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ORCHESTRA Project Deliverable: D2.1

Initial target vision for multimodal traffic management ecosystem

Authors:

Ludovic Vaillant, Chloé Eyssartier, Marie Douet (Cerema)

Nicola Cavagnetto, Alessandra Tedeschi (Deep Blue)

Marit Natvig (SINTEF)

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About ORCHESTRA

The long-term vision of the 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. Also, to facilitate optimal utilisation of transport networks and efficient multimodal transport services, both in rural and urban areas.

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 support for 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.

The project will provide a Polycentric Multimodal Architecture (PMA) that specify how diverse system components collaborate and interact, taking into account smart infrastructures, technical and organisational aspects and polycentric governance. The PMA will be supported by: 1) Enabling toolkit, 2) Deployment toolkit, 3) Documented lessons learned.

The project will validate the PMA and related tools and toolkits in two Living labs (in Norway and Italy), collectively covering both road, rail, water, and air transport. The Italian Living lab is focusing on traffic orchestration for the mobility of people, while the Norwegian Living lab is focusing on traffic orchestration for freight. The Living labs will be supported by simulations to enhance evaluations.

Legal disclaimer

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For more information

Project Coordinator: Runar Søråsen, runar.sorasen@its-norway.no

Dissemination Manager (WP7 leader): Jenny Simonsen, jenny.simonsen@its-norway.no

Executive Summary

Within the context of climate change, transport is called to deep changes, through the next decades: a greener mobility is expected through Europe to mitigate the contribution of transport to GHG emissions and, conversely, transport will have to cope with increasing disruptive climate events.

The core hypothesis of ORCHESTRA project is that enhancing traffic management inside a transport mode and between different transport networks could be part of the solution to reach a sustainable and resilient transport system. Thus, a Multimodal Traffic Management (MTM) still has to be designed and needs a favourable ecosystem to occur. The Multimodal Traffic Management Ecosystem (MTME) should take into account the position of diverse stakeholders (*e.g.* traffic managers, fleet operators, technology providers, authorities). A shared vision of what could be the 2030 and 2050 MTME is necessary to base the coming works in the ORCHESTRA project, analysing the barriers, enablers, opportunities, acceptance, and social impact of its implementation.

The MTME **target** vision gathers **normative and subjective assessments** from different sources: a literature review of policy documents; the expertise among the project participants; preliminary interviews with of selected stakeholders; and two first Workshops that gathered CoP members on freight and passengers' topics in October 2021. The MTME vision described is a made up of major goals, projects, shared values and a collective will to achieve the goals (Godet, 2007).

Main Goals: By 2050, 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. In 2030, it is essentially a question of afterwards adaptation.

Major actions: By 2050, technological innovations in intelligent transport systems (ITS), together with great improvements of transport and data infrastructures at local (in cities) and European (TEN-T) levels are implemented by 2050. Digitisation, artificial intelligence and bio-mechanics will improve the MTM and support new transport services mixing old and new means of transport (Drones, CAVs). Thanks to standardised protocols, a traffic orchestrator is able to take or suggest decisions during disruptive situations. The 2030 horizon is an experimentation step for these projects, where implementation is more advanced in passengers than in freight transports.

The MTME implementation relies on a **system of shared values indispensable to MTM**: the green transition suggests introducing key performance indicator (KPI) in the MTM business models. Data sharing needs trusty, liable, secure, safe and transparent data exchange and decision protocols, as well as fairness, inclusiveness and cooperation among stakeholders.

A collective will: for such MTM to work, the rules of cooperation between the stakeholders must be defined: rules of responsibility for all modes of transport and new business models. Governance should prevent advent of monopoly. A radical mind change is expected, but it seems to be more likely to happen through passenger transport ecosystem than through the freight one.

This first target vision strengthens ORCHESTRA partners to develop a polycentric distributed management system, which will be provided to CoP members through other workshops to refine this first target vision, next year.

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List of Abbreviations

Table 1: List of abbreviations

Abbreviation	Explanation
ANSP	Air Navigation Service Providers
API	Application Programming Interface
ATCO	Air Traffic Controller
CAV	Connected and Autonomous Vehicles
CoP	Community of Practitioners
DoA	Description of Action
EC	European Commission
GA	Grant Agreement
GDPR	General Data Protection Regulation
GHG	Green House effect Gasses
KPI	Key Performance Indicators
MaaS	Mobility as a Service
MTM	Multimodal Traffic Management
MTME	Multimodal Traffic Management Environment
PI	Physical Internet
TEN-T	Trans-European Network - Transport
TO	Traffic Orchestrator
UAM	Urban air mobility
UN	United Nations
WP	Work Package
WS	Workshop

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List of Definitions

Table 2: List of definitions

Definition	Explanation
Governance	"Governance has been defined to refer to structures and processes that are designed to ensure accountability, transparency, responsiveness, rule of law, stability, equity and inclusiveness, empowerment, and broad-based participation. Governance also represents the norms, values and rules of the game through which public affairs are managed in a manner that is transparent, participatory, inclusive and responsive. Governance therefore can be subtle and may not be easily observable. In a broad sense, governance is about the culture and institutional environment in which citizens and stakeholders interact among themselves and participate in public affairs" (UNESCO)[1].
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.
Practitioners	The "Practitioners" are (DoA-PartB: p5, p10): - Infrastructure and traffic managers: road, railways, waterways, seaports, airports. - Transport operators in each transport mode. - Technology providers. - Authorities (regulators). - Academia from diverse disciplines (experts).
Resilience	According to BERKES, COLDING, FOLKE (2017) "In sociology and ecology, resilience characterises an organisation or a social body that is able to rebuild itself after having been substantially affected by an exogenous attack".
Scenario	According to Durance, Godet (2010) "a scenario is not a future reality but rather a means to represent it with the aim of clarifying present action in light of possible and desirable futures. […] scenarios have to respect the following five conditions: pertinence, coherency, likelihood, importance and transparency".

1 http://www.ibe.unesco.org/en/geqaf/technical-notes/concept-governance

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Definition	Explanation
Target vision	The vision is a shared and precisely described image of a desired future. The vision is made up of optimal goals and objectives that can indicate the long-term direction and that should guide the collective strategy of policy makers, stakeholders and citizens. According to Godet (2007) a foresight vision is composed of four elements: - The general goals, i.e. general goals perceived as possible that one will strive to achieve. - Major projects that shape the future. - A system of shared values. - A collective will to achieve objectives.
Traffic Orchestration	Traffic orchestration aims for optimal traffic flows. This will be a trade-off between many performance targets, those of the transport operations and chains included. The shared data and the network user's credentials facilitate dynamic decisions adapted to 1) the network and traffic situations across networks and modes; and 2) the transport operations and multimodal chains the network users are a part of. The traffic management will include. • **Transport demand management** to mitigate the negative effects of transport (congestion, emissions, etc.) through controlling transport volumes and transport types (e.g. toll roads, road pricing, access control, restrictions for fossil vehicles, etc.) • **Demand capacity balancing.** This is to balance demands with capacity to anticipate and mitigate disruptions through accurate forecasting and target time of arrivals. • **Decision support** supporting optimal **traffic management measures** for resilient mitigation strategies in normal situations as well as in case of incident, accident, disruptions, and disasters. Arbitrations models will be used to balance conflicts between different performance targets. (DoA, p8)

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1 About this Deliverable

1.1 Why would I want to read this deliverable?

This deliverable (D2.)1 provides a shared vision of where partners and CoP members want to get for multimodal traffic management for 2 different times (2030 and 2050). Those two horizons match with the Green Deal horizons. It serves as a guide for the project.

It develops the ORCHESTRA target vision for European polycentric integrated multimodal traffic management, both for passengers and freight transport.

It describes the design and the implementation of the two workshops.

It must be considered as a basis for deliverable D2.2 (environment analysis), and D2.3 and D2.4 (scenarios). In addition, it is an input for work package 3 (WP3) (polycentric traffic management design), WP4 (Enabling toolkit, organisation and business model), WP5 (living labs, trials and simulations) and WP6 (evaluation and lessons learned). The objective of D2.2 is to identify the variables that need to be considered to achieve the target vision. While D2.3 and D2.4 aims at defining the scenarios, taking into account the elements identified in D2.2.

1.2 Intended readership/users

This Deliverable is of interest for the EC, as well as beneficiaries of other H2020 projects interested in understanding ORCHESTRA's vision of future mobility and traffic management.

1.3 Other project deliverables that may be of interest

In addition to this report, the reader is invited to read the other deliverables dealing with vision and scenarios:

- D2.2: Pre-studies on environment analysis and drivers.
- D2.3: Initial scenarios for multimodal Traffic management
- D2.4: Final scenarios for multimodal traffic management

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2 Introduction

2.1 The main future global challenges

In the next 30 years, Climate Change will directly and indirectly modify the way we think transports. **Climate change will influence the transport demand**. It will affect people settlement through migratory flows and the increase of the density and the sprawl of the urban areas. It will also change the location of the food production and the global exchange routes. Transport will also suffer from more and more frequent extreme weather events. And inversely, we know that **transport sector influences the climate change** because of its GHG emissions that represents 16.2% of global emissions (Ritchie & Riser, 2020)[2]. Transport sector emissions are mainly due to road transport that weights 11.9% of global emissions (Ritchie and Riser 2017). The importance of transport for climate action is further recognised under the UNFCCC[3] : the transport sector will be playing a particularly important role in the achievement of the Paris Agreement.

Despite the contribution of transports in the climate change, **main trends studies forecast a growth in the transport sector.** Thus, the road passenger transport is expected to grow by 16% from 2010 to 2030, and by 30% from 2010 to 2050. The growth is even more significant for freight. Considering that the demand for freight transport will still be primarily driven by economic growth, total freight demand (domestic and international) may triple (in tonne-kilometres) from 2015 to 2050 (OECD, 2017). The global freight transport demand may grow by 3.3% annually prior to 2030, while for the 2015-50 period the average growth rate may be slightly lower (3.1%) affected by lower growth in the underlying economic projections (OECD, 2017). In this perspective, the United Nations Economic Commission for Europe Group of Experts on Climate Change Impacts and Adaptation for Transport Networks and Nodes (2020) alerts on the importance of considering climate change and extreme weather and on strengthening the climate resilience of inland transport assets, networks and nodes. And the European Green Deal calls for a 90% reduction in greenhouse gas emissions from transport, in order for the EU to become a climate-neutral economy by 2050.

