, unforeseen accident in road network (same as in section 5.4.1)
- Freight transports are affected by reductions in network capacities.
- The TSP has provided all relevant information to the TOs along the transport chains as described in section 5.2.1.
- The TSP has a subscription on information from the TOs along the transport chains.

Stakeholders involved:

- Transport orchestrator TO_{road} in main road governance area where the accident happens.
- Transport orchestrator $TO_{private}$ in private road governance area providing a possible short detour
- TSP organising transport chains that are or may be affected by the situation.
- FO planning and managing transport operations on request from TSP. The transport operations are or will be affected by the situation.
- NUs in the network that are or will be affected by the situation.

Issues addressed:

- Early detection of situation
- Support to TSP and FO
- Early notifications support the organisation of new transport alternatives
- Priority of time critical transports

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Detailed scenario description:

1. Transport operations reported to TO_{road}, identifies the FOs and TSPs involved. Thus, there is a known link between the transport operations and the FOs and TSPs, and TO_{road} can notify all TSPs and FOs affected about the network situation if they subscribe to such information. TSP and FO have the following subscriptions, of relevance
   a. A subscription on notifications related to the network segments managed by TO_{road}
2. A subscription on notification related to transport operations linked to three transport chain (TC1, TC2, and TC3) that may be affected by the accident.
3. As a consequence of the above, TSP and FO receive a notification for TC1 and TC3. The FO has not yet properly planned and reported the transport operation linked to TC2. Thus, no information related to TC2 is received.
4. TSP starts working on how to handle the situation. The transport characteristics of the chains are inspected.
5. The transport operations for TC1 and TC2 will start in 2 and 3 hours respectively.
6. The transport operation for TC3 is ongoing and is probably already affected by the accident.
7. The ongoing TC3 is time critical. The cargo is fresh seafood, and the next leg is a scheduled train transport. There is no alternative before the next day. If the cargo cannot catch the train, it has to go by road (and cause an even higher traffic density). If delayed, the food may have to be destructed.
8. The planned transport operation for TC1 is also time critical. The cargo must reach the next leg, which is by sea.
9. The planned transport operation for TC2 is not time critical.
10. TSP takes the following decisions:
    a. Try to get a priority for the transport operation linked to TC3.
    b. Try to find an alternative to the current sea leg for TC1. Due to the early notification from the TO this is doable. Another vessel with a departure 2 hours after the first vessel has the capacity to take an extra container.
    c. TC2 can wait till the normal situation is restored.
11. FO receives the same notifications as the TSP. Thus, the FO is also prepared, and TSP and FO coordinate their actions.
    a. FO sends a priority request for the transport linked to TC3. It is justified by the type of cargo (fresh seafood) and the necessity to reach the green train service instead of going by road.
    b. FO re-plans the transport linked to TC1. It is re-routed to the port via another part of the network instead of going to the railway terminal.
    c. FO and TSP agrees that the transport of cargo linked to TC2 can wait.
    a. FO re-plans the transport linked to TC2. The cargo is consolidated together with other cargo planned for transport another day. This increases the load factor of this transport.
    b. FO must also handle time critical cargo from other TSPs. The truck originally planned for the TC2 transport is used to transport more time critical cargo via an alternative, but longer route. The ability to postpone the TC2 cargo facilitates a better resource utilisation, which is important due to the long route.

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6 Implementation scenarios

The implementation scenario related to the previous target vision scenario provides developments following the selected KPAs in section 4.2. The different topics are all covered, but to varying degrees of depth. Indeed, the material available at the time of the report is still incomplete. This section will be further developed in the course of the project and stated in D2.4.

6.1 Regulation and policy

The regulatory and policy framework influences the implementation of MTM(E) systems. As analysed in D2.2 (Pre-studies on environment analysis and drivers) the current legal framework both functions as a driver and barrier in different aspects. This chapter will focus on the barriers within the current regulatory and policy framework by defining the gaps. Therefore, necessary development in policies and regulations for the improved realisations of the MTM(E) will be outlined.