In this context, the advent of **sustainable transport** is expected by most of countries all over the world. According to United Nations, sustainable transport is a transport system that reaches the objectives of universal access, enhanced safety, reduced environmental and climate impact, improved resilience, and greater efficiency. In its 2030 Agenda for Sustainable Development, UN introduces sustainable transport as mainstreamed across several of the 17 Sustainable Development Goals and targets, especially those related to food security, health, energy, economic growth, infrastructure, and cities and human settlements. **Strengthening the links between all modes of transport** is one of the Resolution adopted by the UN to achieve the Sustainable Development Goals (UN, 2017).

2 From data of Climate Watch : https://www.climatewatchdata.org/

3 UNFCCC: United Nations for climate change Convention. https://unfccc.int/

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2.2 Multimodal Traffic Management (MTM): a key issue to reach a sustainable transport system

Connectivity inside a transport mode network and through different transport networks is one of the next decades challenge Europe intend to cope with. “The preservation of supply chains and a coordinated European approach to connectivity and transport activity are essential to overcome any crisis and strengthen the EU’s strategic autonomy and resilience” (EC, 2020-b).

Even if EC acknowledges that “investment in transport infrastructure across the EU is key to ensuring connectivity, the sustainable functioning of the economy and cohesion among Member States” (EC, 2020-b), **more sustainable forms of connectivity have to be promoted**. Ports and airports are one of the major applications of this policy: “Ports and airports are key for our international connectivity, for the European economy, and for their regions. […] Ports and airports should become multimodal mobility and transport hubs, linking all the relevant modes” (EC, 2020-b).

Nevertheless, **coordination and synchronisation across modes is still not effective**: traffic management remains implemented in silos. Therefore, the transport system encounters a limited optimisation (DoA):

- Transport services are sub-optimal because they are adapted to the needs of one or a few stakeholders (e.g. fleet operator).
- Integration across modes is poor (just a few of multimodal standards)
- There is a lack of traffic management support for multimodal services.

In this context, MTM appears as a key issue to reach a sustainable transport system. MTM relies on a core system of data exchange that ORCHESTRA project intends to design: the main aim is to provide technical and organisational solutions to enhance collaboration and synchronizing of operations within and across transport modes, enabling new processes for more efficient traffic management.

2.3 The implementation of MTM needs a favorable environment

The MTM implementation needs a favorable environment, which is an **ecosystem** 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. In other words, the **Multimodal Traffic Management Ecosystem (MTME)** shall support (DoA):

- 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.

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3 Preliminary input for a definition of MTME

According to the ORCHESTRA consortium agreement, traffic management currently operates in silos: flows and problems are examined mode by mode, or sometimes network by network, and there are few examples of multimodal traffic management, which is detrimental to transport resilience. In this context, the implementation of multi-modal traffic management raises many technical, security, economic issues. Four major challenges of multimodal traffic management may be identified. They deal with:

- ✓ The choice of the ultimate objective: several competing objectives, from different actors, inevitably confront each other in a multimodal transport system. For instance, Topp (1995) notes that the (management) system cannot select traffic according to how essential it is for the city's functions (e.g. service, delivery and business traffic). The challenge is here that the more data is shared on the transport operations, the more informed decisions will be made.
- ✓ The acceptability of the objectives and of the operational management tools implemented by the stakeholders;
- ✓ The infrastructure, vehicles, data exchange systems choices, that will ease or not the data collection and exchanges.
- ✓ The regulation choices (managerial and political governance), which are all the more crucial the higher the spatial level concerned: the wider the spatial is, the higher is the number of stakeholders that have to coordinate their action.

3.1 About multimodality in transport: the issue of the spatial scale

There is a persistent misunderstanding of what multimodal traffic management is or can be. Freight specialists and passenger specialists do not have the same understanding/use of the term "transport mode". Indeed, apart from those who are interested in urban logistics, freight specialists immediately think of an inter-urban, national, or international level. For them, the infrastructure used or the space used defines the mode of transport: road, rail, waterway, sea or air. Many specialists in passenger mobility focus on the level of urbanised areas; for them, the "mode of transport" refers to the land transport vehicle that can be used: the car, the bicycle or public transport such as buses, trams or regional trains.

The spatial, technical, and operational implications of this divergence are fundamental. In the passenger context, the analysis of multimodal passenger traffic management issues, at least at the level of certain densely populated areas, seems to be sufficiently advanced to lead to the implementation of already effective technical tools, with pragmatic governance that is still being sought (Mulley and Yen, 2020; Shibayama, 2020). In the context of freight, the analysis of multimodal management issues is still in its infancy, even if models have been developed, particularly to optimise intermodal flows passing through network nodes (ports, etc.).

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3.2 MTM as a resource management

Whatever the level of analysis to be taken into account (inter-urban, local, national, international, etc.), what should be taken into account in multimodal traffic management? In their review, SteadieSeifi et al (2014) categorise the literature on operational planning problems into two: resource management and route re-planning (but in essence, it comes down to the same thing, since an available route can be considered a resource). For these issues, there is no doubt that Intelligent Transport Systems are useful. Traffic management is not limited to linear infrastructures (roads, railways, waterways) but also includes their nodes or hubs (Ports, Airports). Topp (1995) introduces as well the management of parking spaces, the location of which, and generated flows, etc., that can lead to urban congestion.

The capacity of network nodes is an important consideration in resource management. Fialkin et al (2017) point out that the functioning of a multimodal hub requires good management of internal and external flows. Their analysis considers the impact of flow management on traffic in the streets adjacent to a hub, to improve safety near large complexes such as seaports. In a similar vein, Hosseini and Al Khaled (2021) model to identify the points of the networks that need to be strengthened (segments and/or nodes) to cope with traffic problems; their study case is extremely large, as it is the Mississippi River basin.

3.3 Decision horizons of MTM

Multimodal transport planning models can be classified into *strategic, tactical and operational* models, depending on the decision horizon involved. Any operational multimodality needs strategical and tactical frameworks. Typically, modal shift needs to be prepared. It cannot run in an operational way without anticipation. For instance, changing a failing sea transport solution into a railway solution must be studied before its implementation.

The link between multimodal transport and MTM has not been deeply studied yet. The academic literature about MTM is very scarce. Elbert et al (2020) note only four academic references on the subject of network flow planning since 2008. In the perspective that the MTM should enhance multimodality, the analysis of Elbert et al (2020) suggests that the ORCHESTRA project should fall into the three-decision horizons: strategical, tactical and operational MTM planning.

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4 Method to describe a MTME target vision

4.1 The overall approach

The method used to establish the MTME target vision and its elements is based on subjective and normative assessment. It gathers data from different sources:

- A literature review of different documents, particularly policy reports.
- The expertise of the project participants.
- Preliminary interviews with selected stakeholders.
- The two Workshops outcomes.

Illustration 1 gives an overall sight of the MTME design and Table 3 details how the different sources of data feed the target vision through its four elements according to Godet (2007) as described in section 2.4.

Illustration 1: General overview of the MTME target vision design (Source: Authors)

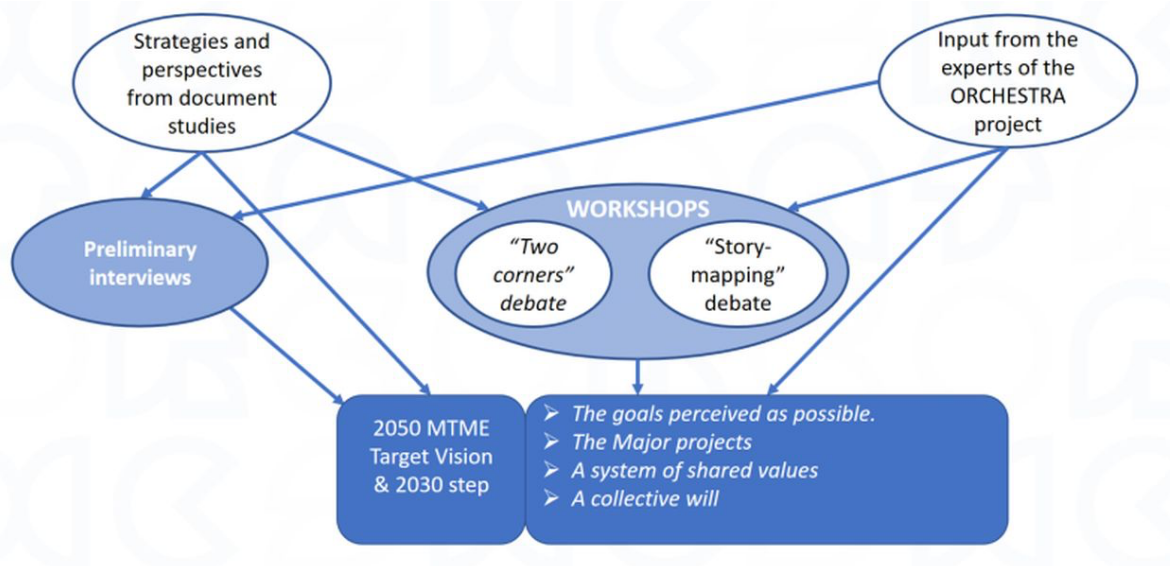

Table 3: Sources of Data that feed the four components of the MTME target vision according to Godet (2007)

Elements of the **target vision** / *Data origin*	Literature review	Experts form ORCHESTRA	Preliminary interviews	Workshops
The general goals, i.e. general goals perceived as possible	X	X	X	X
Major projects that shape the future	X	X	X	X
A system of shared values			X	X

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A collective will to achieve objectives			X	X

4.2 Document studies

The review of the literature mainly aims to point out the general goals of and the goals perceived as possible by different stakeholders and the major projects they intend to carry out that could influence the MTME. The selected documents are these produced by:

- The authorities in charge of the regulation of the mobility and transport sector: European Commission and United Nations. Typically, they provide foresight studies that feed the goals to achieve regard to the development of freight and person transport, and the normative actions (policy documents, infrastructure investments) that will support the trajectory to reach these goals.
- EU technological platforms that provide expert studies related to a particular topic (such as digitalisation of data, automation, Physical Internet).
- The DoA of the ORCHESTRA project which details the results it intends to provide within MTM and MTME.
- Some previous European projects results were also highlighted, such as the Mobility 4 EU report («Action Plan for the Future Mobility in Europe»).

The review of the literature also paid attention to some academic papers pointing out relevant aspects of the MTME.

4.3 Expertise from the partners of the project

The expertise from the partners of ORCHESTRA project is also a major input for concerns and for practitioners' issues (such as ITS Norway, NPRA, FSTechnology, or IOTA). The ORCHESTRA partners could give their point of view during the workshops.

4.4 Interviews

4.4.1 Interview objective

Preliminary interviews aimed to give a first insight of MTME throughout specific use cases of coordination between some traffic and infrastructure managers. These face-to-face interviews were carried out as preliminary data collection before the two initial workshops.

They were expected to provide a first input from partners/CoP members concerning the target vision as a basis for D2.2 (environment analysis to identify the variables that need to be considered to achieve the target vision) and D2.3 and D 2.4. (that aims at defining the scenarios) and D6.1. (evaluation).

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4.4.2 Plan for interview

The preliminary interviews are bounded to the expression of the vision of the MTME from some practitioners' point of view. They do not cover the scenarios construction neither their implementation. So, the information sought by these interviews is bounded to the following:

- Data about present situation in traffic management from a mono-modal point of view and from a multi-modal point of view. This for different infrastructure managers in different countries, regions, eras (rural, urban).
- Data about the outcomes, the benefits, the practitioners could expect from MTM, during nominal traffic management situations, and disruptive situations.
- The feedback from practitioners regarding to the vision of MTM described in European commission documents.
- If possible, data from a practitioner, about his/her realistic vision of MTME by the different horizons (mainly 2030 and 2050), the expected effects (short term) and outcome (long term) on traffic management, first without autonomous vehicle –AV- (H2030) and second with AV (H2050).

4.4.3 Selection of respondents

Seven interviews have been carried out in France (6) and Italy (1) in September and October 2021. The stakeholders participated in the interviews are described in Table 4. In France, local stakeholders were selected because of their implication in the Brexit implementation, as infrastructure managers or authorities: highways, ports. The Brexit context gave indeed a relevant use case of coordination through the infrastructure stakeholders involved in a multimodal freight transportation chain with an increasing need of on-time data exchange. The different infrastructure managers had to prepare the Brexit implementation and coordinate the ones with the others to mitigate the possible consequences of the Brexit upon the traffic regulation. The French Ministry in charge of transportation was sought to provide a national point of view on intermodal passenger and freight traffic management and the inclusion of ITC. The European Passengers Federation was selected to give the passengers (users) point of view.

Table 4: Seven interviews carried out with different stakeholders

Type of Stakeholder	**Affiliation**	**Function of the respondent**	**Passenger/ Freight purpose**
Road infrastructure manager	Public highways manager in the North of France (DIR-Nord)	Manager in Intelligent Mobility Unit	Passenger/ Freight
	Private highways manager in the North of France (SANEF)	Operation manager	Passenger/ Freight
National authority	French Ministry in charge of transportation (DGITM)	Innovation mission	Passenger/ Freight

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Regional ports regulator	Regional Council of Hauts-de-France (Calais & Boulogne-sur-Mer Ports)	Manager of Ports, Sea and Coastal Affairs	Freight
		Manager in operation and maintenance department + Manager in the user interface and port coordination department	Freight
Port authority	The port of Dunkerque	Manager in the GPMD's IT and Networks Department	Freight
Users' lobby	European Passengers Federation	Senior Researcher	Passenger

4.4.4 The questions asked to the respondents

The interviewers had an interview guide to follow composed of general and specific questions detailed bellow.

Questions asked to the Brexit stakeholders:

1- When I say "multimodal traffic management" what does that make you think of?
2- In the context of the consequences of Brexit on the management of cross-Channel traffic:
   - What difficulties have you faced in managing traffic on your infrastructure?
   - Who do you deal with for traffic management? And for what purpose? …
3- Do you have any MTM project?
4- Do you think a MTME should help to cope with this disruptive situation (For instance: a storm that interrupts the traffic on the sea or traffic event on the highway leading to the port)?
5- When I say "Connected / autonomous vehicles (CAV)" what does that make you think of?
6- We are going to give you statements about the future multimodal traffic management in Europe. Tell us if you: Totally agree / Agree / Disagree / Totally disagree ? And for what reasons?

Description of the vision for MTM in Freight transportation in Europe:

- In 2030, freight transport, whatever the mode of transport, will take place in a paperless environment.
- In 2050, all means of freight transport will be brought together through multimodal terminals and an intelligent traffic management system for all means of transport.

Questions asked to the other stakeholders:

1- When I say "multimodal traffic management" what does that make you think of?
   - Effects and outcomes expected in the short term (2030) and long term (2050)?
   - Which difficulties and barriers you foresee for MTM?

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  - Which benefit could you expect from MTM?
2- Do you think a MTME would help to cope with this disruptive of situation?
3- When I say “connected / autonomous vehicles” what does that make you think of?
  - Effects expected in the short term (2030) and long term (2050)?
  - Which difficulties and barriers you foresee for MTM?

4.5 Workshops based on the use of innovation games

In order to build the shared target vision for the future of MTME, two initial workshops were organised in October 2021. They gathered project members, practitioners from the ORCHESTRA Community of Practice, and other transport stakeholders. They were arranged, one at each of the project's Living Labs: Herøya (Norway) and Milan (Italy). The workshops addressed resilient and holistic traffic management and how such traffic management can support future passenger and freight transport across all transport modes, in particular:

- Situations where resilient traffic management may contribute to improve the different modes balance and make each transport more efficient, sustainable and reliable.
- The adaption of resilient traffic management to the needs of transport service providers and end-users.

4.5.1 Workshop objectives

The objectives of the workshops were to get input on:

1) Relevance of MTM for multimodal transport.
2) Stakeholders’ opinion on MTME: enablers, difficulties.
3) Use cases for the different transport stakeholders.

The workshops were based on the use of innovation games, which were considered as the best way to engage the participants to give relevant input to design a target vision. They were supported by two different sessions, explained in the following subsections:

- First, a "Two Corners Debate";
- Then, a "Story Mapping Debate".

Thanks to the audio registration of the debates during the two sessions, and the post-it stuck on the map, facilitators were able to transcript the ideas exchanges. Considering all these ideas as pieces of a puzzle, they provided input to a common vision of the future MTM.

4.5.2 The two corners debate method

In the first session, participants took part in the “Two Corners Debate” that lasted about 30 minutes. In the “Two Corners Debate”, two provocative sentences, related to the future vision for MTME, were presented to participants who had to decide in a short time if they mostly agree or mostly disagree.

Then, they spontaneously split up into two different groups, depending on the answer. Mostly agreed chose one table, mostly disagree chose the remaining one. The tables were at the two

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opposite corners of the room and a sign indicated which table would be for the participants that mostly agreed or mostly disagreed.

The physical division of the two groups helps creating situational "teams" that discuss their thesis, finding common motivations for their agreement or disagreement and summarising them in order to be presented to the other group. The main goal of this step is about encouraging participants to discuss different thesis, bringing out contents, characteristics, and details about their opinions about mobility in 2030 and 2050 in order to agree on a common point of view.

After this convergence phase, a representative of each group presented the agreed and summarised point of view to the other group, in order to convince members of the other group to change their mind and join the 'opponent' group.

This way, participants had the opportunity to grow their opinions, thanks to the debate, and to exchange information, and they could also change their minds or try to change other participants' mind.

The two statements claimed for the freight workshop dispute were:

- "In 2030, the transport service providers (e.g. logisticians) and fleet operators will share data on their transport operations with traffic orchestrators of the relevant networks both before the start of the operations and in real-time during the operations".

- "In 2050, the multimodal traffic orchestration will help to manage disrupted situations when they occur and to anticipate them. The daily incidents as well as foreseen and unforeseen situation will be mitigated and handled".

The two statements claimed for the passenger workshop dispute were:

- "In 2030, all actors involved in passengers' traffic management across all modes of transport (e.g. transport service providers, infrastructure management companies, air traffic management authorities...) will share data on their transport operations with Multimodal Traffic Orchestrator Tool both during the traffic planning phase and in real-time to optimise their operations and services".

- "In 2050, the Multimodal Traffic Orchestration Artificial Intelligence will help to manage disrupted situations when they occur and to anticipate them. Delays, problems as well as foreseen and unforeseen situation will be mitigated and handled".

4.5.3 The Story-mapping method

The second session of the workshop involves the Story-Mapping method. The workshop participants have to give their own opinions about two pre-designed MTM scenarios within 2030 and 2050 for each workshop (see Annex A). Those scenarios are graphically represented through a story-map made up of different user stories.

Story-mapping allows the representations of different sequential scenes on a timeline and could also support the representation of multiple actors' points of views and relations. All the participants are split up in small groups formed by 4/5 people in order to allow more in-depth discussions and

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exchange of ideas. The groups are made up of participants from different transport modes and/or with different roles and expertise to provide complementary inputs and point of views.

All participants have to summarise their contributions in a short sentence. These contents, written on different post-its (green coloured for positive statements, red coloured for negative ones and yellow coloured for neutrals), are stuck on the story-map board.

Then, the whole group go through all the attached post-it and participants will be allowed to comment what they wrote, sharing their thoughts, opinions and statements along the stories, identifying enablers, barriers and possible solutions for the different issues arisen. This allows us to implement elements and visions to ORCHESTRA's one.

In this second step, we expect small groups to interact with each other, discussing the 2030 and 2050 scenario from their point of view. This step helps us implementing elements from different stakeholders, identifying needs and problematics related to MTME visions in 2030 and 2050 and thus refine ORCHESTA scenarios and use case in Living Labs. The whole Story-Mapping activity lasts around 90 minutes (45 for each scenario).