6.1.1 International multimodal transport

On an international level there is a lack of regulation, which addresses international transports, which are undertaken with more than one mode of transport. However, with several international conventions in place for unimodal transport of person and freight as well as differing national laws the applicable liability rules concerning different modes of traffic vary. None of the international treaties in force cover operations, which involve more than one different mode of transport (UNCTAD, 2003). The United Nations Convention on International Multimodal Transport of Goods (1980) is not in force, since not enough parties have implemented it (UN, 1984, a). The contract deals with liability issues, defines responsible roles as well as special rules on dangerous goods amongst other aspects (UN, 1984, b). In order to harmonise rules on international multimodal transport of goods the collaboration between state parties in negotiating necessary adjustments in order for the treaty (UN Convention on International Multimodal Transport of Goods) to achieve the necessary acceptance amongst parties should be fostered. Further activities on the topic of have been issues by the UN ESCAP and the Working Group on Dry Ports analysing the need for harmonisation of legal frameworks for multimodal transport operations in Asia and the Pacific (UN, 2019).

6.1.2 Legal framework on emission reduction and air quality

Moreover, the implementation international, European and national regulation on emission reduction is beneficial for the MTM(E). One of the benefits for companies to become a part of the Orchestra platform is the potential to reduce emissions linked to the transport of people or goods. With an overall increase of transport chains leading to increasing emissions, the need for companies to implement innovative and more sustainable solutions will raise. On an international level the enforcement of the Paris Agreement is important, committing treaty parties the goal to limit global warming preferably to 1.5 degrees Celsius (UNFCCC, 2015). Moreover, on the European level the Green New Deal lays out emission reduction goals of 55 % until 2030 and 95% until 2050 in comparison to the 1990 rate (EC, 2019). The overall goal to become climate neutral until 2050 was adapted in the European Climate Law, rendering them legally binding (EC, 2021). Some national laws on climate protection through emission reduction also draw on emission reduction goals for specific sectors within a specific time frame. For example, the German national law on climate protection has identified sector specific emission reduction goals, stating a goal to reduce emission within the transport sector of 48% until 2030 (Umweltbundesamt, 2022). Moreover, local air quality

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regulation influences the need for transport companies to reduce their local emission in order to meet certain standards. However, the enforcement of the emission reductions and air quality requirements is important and gaps can be identified (European Environment Agency, 2022). Moreover, a European roadmap to prepare sector-specific paths to climate neutrality are missing, but acknowledged in the EU Climate Law (EC, 2021).

6.1.3 Cybersecurity and liability

In regard of the topic of cybersecurity the gaps concern the dependence on digital technology of the Orchestra concept. Cyber security requirements following out of regulation, such as regulation the NIS Directive (EU, 2016) need to be implemented by the stakeholders involved. However, globally regulation on cyber security standards is relatively narrow and more focus on the topic is needed to bridge the gap, in order to optimise the stakeholders' investments on the topic, as well as overall risk (Chan et al, 2021). The proposed broadening of the scope of the NIS2 Directive should be implemented, leading to an overall increase of cyber security in Europe (EP Think Tank, 2021).

Stakeholders of the Orchestra solutions might be reluctant to become part of the network in case this increases the risk of cyber-attacks. Therefore, insurance should provide solutions that can help interested stakeholders in their risk assessment induced by MTM, reducing it to an amount, which is acceptable for them. One of the risks, which should be tackled is the TO’s responsibility for unforeseen events related to cyber security, such as data leakage. However, an increase of the overall transport costs due to the additional cost of insurance should be avoided, as the benefits need to outweigh the additional necessary investments.

Moreover, the European Parliament and the Member States need to adopt the Proposal on a laying down harmonised rules on artificial intelligence, the so-called Artificial intelligence act (EC, 2021). Harmonised rules on Artificial intelligence are needed for the MTM in cases where the applied algorithms are to be categorized as such. An evaluation of this question is inserted in D1.3 (Ethics, Gender and Security Report). Especially, in the high-risk transport sector special requirements are needed for product liability purposes. The current European legal framework on product liability does not take into account the peculiar aspects of artificial intelligence.