Illustration 2: Picture of 2050 passenger vision poster with the post-its (Milano Workshop)

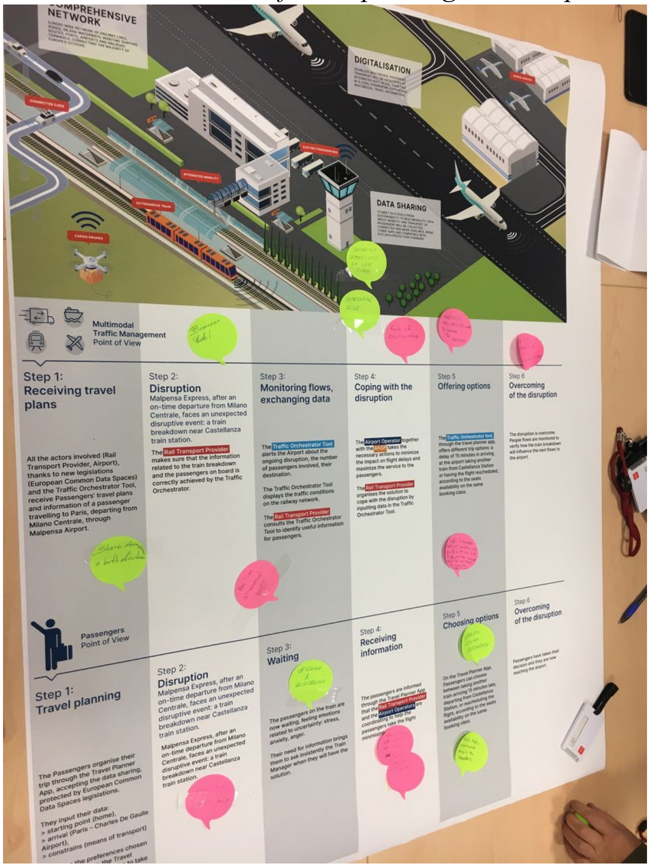

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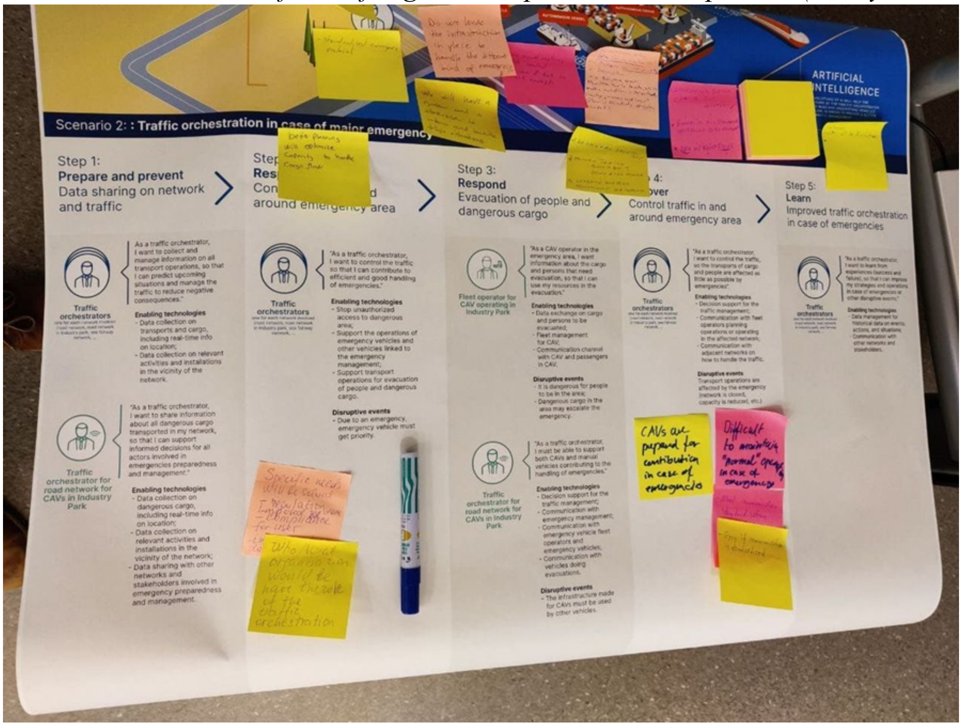
Illustration 3: Picture of 2050 freight vision poster with the post-its (Herøya Workshop)



4.5.4 Workshops participants

The Herøya Industry Park hosted the first workshop dealing with freight MTME, on the 7th of October 2021. This Workshop gathered 20 attendees:

- Partners of the project: Applied Autonomy, Cerema, Deep Blue, Herøya Industry Park, IKEM, ITS Norway, NPRA, SINTEF.
- Externals: Kuehne + Nagel AS, Yara International ASA, Porsgrunn municipality, Vestfold and Telemark county council, partner representatives not involved in the project (NPRA, Herøya Industry Park).

Then, Milan Malpensa International Airport hosted the workshop dealing with passenger MTME, on 28th of October 2021. The 29 participants of the Workshop where from:

- Partners of the project: Cerema, DBL, ENAV, FS-Technology, Gruppo ISC, SEA Milano Airport, SINTEF.
- Externals: Air Pullman, Agenzia Mobilità Ambiente Territorio Milano, Azienda Trasporti Milanesi SPA, AW-Drones Project, European Transport and Mobility Forum, Operators Users Committee, Politecnico di Milano, Proactima AS, Trenor.

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5 Input collected

This chapter aims to:

- Provide a synthesis of the foreseen developments based on available documents.
- Identify aspects that future, multimodal and resilient traffic orchestration must address, based on the data collected from the workshops and interviews.

5.1 Input from document studies and experts

With respect to the foresight vision elements defined in section 2.4, the input from the document studies and the expertise in the project contributes to the *general goals* and *major projects elements that shape the future*.

The academic literature mentions issues identical to those concerning the future of freight: the issue of multimodality, for example the multimodality that can be deployed at a local level to serve a metropolis, the issue of synchro-modality, the issue of new means of propulsion such as bio-fuels and electric propulsion in particular (Guzay et al, 2014). Researchers are also interested in the introduction of new vehicles: autonomous vehicles, drones; they are interested in urban air mobility (Rubin et al, 2019; Busyairah, 2019, Tuchen, 2020), and develop the challenges of shared mobility. Many point to the promise of big data (Chen C et al, 2016, Dib et al, 2017). A very small number of researchers dare to claim that reducing transport demand would be one of the solutions to the planet's ecological challenge (Moriarty and Honnery, 2008).

The European Union, in all its publications dealing of passenger mobility, echoes the issues addressed in the academic literature. The contents of some of its publications allow us to project more precisely to the 2030 horizon, and to the 2050 horizon.

5.1.1 Climate change

Climate Change cannot be ignored, so to envision how the mobility will change in the next 30 years we have to consider all the swings the world of transports could face in the future. If Southern Countries will face the problem of desertification, Northern Countries will become warmer, opening new possibilities for tourism and agriculture. These fast changes will open new commercial routes, due to a probable shift of some economic poles. At the same time, migratory flows cannot be ignored: all the environmental problematics related to Global Warming will open new migratory routes due to the acceleration of frequency, duration and intensity of extreme weather and climate events, such as heavy precipitation and droughts, and causing sea level rise, which can lead to population displacement. In addition, Climate Change-related reductions in land productivity, habitability and in food and water security can also interact with demographic, economic and social factors to increase migration events. Finally, increasing extreme events related to Climate Change could possibly affect the supply, transport and distribution chains, that might become more vulnerable to disruptions (Dellink, et al., 2017).

Sea level rises will also probably impact on actual transport hubs, like ports and airports. Different European airports will be at constant flooding risk with an increase of 2°C in 2100: Pisa Intl. and Venice Marco Polo in Italy, Rotterdam, The Hague and Amsterdam Schiphol in Netherlands, Corvo in Portugal, Bremen in Germany and Ioannis Kapodistrias Intl. in Greece (Yesudian & Dawson,

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2021). All these Climate-Change-related events, together with the possible depletion of the fossil fuels within 2060, will probably force EU to adapt the transport system to the upcoming changes.

5.1.2 Greener mobility

The transport sector is one of the main sources of GHG emissions in the economy, so it will play a key role in the transition to a climate-neutral economy in 2050. Transport sector GHG emissions represents 16.2% of global emissions (Ritchie & Riser, 2020)[4]. Transport sector emissions are mainly due to road transport that weights 11.9% of global emissions (Ritchie and Riser 2017).

To face the problematics related to pollution and Climate Change in the transport sector, the European Commission (2018) launched "Europe on the Move". This is an agenda for a socially fair transition towards clean, competitive and connected mobility with a wide-range set of initiatives that will make traffic safer, encourage smart road charging, reduce CO2 emissions, air pollution and congestion, cut red-tape for businesses, fight illicit employment and ensure proper conditions and rest times for workers. The long-term benefits of these measures will extend far beyond the transport sector by promoting growth and job creation, strengthening social fairness, widening consumers' choices and firmly putting Europe on the path towards zero emissions. The European Commission highlighted how the initiatives focus on digital mobility solutions, fair and efficient pricing in transport, promotion of multimodality, frameworks for alternative energy, roll-out of infrastructure for alternative fuels, improvement in vehicle testing and post-2020 research and investment strategy for all means of road transport.

The main challenges for the transport sector in the EU include creating a well-functioning Single European Transport Area, connecting Europe with modern, multi-modal and safe transport infrastructure networks, and shifting towards low-emission mobility, which also involves reducing other negative externalities of transport. From a social perspective, affordability, reliability and accessibility of transport are key. Addressing these challenges will help pursue sustainable growth in the EU.

Greening the mobility must be the new license for the transport sector to grow. Mobility in Europe should be based on an efficient and interconnected multimodal transport system, enhanced by an affordable high-speed rail network, by abundant recharging and refuelling infrastructure for zero-emission vehicles and supply of renewable and low carbon fuels, by cleaner and more active mobility in greener cities that contribute to the good health and wellbeing of their citizens. Public and private investment in local renewable energy production, in more sustainable multimodal access and in fleet renewals in aviation and waterborne transport must increase. Some of these investments would benefit from the establishment of relevant sustainable taxonomy criteria that cover the specificities of each mode, including during transition to zero emissions. The revised lending policy to be decided by the European Investment Bank (EIB) can equally be expected to be helpful. In EU's vision for the future, sustainable alternatives must be made widely available now in a fully integrated and seamless multimodal mobility system (European Commission 2017).

[4] From data of Climate Watch: https://www.climatewatchdata.org/

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The realisation of Europe on the Move agenda involves changes in European's policies. Lack of a predictable long-term framework by policymakers may lead to investment decisions based on the fear of missing out on the next innovative idea or the whims of the market, creating a glut of options in one place and a lack of them in others. Therefore, policymakers must improve governance systems and involve citizens in the rollout of innovative mobility solutions: they should establish efficient and equitable governance for complex and multimodal transport systems.

5.2 Input from workshops and interviews

Increased connectivity between different means of transport allows an easier multimodal experience for freight forwarders and shippers: technology's innovations like full automated CAVs, together with great improvements of infrastructures equipment at a European level, like the TEN-T, and locally in cities, has helped reducing pollution and GHG emissions while improving infrastructure users' experience of travel.

Many aspects must contribute to the expected results within connectivity. The results from the two workshops and the interviews are merged as they partly overlap. However, if the results in particular are related to person or freight transport, this is commented.