6.1.4 Safety requirements and CAVs

The Orchestra platform would benefit from regulation on safety requirements, which would harmonise the fragmented safety requirements for each specific mode of transport. The question of safety requirements for unforeseen events from either outside the Orchestra network, but effecting it, or from failures inside the network, either from staff or facilities is closely linked to the topic of liability.

Moreover, the use of CAVs in the Orchestra network and how they could be incorporated into the overall network poses open questions. First, there is a need of protocols dealing with possible technical failures regarding CAVs moving on public and private infrastructure.

The German legislation on the topic of automated and autonomous cars can be used as a benchmark due to its early adoption to the topic (ADAC, 2022). Right now (by 2022) the legal framework is designed to autonomous cars that are not privately owned, but are operated by public transport companies. The technical operators are then hired by the companies in order to operate them.

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For autonomous cars a technical operator is needed in either inside the vehicle or close proximity overlooking the decisions.[3] Therefore, in emergency situations third parties (like authorities, or the traffic orchestrator) will reach out to the supervisor. If authorities or TOs would be able to control the autonomous cars or vehicles directly, this would pose additional liability questions. The question of how to handle the take over of control for third parties will also be relevant not only for cars, but also other vehicles. Besides, with the requirement of one technical-supervisor for every moving vehicle, there is still close monitoring necessary

However, with the technology evolving further the legal framework will most likely open up for different supervision requirements (Hartwig)[4]. For the private use the question of whether there will be a right to disconnect the CAV, or whether it will be strictly necessary through traveling in a GA, needs to be explored.

Further, within the German legal framework there is no differentiation between private and public ground as such, but rather the question of whether the private ground is still available to the "open public". For example, in case of the Heroya industrial park, the fact that logistic staff from outside need to enter, would be enough for regulatory law, like traffic codes, to apply.

6.2 Smart infrastructure for automation and integration of CAVs

This section deals with gaps to fill and barriers to overcome.

6.2.1 Infrastructures enhancement

The required infrastructure may be both public and private. Infrastructure owners, under the supervision of the transport authorities, are responsible for ensuring infrastructure readiness for automated and connected vehicles. Transport infrastructures are most often public infrastructures, nevertheless, they are integrated with many different private infrastructures. For a seamless modal shift, both of them ought to be equipped with the necessary technology according to the latest standards and regulations.

The transport network infrastructure must be developed to meet standards and regulations adapted to the needs within different modes. The following gaps must be filled:

- Definition of the required capabilities of the infrastructure related to data collection (data collection from CAVs included) and provision of data to the connected vessels/vehicles and to traffic orchestration.
- Strategies for the handling of different levels of equipment in different segments of the network and in adjacent networks (e.g. private networks). Vehicles may have to operate in different areas under different types of networks, and the network in rural areas may for example not have the same equipment as the available network in cities and other network segments with high traffic volumes. This raises regulatory, economic and financial questions: infrastructure managers (public as well as private ones) will focus on the economic profitability of the investment from

[3] Gesetz zum autonomen Fahren (Law on automated driving), July 2021.

[4] Hartwig, Self-driving and cooperative cars, Opportunities for safe, efficient, and sustainable mobility for everyone, Perspectives, needs for regulation and regulation.

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their point of view and also from the point of view of the community. In addition, there is the question of financing these investments: will they be public, private, or a combination of both?

- Standardisation of all relevant aspects related to the capabilities of the infrastructure, e.g. how it should communicate with and support the automated and connected vehicles, how it should communicate with the traffic orchestrator and support the traffic orchestration process, and how it should operate under relevant situations.
- The basis for the services needed must be in place, such as the communication network infrastructure (base stations, satellites, etc.), communication protocols adapted to the needs, and geo-positioning systems (e.g. Galileo).
- Regulations, mechanisms (testing procedures, etc.), and bodies for certification of infrastructure technology to ensure that it complies with standardised specifications. In addition to a final approval, the certification must also address the software and hardware implementation processes – to ensure quality assured implementation processes and compliance with requirements.
- Development of investments in, and roll out of sensors, communication equipment and other required equipment along the infrastructures. All hardware and software components must comply with the required regulations and standards.

6.2.2 CAVs implementation

The implementation of CAVs must be achieved according to standards and regulations adapted to the needs within the different modes. The following gaps must be filled:

- Definition of the required capabilities of the CAVs related to traffic orchestration.
- Standardisation of all relevant aspects related to CAVs, e.g. how they should communicate with each other, how they should communicate with the network infrastructure, how they should communicate with the traffic orchestrator, and how they should operate in relevant situations.
- Regulations, mechanisms, and bodies for certification of the CAVs to ensure that they comply with standardised specifications. In addition to a final approval of the CAVs, the certification must also address the software and hardware implementation processes – to ensure quality assured processes and compliance with requirements.
- Implementation of CAVs. First, this will be how the vehicles/vessels should be connected, i.e. how they should communicate. The next step will be to make them capable of automated operations in dedicated sections or areas of the transport network. The final step will be to ensure that they can operate in the transport network in general and in mixed traffic conditions.

6.3 Data governance and sharing

This section outlines relevant issues for the MTM(E) implementation of data governance and sharing from a regulatory perspective. Therefore, gaps and possibilities on the topics and data access, data ethics, data quality, and ownership, as well as standardisation are explained.

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6.3.1 Data access

In regard to multimodal transport and data sharing on a European level the ITS Directive and the delegated regulation has implemented first steps. However, the ITS Directive merely requires companies to share data they are already collecting under their own terms. In case, that the stakeholders are not collecting mobility data in the first place, there is no obligation to start with the collection and subsequently there is no obligation to share data, not yet collected. The scope of the regulation merely includes collected digital travel data and specific types of traffic data, with a focus on static data and a minor scope of dynamic data. This limitation of scope leads to a limited actual impact (Jochum, 2020). A revision of the ITS-regulation has already been announced by the European Commission, that will include the obligation to share new dynamic datasets (Sustainable mobility for all, 2021). Data access, exchange and availability still remains to be one of the core barriers for the MTM(E) implementation. The absence of an obligation to share mobility data could be tackled by either implementing an obligation, for specific types of mobility data, or provide effective incentives for private companies who voluntarily decide to share their mobility data. While deciding whether a sharing obligation is set into place, or merely incentives will be introduced the regulator needs to take into account, that the more value private companies provide to the types of mobility data they could voluntarily share, the more effectiveness is needed for the incentives. In this regard, real-time data, which is highly needed for the MTM(E) implementation, might have more value to the stakeholders than statistical data. Implemented incentives could have economic value, like tax reductions. The European regulator plans on taking more acting in this field with the Data Act covering both, B2B and B2A data sharing practises next to the proposal for a Data Governance Act (EU, 2022). Moreover, Initiatives like the European Mobility Data Space implement first steps in regard of fostering the collaboration between stakeholders in regard to mobility data sharing. The approach aims at "facilitating access, pooling and sharing of transport and mobility data" (EU, 2021). In this regard the MTM(E) could either take into account the lessons learned from the initiative or it even aim at becoming a part of the cluster.

Besides, in order for the TO to be able to make informed decisions, some relevant local traffic regulation should be digitally available to the TO. These traffic rules could imply speed limits, limited accesses to vehicles with a certain weight, traffic ban during certain time slots, as well as dangerous goods restrictions amongst others. Therefore, the traffic rules need to be digitally available to the TO. In cases where traffic rules are not digitally available, the process of digitization of local traffic rules requires resources.

6.3.2 Data ethics

The required data collection for MTM services may raise ethical concerns in case that personal data is collected. The General Data Protection Regulation (GDPR) offers a detailed European legal framework protecting citizens right to privacy. With this legal framework already in place, the MTM services need to be designed and need to operate in a way that is in compliance with data protection rules. Therefore, the notion of privacy-by-design included in Art. 25 GDPR needs to be implemented, if possible. The principle of privacy-by-design ("data protection through technology design") means that appropriate technical and organisational measures achieving data-protection principles should be implemented. In case, where privacy by design could not be implemented for certain features of the MTM systems, but personal data is necessarily needed, other possibilities rendering the proceeding of personal data legal should be assessed on the basis of Art. 6 GDPR. Legal grounds for the proceeding of personal data could be consent of the personal data subjects, as well as a legal obligation of the data controller to proceed the data required by either European or national laws.