5.2.1 Traffic orchestration

The two workshops discussed the main objectives targeted by the "traffic orchestration" concept. Those shared objectives can be exposed from the workshop participants point view:

- **From the traffic managers' and fleet managers' point of views:** the aim is to facilitate traffic flows and transhipments with a better daily traffic management on each infrastructure, and through networks interconnections. Identified sub-objectives are:
  - To avoid traffic and bottlenecks, for instance, to avoid that too many vessels/trucks arrive at the same time.
  - To optimise the capacity in the whole transport network. A better planning can help to optimise capacity to handle cargo flows. To avoid congestion around terminals/ports due to waiting vehicles/vessels, "just in time" arrivals is eased by MTM. E.g. related to public transport: transfer capacity from road to train, etc.
  - To overcome delays/disruptions.
  - To facilitate good communication between infrastructure managers and users. This could lead to actions in favor of traffic fluidity and safety. For instance, a highway manager will be able to communicate more easily and more quickly to users about the fact that workmen are on an emergency lane on the roadside.

- From the cargo owners' point of view the aims are:
  - To get more predictable deliveries. Thanks to the use of CAVs, which has diminished risks in the supply chain.
  - To be more flexible, in case of a disruption in one place. As a shipper, who aimed at a value chain optimisation, can now easily fulfil his order on time by changing the supply chain, accordingly.

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- **From the forwarders' point of view**: New attractive services can be offered to shippers. The following aspects were addressed:
  - With better traffic orchestration, the deliveries can be operated more according to plan.
  - Optimisation of volume / CAVs: Data on the cargo can be shared to facilitate optimal consolidations and transports.
  - Forwarding services based on new technologies have become a niche market which forwarders can now rely on to offer new services and implement a differentiation strategy in a highly competitive environment. Relevant logistics data will be shared as technology gets more common – customers will demand it as a competitive market builds around this kind of information.
  - The cargo owners will choose the freight forwarders that can offer new services for better multimodal transport.
- From the authorities' point of view: The following was addressed:
  - Through an integrated and multimodal data system, it became possible to change means of transport to achieve environmental benefits.
- **From the traffic control centre's point of view:** The Traffic Operator in the traffic control centre can take more informed decision and actions. Some examples of the input received are provided in the following:
  - **Avoid incidents and accidents:** Traffic or vessels/vehicles may for example be stopped in time in case of extreme climatic events.
  - **Prioritise**: Is a flight so important that it should be allowed to block other air traffic? This question has to be asked even before the fly taxi is proposed. It could be only for emergencies: "I have to make surgeries, someone is dying", "I have to bring something very important" … In such cases, it must be confirmed that the flight is important to the society? **Just in time arrivals**: Just-in-time arrivals are not consistent with efficient roads traffic flows: Just in time arrival may mean that you "store things on the road" – the trucks may slow down to arrive just in time and decrease the efficiency and reduce the capacity. Just in time may however be implemented in a smarter way. The vessels/vehicles may be directed to wait in a holding area before they start on the last mile(s). This may however conflict with the resting time rules. Just-in-time arrivals may enhance the problems in case of disruptions – the problems may be more difficult to deal with. At sea, a reduction of the speed is not a problem, because the ship-owner can save a lot of fuel.

5.2.2 Data sharing

Data sharing is a challenge. It is not sufficient to make the data open. The data sharing has to be standardised. Standardisation must address different items: data content, data format, data collection, data exchange protocols, emergency protocols. Some precisions was brought during the workshop:

- Data collection:
  - There are connection challenges between vehicles, as well as between infrastructure and vehicles. In this context, traffic data collection is supported by distributed and fixed sensors. Sensors can not only report on road and infrastructure condition but

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also record fine grain information on utilisation and congestion which might help to manage the existing system more efficiently and to decide, with better information, when and how to expand capacity to handle congestion and delay.
  - With sensors in all vehicles, much data can be collected, and the data can be used to predict and discover incidents and accidents.
  - Big Data with data analysis and Artificial Intelligence will facilitate smart handling.
  - For a long time, data for cargo and transport were divided. However, in 2050 they no longer are. Fleet management generally focuses on the vehicles. But, traffic orchestrators will also pay attention to flows which focuses on the supply chain process. As we remind the Beirut (Lebanon) port accident on the fourth august 2020, the disaster prevention must take into account the nature of transported goods, particularly dangerous cargo. Evacuation of people and goods is orchestrated with the help of a dynamic and real time evacuation system.
  - All the documents will be digitalised, and this will help data sharing

- Communication and data exchanges standardisation:
  - Data is shared in real-time.
  - Interoperability is a main success criteria enabled by the data exchange system implementation. For instance, CAV operation requires Fleet Management Systems (FMS) that talk to other FMS: Standardisation is needed.
  - Communication protocols/standards for communication disruptions are available in 2050.
  - Automated data sharing is needed and a federated system at a lower level must be implemented.
  - A lot of data must be encoded, and it might be a challenge to encode all the different choices people may wish. All the options will depend on the impact of all the solution in the system.

5.2.3 New transport services and means

All transport modes need to be represented and that include new transport services and means:

- **Bike or scooter:** In a case of disruptions, a scooter or a bike may help a passenger to bypass a traffic jam. He/she could have access to a bike sharing service. It depends on the distance to cover and the type of road (highways may for instance not be open to bikes or scooters). Alternative roads should be used to reach a multimodal hub (such as an airport) with bikes or scooters.
- **Last mile solution:** There will be a better integration between logistics and movement of passengers. Currently (2021) they are functioning in two different ways but in the future, there will be connection. One could say: “I would like to take the bike but I have my luggage, so my only option is to take the car or a drone”.
- New technology in vehicles and vessels will as time goes ensure zero emissions from the operation of the vehicles, but this will however require investments.

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5.2.4 Connected and Automated Vehicles

Increased connectivity between different means of transport will allow an easier multimodal experience for freight forwarders, shippers, and passengers. Technology's innovations like fully automated CAVs, together with great improvements of infrastructures equipment at a European level, like the TEN-T, and locally in cities, will help reducing pollution and GHG emissions while improving infrastructure users' experience of travel:

- **Comfort, and timesaving benefits:** Fleet managers see comfort, and timesaving benefits for the passengers of the vehicles.
- **Improved safety for road users:** The deployment of the CAVs technology will also improve the safety of road users. For example, if a vehicle brakes suddenly, the vehicles following it will receive an alert almost instantaneously. As 100% of capacity can be used through automation, businesses will want to use this technology, as they can save money through this.
- Infrastructure developments

The transport infrastructures will evolve:

- **Airport**: it will not be the only option to fly with planes. There will be places nearer the cities where we can share smaller planes. Drones can land and take off from roofs.
- **Multimodal terminals:** the evolution of infrastructure and the building of new ones has encouraged and enhanced multimodal mobility across Europe. Nodes, such as ports, airports, and inland multimodal platforms, become fundamental interactions places for traffic management.
- **TEN-T comprehensive network:** Thanks to the TEN-T comprehensive network, Europe has now a high efficiency freight high-speed railway network connecting the most important intersections of European cities and ports.

Important digital infrastructures have to be implemented to reach the expected results.

- **A standardised digital infrastructure deployed across Europe.** A telecom-like infrastructure where you connect technically to the forwarder is needed. If you can connect to an access point you can reach your forwarder and connect with all – as with roaming within telecom. Do we need a central directory? We do not have that for the internet. A sort of "name server" as the Internet is needed.

5.2.5 Efficient disruption management

Different kinds of disruption ought to be taken into account:

- **Disruptions due to climate change:** The climate in Europe has changed. Transport stakeholders must face frequent and intense disruptive situations due to climate disorders that affect global trades. Across Europe, disruptive situations must be registered and analysed. All the consequences on the traffic management must be explored, and public authorities, traffic managers, freight forwarders, passengers have to adapt their ways of operating in order to diminish these consequences.

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- **Other foreseeable disruptive situations:** Multidisciplinary approaches are necessary to identify the maximum of foreseeable disruptive situations. They need to work with different specialists with their different insights.
- **New disruptions:** These may occur due to the implementation of ORCHESTRA MTM Concept.

Disruption management must:

- **Improve traffic orchestration in case of emergencies**: Data collection and data analysis facilitate learning and risk assessment. Thanks to the A.I.: Data collected can be re-used in training scenarios for Human training based.
- **Find and present impact:** We need the data to build a tool able to elaborate in real time all the inputs. With a tool like that we can assess the impact of a disruption on all the system.
- Regulations and standards: These must consider the climate change and how to prevent critical events that could be the main source of disruptions. That implies an improvement in international regulations regarding emission taxes and supporting (nudging) green alternatives.
- **Prevent concentration of people in one place:** It could be a problem in concentrating too many people in one place. If a disruption happens, then all are blocked. A transport orchestrator should split up people flows in different ways to reach a single destination, even if there is one path that is better than all the others
- **Transport orchestrator disruption:** Disruption within the transport orchestration itself has to be considered.
- **Standardised emergency protocols:** Such protocols must provide a framework for how the communication should be implemented in disruptive situations.
- **Move people from an airport to another airport:** In case of major disruption in an airport, it will be possible to use the TEN-T connections in 2030, from an airport to another. For example. Amsterdam to Brussels is about one hour by train. Connecting different airport by high-speed railway could be a solution. Also, you could present different options to the user so he/she could choose the preferred solution.
- **Connected and Automated Vehicles (CAVs):** CAVs might be a resource in rescue operations. The rescue functionality must be standardised and included as a part of the CAV solution. Quality of algorithms for CAVs must be very high in order to avoid accidents, etc. Nevertheless, some manual routines are still needed. Everything cannot be automated. The traffic orchestrator must handle some situations.
- **Save time: carry out certain formalities during the disruptive situation:** For instance, to make the check to the access of the flight during the delay of the train. The information has to be shared with the flight provider.
- **Communication to inform other service providers and the passengers:** when there is a disruption you can inform as soon as possible the passengers (e.g. there is a strike next Friday) to let them better organise the other service providers that could be impacted by the disruption.

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6 2030 and 2050 Target Visions

6.1 Target vision elements for 2030 horizon

The 2030 vision of MTM is presented according to Godet's (2007) vision elements, as described in section 2.4 and depicted in Illustration 1 in section 4.1. The vision elements are: the general goals, the major projects that shape the future, the system of shared values, and the collective will to achieve objectives.

The 2030 vision is more the description of an on-progress process than a well-bounded milestone picture of MTME. For instance, any standardisation process is long and complex.

6.1.1 Goals and major projects

6.1.1.1 Green transition

The European commission's main goal is the cut of the 55% of GHG emissions by 2030. At least 30 million zero-emission vehicles will be in operation on European roads and 100 European cities should be climate neutral. The high-speed rail traffic will double, and the passengers should be given the opportunity to schedule collective travels under 500km with climate-neutral choices within the EU (European Commission 2020). Related to the green transition:

- KPI support transparency, for instance, the transparency on GHG emissions. The KPIs supports that transport users pay the full price of their footprint.
- Transport operators report environmental target and pay penalties if they do not meet the emission requirements.
- Automated mobility

Automated mobility and multimodality will be partially deployed, thanks to two linked innovations:

- the large-scale deployment of automated mobility;
- the Core Network of the TEN-T (European Commission 2020).

The backbone of the Core Network (Illustration 4) is represented by ten Core Network Corridors, where were identified to streamline and facilitate the coordinated development of the Core Network, with two horizontal priorities: the European Rail Traffic Management System (ERTMS) and Motorways of the Sea complement these.

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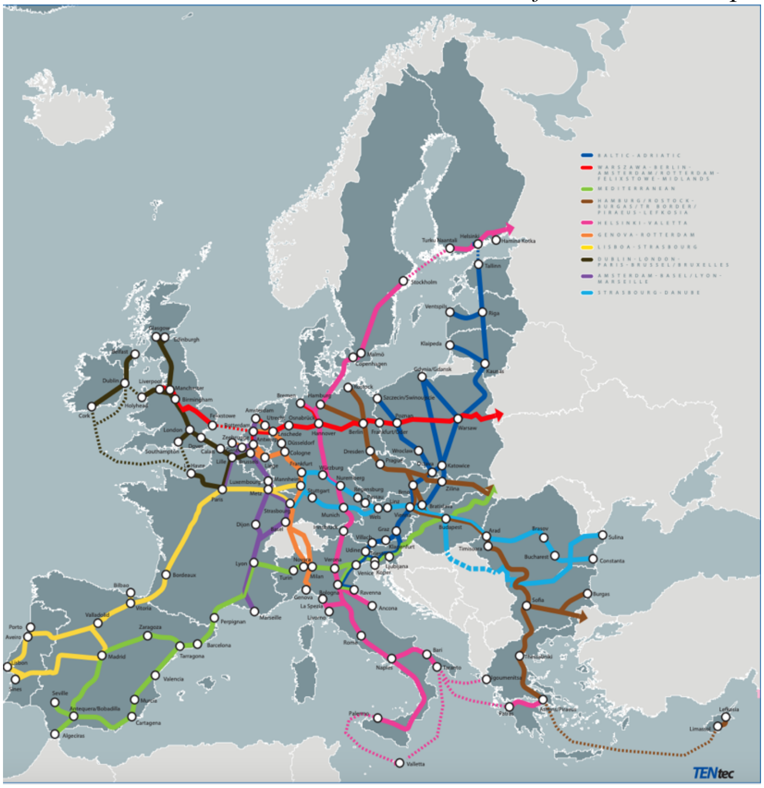
Illustration 4: The Core Network Corridors of the Trans-European Transport Network (TEN-T)



Thanks to **large-scale deployment of automated mobility,** it will be easier to integrate different modes of transport. A core multimodal seamless experience is possible with upgraded infrastructures, upgraded connections between different modes of transport and with Open Data strategies and crowd searching for transports.

There will be in fact **a European Common Mobility Data Space** collecting, connecting and making data available to meet EU objectives from sustainability to multimodality. Data about mobility and transports of passengers will be collected, connected and made available, functioning in synergy with other key systems like energy, satellite navigation and telecommunications, being cyber-safe and compatible with EU's data protection standard.

Mobility will have changed also because of the introduction of **new technologies** to transport people. Public transport operated by autonomous vehicles will be able to cope with a limited number of driving situations at low speed: these will most likely require human supervision or operate on a very short range, but the number of situations that these vehicles will be able to handle will increase with time. Many private vehicles are already connected with cellular technologies and all new cars from 2022 will be connected to the internet: this kind of connectivity enables access to information on traffic conditions ahead (i.e. accidents, roadworks, environmental conditions), but will also allow large scale fleet data to be gathered within privacy policies to know even real-time traffic conditions, allowing vehicles to coordinate their manoeuvres in complex traffic situation. The now emerging 5G technology will be considerably consolidated, providing more complex and improved services, allowing to coordinate automated vehicles with other means of transport (i.e.

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high-speed trains, airplanes…), improving multimodality and MaaS. New technologies regarding Urban Air Mobility (UAM) will be introduced. In urban areas, electrical vertical take-off and landing vehicles (eVTOLs) will provide short journeys for up to ten people. Electric (or hydrogen, or hybrid) aircraft will provide short-medium range hops between fixed locations for 10+ people. These new classes of air vehicles will reduce ground congestion using airspace resources, improving connectivity in rural areas, increasing consumer's choice, and integrating different parts of a seamless journey (UK Research and Innovation 2021).

6.1.1.2 Multimodal services

Mobility-as-a-Service (MaaS) will be widespread. Thanks to the increasing multimodal travel offers, integrating various forms of transport services into a single mobility service accessible on demand will be easier. Passengers will be considered as users for a transport service that will offer added value by using a single application to provide access to mobility with a single payment channel instead of multiple ticketing and payment operations. MaaS will help users in disruptive situations, solving the inconvenient parts of individual journeys and the entire system of mobility services (European Commission, 2020)

The legal framework within the EU will support the access to **multimodal travel information**, booking and ticketing services, while at the same time looking at the rights and obligations of online intermediaries and multimodal digital service providers selling ticketing and/or mobility services: seamless multimodal passenger transport will be facilitated by integrated electronic ticketing.

6.1.1.3 Digitalisation

The EU sees **digitalisation** (of tools and practices) as the universal panacea for optimizing multimodal traffic management. It argues that by 2030, the movement of goods by any mode of transport will take place in a paperless environment; automated mobility will be deployed on a large scale; a trans-European multimodal transport network, equipped for sustainable and intelligent transport with high-speed connectivity, will be available by 2030 for the core network (TEN-T) and by 2050 for the global network.

A **new data business model** remains a challenge in 2030. Several actors need to be inolved. Discussion and agreement are necessary between partners, to know how to get benefits from the system and to present the best option to the customer. Furthermore, it remains an issue related to the cost of the technology: the technology to have a common data-sharing platform already exists. The problem is that freight transport is too cheap-oriented to implement such platform. The issue regards the investments, not the technology: a common data-sharing platform requires big investments in a cost-saving driven context.

Digital transport documents will be generalised to sea and air transportation, and to other modes of transport such as road, railway. Digital documents will also arrange to access to data.

In 2030, freight transport, regardless of the mode of transport, takes place in a paperless environment. Shippers will be able to transport their goods with multimodal door-to-door waybills. In fact, even if many freight transportation stakeholders –including infrastructure managers- adopted ITS (digital) tools for regular traffic management, the main issue of the 2030 "TO" horizon is still about the human background. **The paradigm shift planned for 2050 has not yet taken**

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place. The transport business model has not changed yet, and the data sharing business model is still looking for itself in 2030. Stakeholders still have to establish a common platform of rules for coordination.

6.1.1.4 Common European Data Spaces

The European strategy for data –adopted in the early 2020's[5]- aimed at creating a single market for data that would ensure Europe's global competitiveness and data sovereignty. In 2030, a trans-European multimodal transport network, equipped for sustainable and intelligent transport with high-speed connectivity, is available by 2030, for the core network (not in the rural areas). But, we need some policies to help the data sharing: it is an issue, but a main issue could be coding the policies that now are quite informal.

Common European data spaces ensure that more data become available for use in the economy and society, while keeping the companies and individuals who generate the data in control. Nevertheless, clouds and API (Application Programming Interface) are still missing. Thus, in 2030, a common data-sharing platform across companies will not be operational yet.

Furthermore, it remains an issue related to the cost of the technology: the technology to have a common data-sharing platform already exists. The problem is that freight transport is too cheap-oriented to implement such platform. The issue regards the investments, not the technology: a common data-sharing platform requires big investments in a cost-saving driven context.

Furthermore, **clouds and API are still missing.** In 2030, a common data-sharing platform across companies will not be operational yet. There are many challenges to cope with. Among them, transport stakeholders still have some concerns about sharing their Data for several reasons.

- First, because stakeholders had 'closed' their respective data collection and processing system in order to secure them. Most public organisations had followed this path since the beginning. In the same way, within a transport highly competitive landscape, companies do not totally rely on the data sharing system that still does not get a trustworthy third party.
- Second, Data owning became a more and more valuable asset, which companies exploit to design new business. A rules framework is still expected to regulate the sharing of the benefits generated from data sharing between stakeholders.

6.1.2 A system of shared values

6.1.2.1 Data sharing

In 2030, data on person transport services, real time data from transport means included, are openly available. Such data are used by traffic control centres to provide better services to such transport operations.

Data sharing on freight transport chains and operations has started but is still limited when it comes to the sharing of capacities and other business sensitive information. The data sharing has to be

5 https://digital-strategy.ec.europa.eu/en/policies/strategy-data

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standardised, and standards are being developed. They address data content, data format, data collection, data exchange protocols, emergency protocols.

The data sharing form transport means, CAVs included, varies between modes. Standards exist or they are emerging. In road transport, the developments are guided by standards within the areas of C-ITS and CAVs.

The development on data sharing from private transport means has started. Compliance with GDPR is emphasised. Work on privacy protection solutions and mechanisms and related work on data collection legislation are still in development.

6.1.2.2 Trust and liability

Trust makes data collection and sharing more acceptable.

- European legislation defines rules and regulations on how data on transport chains, transport operations and vehicle/vessel movements is to be shared, managed, and used.
- The objectivity of the system is documented. The rules for priorities and other advantages are openly shared.
- The stakeholders managing the data collected are certified as trusted parties by the European Commission or national authorities.
- The use of data is transparent – it is easy to see the benefits and (if relevant) the disadvantages the sharing of data may have for individual stakeholders.
- It is easy to see that GDPR is respected and person data as well as business sensitive data is handled and used in an acceptable way.
- Anonymisation mechanisms is used to protect the privacy of persons.
- Fraud that may give unintended privileges to the wrong actors is prevented by information and cyber security mechanisms and by authentication solutions.

Lack of trust in online transactions and consideration for security and liability issues regarding the information to be exchanged can be obstacles to the adoption of Internet-based applications. While people, cargo and vehicle traceability offer a number of potential benefits, this capability forces companies to ensure the protection of personal information so as not to lose their customers' trust and thus further hinder information sharing.