Besides, discriminatory practices by algorithms must be prevented, taken into account the possible affects the algorithmic decision may have on passengers. Moreover, the information that is fed into the MTM services should not be bias. Moreover, regulations must ensure that the equipment required is mandatory and fully integrated in vehicles/vessels. The equipment needs to support automated actions that do not put an extra burden on the persons operating the vessels/vehicles in terms of need for training, or special competence, etc. Further information on MTM(E) and ethical questions are laid out in D1.3 “Gender, Security and Ethics Report”.

6.3.3 Data quality, ownership and competition

Another gap identified in the legal framework for the MTM(E) is the need for regulation implementing data quality requirements for the use in different sectors. Thereby, it is important to take into account, that there is no abstract assessment of data quality as such, since the Data quality refers to the suitability & usability of data for a specific purpose for the specific user (Horn, 2022). However, data quality is important in order to build business models, reliability, traceability, avoidance of discrimination and bias, compliance with legal requirements (cf. Art. 5(1)(d) GDPR) and cross-organizational cooperation (interoperability) (Horn, 2022). The Data Act, which is proposed by the European Commission and is now awaiting final votes, fosters the development of interoperability standards for data to be reused between different sector (Braun, 2022).

Furthermore, the MTM(E) needs to take into account that data ownership in the sense that is does lead to an exclusive property right is not existing in the actual legal framework, due to the viral nature of data (Kerber, 2016). In fact, the use of data depends on the actual holdership leading to the need of specific contractual agreements (Wiebe/Schur, 2019) between the MTM(E) parties. These will be further explored in D4.4 “Handbook on contractual and administrative implementation.” Moreover, the Data Base Directive (EU, 1996), which will be revised, protects data basis by granting the owner a copy right.

Moreover, the MTM(E) needs to take into account competition law requirements throughout its implementation. It is likely that the compatibility with European competition law is linked to the type of data, that is exchanged between participating stakeholders. Relevant data types, which exchange will less likely fall under the scope of competition law requirements (Lundqvist, 2018).

6.3.4 Standardisation

When implementing the MTM(E) the topic of data standardisation is critical for interoperability aspects. Actors need to be able to exchange real-time data, among other data types. Therefore, standardisation is relevant for the data form, as well as open data exchange systems and communication protocols.

Some standards concerning the road transport data provision has been defined with delegated regulation under the ITS Directive (EU, 2017). Thereby the standardisation applies to the collection of statistic travel and traffic data, as well as dynamic travel and traffic data. However, a gap remains concerning the functioning of CAVs, which is outlined in Chapter 6.2.2. The topic will be further explored in D2.5 “White paper to policy makers for a European multimodal traffic management ecosystem.”

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6.4 MTM functionality

The multimodal traffic management (MTM) functionality will extend the current traffic management implemented for the different modes. These extensions will facilitate the new traffic orchestration measures within each network and also across networks and modes.

The new functionality must be agreed upon and implemented for each mode. The extensions needed may vary between the modes since the starting points varies (demand capacity balancing is for example to some extend already implemented within air transport but not at all for other modes) and because the modes have different needs.

6.4.1 Transport demand management

Transport demand management is, as described in section 3.4.3, about more or less automated measures taken based on well-defined conditions. To facilitate this, the following steps must be taken:

- Further experimenting with MTM solutions and trials to gain knowledge and to find possible solutions. This includes explorations of the measures needed, the implementation of the measures by means of generic services (use of existing services included), and the effects on the traffic, etc.
- Standardisation of all relevant aspects related to the new services needed. For the interactions with the Network Users, there will probably by mode-specific standards. The standards will among others define the required capabilities of MTM systems regarding transport demand management, and different levels of MTM for use in different types of networks (e.g. urban/rural networks, networks with dense traffic, networks with mixed traffic, and networks dedicated to CAVs).
- Regulations, mechanisms (testing procedures, etc.), and bodies for certification of MTM solutions must be in place to ensure that it complies with standardised specifications. In addition to a final approval, the certification must also address the software and hardware implementation processes – to ensure quality assured implementation processes and compliance with requirements.

6.4.2 Demand capacity balancing

Demand capacity balancing, as described in section above, about measures taken to handle imbalance between traffic volumes and network capacities. To facilitate this, the following steps must be taken:

- Further experimenting with MTM solutions and trials to gain knowledge and to find possible solutions. This also includes coordination and collaboration with other networks and modes.
- Standardisation of all relevant aspects related to the new services needed. The standards for the collaboration across networks and modes must be common to all modes.
- Regulations, mechanisms (testing procedures, etc.), and bodies for certification of MTM solutions must be in place to ensure that it complies with standardised specifications. In addition to a final approval, the certification must also address the software and hardware implementation processes – to ensure quality assured implementation processes and compliance with requirements.

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6.4.3 Decision support

Both transport demand management and demand capacity balancing (see above) will make use of decision support. This is software that supports decisions. The following steps must be considered:

- Experimenting with different types of decision support regarding how human decisions can be supported and how far the automation in the decision taking can go.
- Regulations, mechanisms (testing procedures, etc.), and bodies for certification of the software implementing the decision support. The aim must be to ensure the ethics in the decisions and faire decisions that comply with rules and regulations.

6.5 Acceptance for traffic management operations and autonomy

Change processes are often complex as they encompass many issues, among which the enablers described previously. They require in-depth investigations to consider appropriate support measures. These will be studied later and described in D2.4 after the refinement of the present scenario.

6.5.1 Interest in participating in the MTME

The first point that seems obvious is that the actors must see an interest in participating. In short, they will be all the more likely to follow the recommendations made to them if they seem relevant and allow them to be more effective in their work.

Time and cost saving

Acceptance for a MTME may also come from a reduction of time lost in traffic congestions (passengers and shippers). Passengers may save more time for leisure rather than for going and returning from work. Increasing productivity thanks to reduction in commuting times and to accurate forecasts may be a decisive enabler.

Green motivation

Concerns about sustainable development have made companies aware that they have a social responsibility (Corporate Social Responsibility - CSR). More and more companies are defining and implementing appropriate strategies; this may include greener transport management, internalization of external costs, and also modal shift, which is favorable to the development of the MTME. Many logisticians want to decarbonize supply chains and consider that multimodal optimization should be addressed to maximize asset utilization and to achieve synchro-modality (D2.1, sub-section 6.2.1.4).

As a consequence, one should demonstrate scientifically that the MTM concept is more green-friendly than the "old" traffic management system. The question here is: Is the reduction of GHG emissions from the transport sector generated by the MTM implementation enough to compensate the GHG emission generated by the data management system (particularly by the data centers)?

Inclusiveness

Furthermore, it is hoped that a more efficient multimodal transport system will also be more inclusive, especially for people who do not own cars (passengers) or are disabled.

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6.5.2 Acceptance of the Traffic Orchestrator (TO)

The introduction of the TO as a new decision-making partner may have consequences for the decision-making processes, which may partly escape the control of traditional infrastructure managers or fleet operators, who would now be under the potential control of the TO. It will be necessary to ensure that the actors are not relieved of some of their tasks by the TO, or at least, if this is the case, that these tasks are not central and that they would be willing to stop managing them.

The question of the reliability of the information given by the TO will play a role in the acceptance of the resulting operations.

The other point concerns the difficulty of implementing the instructions given by the TO, in other words, the difficulty encountered must be compensated for by the interest shown in it. However, the difficulty encountered can be compensated for by the "facilitating conditions", support from colleagues, support from the hierarchy, etc. Various studies show an impact of experience on acceptance.

Paradoxically, increased information exchange may increase the information asymmetry between the traffic manager and the infrastructure users. This would be the case if the rules of action on the data and the decision processes were subject to a black box. Therefore, the decision algorithm must be accessible and understandable to all.

6.6 Operational practices and decision making

6.6.1 Training modules

The ORCHESTRA MTM concept will change the skills and jobs of the stakeholders/ actors and will affect their relations. Thus, the implementation scenario includes trainings modules dedicated to MTM under ORCHESTRA concepts.