- Objectivity of the system must be provided to avoid mistrust in the system.
- GDPR and privacy concerns in real-time location of vehicles.
- Artificial intelligence (AI) adapted to the needs in traffic orchestration:
  - The evolutions of AI will help the traffic orchestrator to read and understand traffic flows and facilitate better traffic management. The access to relevant data is however crucial.
  - Big Data including data collection and data analysis will facilitate smart handling.
  - Artificial intelligence can be used to make predictions. An AI system can better predict what will happen. It uses patterns for recognition. It raises some ethical aspects of a knowledge-based decision: the rules for prediction should be understandable and possible to be verified. We have to find way to explain the decision. How to share the decision patterns? How to verify a decision taken by the system? For instance: Include/exclude groups.

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- Communication and data exchanges standardisation: Data exchange must not disturb business through competitors. The benefit from sharing data must be higher than the disadvantage. We know that only the data needed can be shared with the traffic orchestrator and confidential data can just be shared between companies.
- Standardised emergency protocols give the framework to how the communication should be implemented in disruptive situations.
- To prevent from the advent of **a private monopoly situation** in data infrastructures and management. Such a scenario could occur because of the economy of scale mechanisms that support the data industry's markets. For instance, automotive players are becoming mobility providers. **The risk is that *« the winner controls the whole value chain ».*** Yet, the participants agree that one should prevent from any external company intrusion in local communities (traffic orchestrators). The power of decision must stay inside a community shaped around a MTM system.
- Anonymisation:
    - You need to have a way to know that the user is executing the trip. You can track position but there will be issues of privacy: anonymisation is fake, because cannot only be the removal of the name.
    - The information for the whole trip should be anonymised for the passenger. It could a number for each passenger that could be used for all the modes of transport. But there is Google, Google know where you are but they can use it by check.

6.1.2.3 Cooperation

A radical paradigm change in the willingness to cooperate has occurred. This is the cornerstone to evolve from a silos traffic management to a multimodal transport-integrated orchestration. The paradigm change is supported by data sharing enabling the traffic control centres to become more predictive and not only real-time action based.

For all that, the main change occurred in the stakeholders' mindset regarding coordination and cooperation:

- Transport service providers and fleet operators see the benefits in collaboration with the MTM. The collaboration and adaption to the traffic management strategies will be beneficial with respect to everything from customer satisfaction to economic results.
- MTM within different modes and network starts to see benefits that can be gained from better coordination and collaborations, in particular in the case of abnormal situations and disruptions.

6.1.2.4 Fairness / Inclusiveness

The fairness of the traffic orchestration is crucial as it arranges for an increased willingness to share data. In 2030, initial versions of rules and regulations for fair traffic orchestrations are defined and regulates:

- The strategies used in algorithms for transport demand managements and capacity balancing (e.g. access control, priorities, economic incentives, etc.).
- The transparency of algorithms.

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- Documentation requirements regarding decisions, e.g., regarding decisions that may have economic effects on specific actors.
- Requirements regarding inclusiveness, e.g., the opportunity to require use of digital tools that may exclude parts of the population.
- Requirements regarding spatial fairness, e.g., the opportunity to differentiate traffic orchestration measures between different areas (urban, rural, rich, poor, etc.).
- **CAVs' management**. Managing traffic where all vehicles are CAVs or managing mixed traffic where some vehicles are manually controlled and some are CAVs are two very different use cases. In 2030, automated freight means are implemented at local scale within exclusive right-of-way transport specific areas: some autonomous cars, trucks, trains, ships runs.

Some use cases in which Fairness / Inclusiveness issues are addressed, were given during the workshops:

- Transport Orchestrator should help **ALL the users in having access to the knowledge** of the whole transport system, not only local ones. Transport Orchestrator should provide a various range of possibilities, particularly green possibilities, also in terms of comfort.
- **How will the Transport Orchestrator be inclusive**? Age is growing, there are countries where the deployment of digital artefacts is underdeveloped. Thus, what would be the social impact of this new kind of transport, will it be social inclusive or only the skilled/rich ones can travel seamless? There are very different levels of service, so it does not seem democratic. Taking an electric vertical take-off and landing (*eVTOL*) aircraft is obviously more expensive than taking the Malpensa Express, so it can create social divide.
- **A fair transition to a data-sharing freight transport system is required.** MTM is founded on data and algorithms that use those data to take or suggest decisions. Therefore, it creates "winners and losers". How is the objectivity of the system ensured? For instance, the Transport Orchestrator has to decide which traffic mode/flow gets priority.
- **Spatial fairness: urban Versus rural / rich versus poor areas**. Because of a high level of investments, MTM systems should be implemented in the main cities, where the generation of benefit concentrates. That why at the beginning, autonomous vehicles were thought to be used in urban areas. Thus, this emphases the gap through rich and poor areas. They might be solutions for rural freight services, because public transport is very costly in remote suburbs and outside towns. It might be relevant to offer services with autonomous shuttles out of terminus railway stations.
- **Ethics in CAVs' management**. Managing traffic where all vehicles are CAVs or managing mixed traffic where some vehicles are manually controlled and some are CAVs are two very different use cases. In 2030, automated freight means are implemented at local scale within exclusive right-of-way transport specific areas: some autonomous cars, trucks, trains, ships runs. But, the AI knowledge-based decision routines arise ethical aspects that has not reached a consensus, so autonomous vehicles are not allowed in the public areas. Furthermore, a risk mitigation framework is missing in the man-machine interaction.

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6.1.2.5 *Optimisation*

Optimisation is one of the main values that found the MTM vision. The aim of a MTM may, depending on whether it is a private MTM stakeholder with a business economic strategy or a public MTM actor with a societal economic strategy, optimise according to different types of costs/benefit assessments where the costs may be economic, societal, and/or environmental.

For transport service providers and fleet operator, optimisation applies to the transportation modal and route choices, and to the use of resources. The results of such optimisations may be sub-optimal, and not optimal to the society. In 2030, MTMs are obliged to optimise to the best of the society and the environment, and optimisation applies to the management of infrastructure capacity during normal situations as well as disruptive events. The costs to handle complex situations and disruptive events higher must be considered. Would a implementation of such optimisations be higher and more efficient than not implementing one?

The MTM optimisation strategy may enter in conflict with the optimisation strategy from another stakeholder, because they may not have same constraints and goals. In the worst case, companies may sue the traffic orchestrator due to financial losses caused by traffic management measures. The concern here is the balance of power that is the power of one to influence the decision of the other. The core question is “who decides what?”, and the rules for the decision taking must be well defined and transparent.

6.1.2.6 *Safety/security*

The safety in road transport has increased due to extended driver support and automation, and the degree of automation is gradually increasing is manually operated vehicles.

With increased data sharing and automation, information and cyber security in more important than ever. Security gaps has been detected, and work on improvements are going on.

CAVs are continuously becoming safer, but still there are limitations in their roadworthiness and ability to operate in mixed traffic. The maximum speed is limited, and they are only allowed to operate in parts of the transport network. The A.I. knowledge-based decision routines arises ethical aspects that has not reached a consensus, so autonomous vehicles are not allowed in all public areas.

Some use cases in which safety/security issues are addressed, were given during the workshops:

- <u>Drones:</u> Someone has to control drones: we have to consider safety, imagine 30 drones flying from a city to Malpensa. We need a system to manage that: a new network could help, a new way to prioritise traffic and resolve conflicts.
- <u>Automation has great advantages from the human factors point of view:</u> A human driver will always be affected by all that concerns human performance, an autonomous vehicle is automated, so is more able to be “scheduled”. By now, we could reach an automation level in cars that could support the driver in limiting the human error, implementing also the connection with other vehicles, giving in exchange real time data for a tool like a traffic orchestrator.
- <u>Cybersecurity:</u> Data sharing in case of dangerous cargos is useful (e.g. the accident in the port of Lebanon). However, there is a highjack risk that may lead to the situation when some information may fall in wrong hands. Imposed safety data in standard forms are required.

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- GDPR and privacy concerns in real time location of vehicles.

6.1.3 A collective will

6.1.3.1 Experiments and learning

Different infrastructure and traffic managers are more and more likely to host traffic tests for autonomous and connected vehicles, as they already have done this since the early 2010s. Therefore, they can prepare to receive future traffic of CAVs on their infrastructures. Vehicles manufacturers mostly carry out those experiments.

The competences of the traffic managers have to be improved respect to training, responsibilities, rules, coordination between stakeholders.

6.1.3.2 Governance

Governance is not a guaranty of success but is a way to describe how stakeholders coordinate together to reach a common goal.

From a governance standpoint, the main challenge of MTM is to organise cooperation with the most relevant stakeholders, in the most relevant perimeter, and to fill missing links. There will be different governance levels depending on location, etc. A cross border coordination may be difficult so an EU regulation may be needed. An improvement in international regulations regarding emission taxes and supporting (nudging) those green alternatives. Regulation should also support the coordination between stakeholders: for instance, taxes saving motivation can help to reach emission goals, in the context where Companies have report for their GHG emissions.

6.1.3.3 Who should be the "traffic orchestrator"?

The traffic orchestration responsibilities and governance levels must be defined and assigned.

- **A centralised system**: A centralised system may arrange for optimal transports. This will require a new role and an existing or a new organisation must take this role. It will be a challenge to manage all modes and networks in a consistent way. One option may be to limit the role of the central system to handle just coordination between modes, networks, and governance areas. But a centralised system may not be required for this purpose.
- **Distributed system**: the traffic orchestration for the different modes and networks can handle in a distributed way. To arrange for coordination and collaboration is needed, they can exchange information on statuses and capacities, and they can collaborate and coordinate the distribution of traffic across the modes and networks.

6.1.3.4 Managing disruptions

An intense cooperation between the MTM stakeholders and the passengers are needed to manage disruptions. As a result, it is possible to use the time of the disruptive situation to carry out certain formalities that should have been carried out later in the journey.

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6.1.3.5 Low flexibility in case of disruptions

In 2030, the freight transportation business models do not cover the demand for transhipment to other operators in case of disruptions. In such cases, an operator cannot just hand over the cargo to another operator. The business models do not support such actions. For instance, if something happens at sea, they just wait and see. This creates long delays and congestions. The actors do not communicate yet with each other to find alternatives. Nevertheless, we know that sharing transport capacity is possible, as ship-owners have already create join ventures to share slots since a long time.

6.1.3.6 Risk management

It would be too expensive to plan for ALL the eventualities. The implementation of MTM in different situations may be the result of a cost/benefit assessment. Are costs of mitigating the disruptive events consequences higher than not to do so? Would such kind of a system in this way be more efficient than not implementing one?