The skills of the stakeholders and every actor must be matched to the tasks expected from him/her. Thus, for instance, The TO must have technical skills (management of the IT tool), be able to answer questions from the various players (if necessary) but also be able to take decisions himself or herself in the event of an "unanticipated" events. Just like what is done in the context of road crisis management, it would seem relevant to carry out exercises. In other words, to create scenarios of foreseeable as well as unpredictable situations which will then be tested on the TOs to see if their reactions are appropriate and, if not, to suggest ways of improving them. These training sessions are carried out every six months in the context of road crisis management in France. It could be the same in this case.

In order to define a training module, first every actor shall be categorized into one stakeholder category. Second, the role and responsibilities of every stakeholders shall be defined in context of scenario. Following this; the skills of every actor can be defined and the training module can be specified for each actor.

Trails may deal with the following topics, at least:

- Data Communication under normal conditions.
- Crisis management under ORCHESTRA MTM.

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- Communication of the solution/suggestion to other stakeholders.
- Respect of the regulations and standards.

6.6.2 Negotiations and trade-offs

The implementation of the ORCHESTRA MTM concepts will imply new negotiations and trade-off between the stakeholders of the traffic management. These negotiations may vary from the different MTM contexts:

- The spatial scale of the coordination (local, international).
- The nature of the stakeholders involved (public, private) and their related strategies.
- The local issues. Negotiations may take into account particular issues linked to the environment of the transport networks, such as such as sensitive activities (hospitals, factories, service areas) or particular risks such as chemical plants, natural risks, etc.

These negotiations should deal with:

- The reference framework for data exchange through the three different situations imagined within the target vision.
- Define the hierarchy of communication and scope of responsibilities.

The operational practices should rely on regular meetings to assess the exchange of the data process and answer the question: is it implemented as planned?

6.7 Business and organisational aspects

6.7.1 Financial environment

In order to encourage investment, specific funds should be set up to provide incentive loans to companies manufacturing vehicles and those operating transport fleets. The financing of smart infrastructure projects, the construction of connected or autonomous vehicles should not be an obstacle. This may require investment banks and other specialised bodies to strengthen the multimodal transport skills of their executives, so that the needs of investing companies are best understood. In addition, tax incentives should be provided to companies wishing to engage in such projects. In particular, the accelerated depreciation formula, which facilitates the return on investment, is generally very much appreciated by company managers.

6.7.2 Flexibility in contractual frameworks

Even if modal shift is possible from a technical point of view (intermodal transhipment hubs for goods, or multimodal interchange pole for passengers) transport contacts and mostly written for a single mean of transport (truck, boat, train). An MTM, as though in the ORCHESTRA project to support door-to-door Multimodal transport services, implies the possibility to change the mean of transportation during the trip. In conjunction, MTM can lead to the possibility to change the service provider during the trip. These ways of doing things are still not very widespread and require new contracts between the different TSP as well as between the TSP and their customers.

The contractual frame raises two crucial insurance issues. The first is the harmonisation of the conditions granted by insurers to carriers of the various modes. Indeed, each mode of transport is characterised by specific 'transport' risks, which correspond to civil liabilities and compensation (in

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case of disputes) specific to each mode of transport. It is therefore necessary to provide for mechanisms to take account of this heterogeneity, in order to meet the expectations of passengers and shippers. The second one deals with the risk management associated to the commercial, contractual agreements for data exchanges. As data is an asset, data need to be insured.

6.7.3 Increased collaboration, coordination and transhipment

From an overall approach, while only vertical integration is considered in usual transport solutions, even within intermodality (i.e. among stakeholders operating at different levels), horizontal integration is crucial in ORCHESTRA MTM, i.e. among stakeholders doing similar activities (e. g. Transportation Services Providers, in different modes; Fleet Operators, Traffic Orchestrators of different Governance Areas).

The implementation of the MTM requires data to be shared transparently and instantaneously, so that the anticipation of delays and congestion can lead to solutions that will ensure the smooth flow of traffic. This requires not only efficient and reliable technical interfaces, but also actors capable of exchanging the information necessary for the end-to-end routing of passengers and freight on a daily basis, without reluctance.

For this, the transport node managers have a key role to play. Indeed, when traffic problems cannot be solved on the transport network links, it is the productivity of the trans-shipments facilities that makes it possible to re-synchronise the routing. In this respect, coordination between road mode actors and actors of other (massified) modes seems much more demanding, as the number of vehicles (drivers if the vehicles are not yet autonomous) is greater, and the information to be transmitted is more "scattered". The players must also be prepared to interact effectively in the event of a cyber problem.

Again, it should be noted that the exchange of data, particularly for freight, makes shippers very vulnerable to commercial competition, as the points of origin and destination of freight may be revealed to competitors.

Another barrier to overcome is that the increased collaboration may not be in line with the competition rules and private strategies. In a context where it is not possible to impose collaboration between private stakeholders, competition rules may take over. D2.2 highlights that the influence of data sharing is an important issue for companies, because "data is considered an asset providing significant pro-competitive effects, increasing efficiency and encouraging innovation [...]. On the other hand, anti-competitive effects could materialize." And because "companies have significant expenses when collecting, processing, and cleaning data", they expect high returns (section 4.5). It should be stressed that the exchange of data, particularly for freight, makes shippers very vulnerable to commercial competition, as the points of origin and destination of freight may be revealed to competitors.

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7 Conclusions

This deliverable provides the target vision scenario for Multimodal Traffic Management (MTM) and the implementation scenario of its related ecosystem (MTME). It provides a detailed description of the role of the main stakeholders-types and the nature of the information exchanged between them, in various traffic management situations: normal situation, foreseeable events, and unplanned events. It also deals with the needed requirements, the gaps to fill up, the barriers to overcome, to reach the MTM target vision and the conditions of their acceptance by the different stakeholders of freight and passengers traffic management.

The initial target vision scenario for MTM, as described in this deliverable, contributes to the fulfilment of the following ORCHESTRA objectives:

(O1) Establish a common understanding of MTM concepts and solutions, within and across modes, for various stakeholders, for various contexts, and addressing safety, resilience, accessibility, emission reduction, and business issues, considering:

- Drivers for change, needs, requirements and success criteria, barriers, and possibilities.
- What multimodal traffic management will do, how it will work, and what it will contribute to.
- Practices for optimisation and decision-making.

(O2) Define 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. The MTME shall support:

- Real-time information sharing
- Orchestration of multimodal door-to-door transport services, adapted to traffic and network situations across modes.
- Integration of CAVs.
- Multi-actor and multi-governance settings where traffic orchestration and use of transport networks are coordinated and optimised across modes and governance areas to facilitate a better utilisation of resources as well as resilience towards disturbances.

D2.3 provides a first alignment of vision, scenarios and uses cases as required by milestone MS2 of ORCHESTRA. Indeed, it describes in detail the implementation of the main ORCHESTRA's concepts, through:

- The description of the coordination/synchronisation between the foreseen role of each stakeholder-type, i.e. Transport Orchestrator, Fleet Manager, Transport Services Provider and Network Users, as they have been defined in D3.1;
- The explanation of how important traffic management measures are taken, and implemented through these stakeholders;
- Some examples of how traffic management supports multimodal transport services in freight and people transports.

These target vision scenarios are input to the modelling in WP3 and selected relevant part if the scenarios will be simulated and tested in the two Living Lab (WP5).

D2.3 also provides the first bases for discussion about the requirements needed to reach the target vision (societal bottlenecks, conditions for the acceptance of the ORCHESTRA's concepts) through

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an implementation scenario. The issues raised need to be explored further, particularly with experts and practitioners of each mode of transport to get a more complete description of the current situation and the next stages on the way to the target vision. This will be done in the continuation of the work in Task 2.3 through other future workshops by autumn 2022 and interviews involving the project's Community of Practitioners (CoP).

These scenarios will be updated through other future workshops (2022-23). This work relies on the CoP throughout 2 workshops in order to check the relevance of the scenarios and determine the best options with practitioners, both for freight and people transport.

The implementation scenario refinement will provide a relevant input for the White Paper to policy makers for a European MTME (D2.5).

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