Coordination between stakeholders is a main issue to prevent unforeseen events. Traffic stakeholders and so the traffic orchestrator, can prepare to manage likely situations but not the unlikely situations. Multidisciplinary approaches are necessary to identify the maximum of foreseeable disruptive situations.

6.1.3.7 Freight stakeholders' resistance

In 2030, the continental freight transportation business model is still mainly road oriented. In the continuation of the previous decades the road remains the major mean of transport in most of the European countries (more than 75% of the tonne-kilometre – source: Eurostat). The shippers' mindset still mostly does not take care of how the transport runs. They most often just want transport to happen, in the cheapest and most efficient way. The road corresponds well to these constraints; furthermore, it can go everywhere. In the contrary, waterway or railway transportation do not serve all the places, and a last mile road transportation is needed through the multimodal hub and the final destination/origin of the flow.

Freight modal shift to heavy transport means (railways, waterways) needs to gather flows and a well-performed transportation in coordination with road transport. But, in 2030 it remains difficult to coordinate between traffic orchestrators of different modes: there are currently no standards addressing how to coordinate between modes. Multimodal transport suffers from the rigidity of the railways traffic management in 2030; transhipments are very constraining. Introducing railway in supply chain belongs to a risk driven decision. Today, the expectations for truck are lower than railway. The issue is the Information time before failure. In addition, intermodal terminals are expensive and time-consuming to build.

6.2 Target Vision elements for 2050 horizon

Many of the elements of the 2030 target vision are still relevant for the 2050 target vision. The system of shared values and many of the collective will elements are the same, and thus they are not repeated here.

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6.2.1 Goals and major projects

6.2.1.1 Green transition

The Green transition is the main common leitmotiv that guides the path followed from 2020 to 2050 MTM, according to the European Green deal (a 2050 “climate-resilient society”) which gave the objective to reduce of 90% the transportation sector emission from its 1990’s level. Actually, «traffic orchestrator» concept has been one of the tool that contributed to get closer to this objective.

If no actions will be taken in the upcoming years, actual trends tell us that emissions will be seven times higher than 1990’s ones: the success of the European Green Deal depends on the ability to make the transport system sustainable before 2050 (European Commission 2019).

To reach climate neutrality, the European Commission (2018) adopted a strategic long-term vision for a climate neutral economy by 2050, engaging all sectors of the economy and society, to achieve the transition to a climate-neutral economy. The transport sector, being one of the main sources of GHG emissions in the economy, will play a key role in this transition. In the light of a wave of technological innovation and disruptive business models (such as ride sharing), both the possibilities and demand for making transport safer, more efficient, and sustainable have increased. Digital technologies help reduce human error and can also create a truly multimodal transport system and spur social innovation (European Commission 2016). The market potential of cooperative, connected and automated driving is expected to lead to the creation of many new jobs (European Commission 2019).

6.2.1.2 Transport sector transitions

Actions from EU should focus in the next 30 years on completing **the Single European Sky II**, ensuring the highest levels of safety and security, supporting the creation of high-quality jobs in aviation, protecting passenger rights, making the best use of innovation and digital technologies, address the risk of capacity shortage and add ensuring aviation’s contribution to resilient Energy Union and Climate Change Mitigation.

In 2017, the Commission agreed to invest €2.7 billion in 152 **key transport projects** that support competitive, clean, and connected mobility in Europe. Through this investment, the Commission is delivering on its Investment Plan for Europe and on Europe's connectivity, including the agenda set out in the Communication "Europe on the Move". Selected projects are mostly concentrated on the strategic sections of the TEN-T to ensure the highest EU added-value and impact. The largest part of the funding will be devoted to developing the European **Railway Network, decarbonizing, and upgrading road transport and developing intelligent transport systems and deploying air traffic management systems.**

The analysis of the implementation of the Intelligent Transport Systems Directive by the European countries demonstrates the strong and constant involvement of most EU countries in intelligent traffic management and information systems (European Commission 2019). These allow for a **better use of the infrastructure**, in particular through better use of road, traffic and travel data and the development of new intelligent transport services, including CAVs and autonomous drones for traffic management. In addition, new open data strategies for transport (e.g., in the United

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Kingdom) or the use of crowdsourcing (e.g., travel-time information in Finland) have led to significant changes and the development of new services (European Commission 2019).

6.2.1.3 Passenger mobility

By 2050 there will not be conventionally fuelled cars in cities, there will be used 40% of sustainable low carbon fuels in aviation, a 50% shift of medium distance intercity passenger from road to rail and waterborne transport, resulting in a 60% cut in transport emissions. Most of the medium-distance passenger transport (300 km and beyond) should travel by rail. From a policy point of view, there will be a full application of “polluter pays” and “user pays” principles together with private sector engagement to eliminate distortions, generate revenues and ensure financing for future transport investments (European Commission 2011).

Considering global trends, in 2040 there will be **a surplus annual demand of some 1.5 million flights** which European airports will be unable to accommodate due to capacity shortages. France and Netherlands risk having the highest unaccommodated demand. These issues are actually impeding the European aviation sector’s ability to grow sustainably and compete internationally, and the inability to grow and compete causes congestion, delays and rising costs. To help the sector to grow, in 2050 **all the Comprehensive Network of TEN-T will be completed**. The TEN-T policy addresses the implementation and development of a Europe-wide network of railway lines, roads, inland waterways, maritime shipping routes, ports, airports and railroad terminals. The TEN-T policy also supports the application of innovation, new technologies and digital solutions to all modes of transport. The objective is improved use of infrastructure, reduced environmental impact of transport, enhanced energy efficiency and increased safety. But, the scarcity of transhipment infrastructure, and of inland multimodal terminals, is pronounced in certain parts of Europe, and should be given the highest priority. Missing links in multimodal infrastructure should be closed. (European Commission 2019)

Moreover, the transport system should work more efficiently overall with **improved transhipment technologies**. Ports and airports are key for European international connectivity, for European economy, and for their regions. In their transition to zero-emission nodes, the best practices followed by the most sustainable airports and ports must become the new normal and enable more sustainable forms of connectivity. Ports and airports should become multimodal mobility and transport hubs, linking all the relevant modes. This will improve air quality locally thereby contributing to improved health of nearby residents. Inland and seaports have a great potential to become new clean energy hubs for integrated electricity systems, hydrogen and other low-carbon fuels, and testbeds for waste reuse and the circular economy. Thus, also nearly all cars, vans, buses, and heavy-duty vehicles will be zero emission and high-speed rail traffic will triple. To reach zero emissions, electricity, hydrogen, ammonia, and sustainable fuel will replace petroleum and create new opportunities for generation, production, and distribution (European Commission 2020)

To make mobility smarter, AI systems will be introduced in traffic management, to improve not just the optimisation, but also safety and security in all transport sector, bringing the death toll close to zero (European Commission 2020). The design of all the means of transport will have to be inclusive and for all, being 1/3 of the population over 60 years old. Most vehicles, on the road and in the air, will be electric. Vertical take-off shuttles will be deployed in urban areas, improving safety and security from 2030 thanks to an improved connectivity and technological evolution.

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Urban Air Mobility (UAM) will be common in urban areas, simplifying road traffic and lowering emissions. Mobile source emissions will not be a concern beyond recreation or sports vehicles. Adoption of level 5 (full automation) autonomous vehicles will be up to 70%, and safety will be improved considerably due to the prevalence of these vehicles: autonomy and connectivity between CAVs will have significantly improved crash avoidance, downgrading crash rates up to 75% from 2020 levels (UK Research and Innovation 2021).

In EU vision, in 2050 **the transport experience for passengers will be seamless**, thanks to AI automation and multimodality. People will be able to move easily and rapidly through Europe thanks to the Corridors and the multimodal hubs, managing the travel with one-ticketing solution. The great majority of Europe's citizens and businesses will be no more than 30 minutes' travel time from the comprehensive network of TEN-T. Thanks to the open-data policy, passengers will be able to experience a journey through a transport ecosystem.

6.2.1.4 Freight mobility

In 2050, all modes of freight transport will be brought together through **multimodal terminals** and an intelligent traffic management system for all modes of transport. In this way, each infrastructure and traffic manager will be able to provide solutions to users for avoiding congestion (EU, 2020 a). The EU also argues that digital transformation is an essential factor in achieving the objectives of the Green Deal (EU, 2019). However, it is not certain that it will actually reduce the environmental costs of mobility (see § 2).

Even if digital techniques could certainly facilitate **the opening up of logistics networks**, we probably have to accept that the problems of standardisation and (technical and commercial) acceptability of the tools can only be solved in the long run. The project SELIS (2016) identifies the challenges associated with separated links of the logistics chains, and highlights these problems of information sharing. The rapid spread of contemporary digital tools, from Intelligent Transport Systems to artificial intelligence and connected infrastructures and vehicles, could, in a few years' time, give long-distance freight transport new prospects. On this point, the results of the EU Mobility 4 project (EU, 2019) could provide a framework for considering the future of multimodal freight transport and thinking of innovative solutions. For example, as this project indicates, **the emergence of new business models** with parcel transport services possibly provided by individual drivers could offer new solutions for freight. Indeed, subject to the necessary regulatory support, "new approaches ... raise hopes that the traffic problems in cities and their surrounding regions can be solved without major changes of transport policies and life style" (Topp, 1995).

It is worth mentioning here the views of logisticians who have thought about how to **decarbonise supply chains** by 2050 and who considered that multimodal optimisation should be addressed. According to a stakeholder consultation conducted through a survey with more than 40 respondents and three online consensus-building workshops, the European Technology Platform ALICE (Alliance for Logistics Innovation through Collaboration in Europe)[6] rank objectives for a decarbonisation strategy in order of potential (i.e. considering impact and feasibility) (ALICE, 2019):

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6 http://www.etp-logistics.eu

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1. Renewable energy in combination with electrification, hybrids and hydrogen
2. Multimodal optimisation
3. Load consolidation and optimisation
4. Use of efficient vehicles, vessels and fleets
5. Synchro-modality and flows synchronisation
6. Improve fleet operation
7. Supply chain restructuring
8. Consumer behaviour.

Two of these objectives can very well match with the objectives of a multimodal traffic management (in bold type, above). The others depend on the user (shippers and carriers) decisions and practices. In any case, multimodal traffic management can thus help to slow down climate change.

According to ALICE, the existing idle capacity of assets and infrastructure in all modes of transport could be better used, and flows could be managed in a more integrated way. Open logistics services and networks connecting seamlessly will maximise capacity utilisation.

As far as management tools and open logistics services and networks are concerned, a question arises: how will multimodal traffic management be coordinated with the **Physical Internet**? In the supply chain management academic world, many researchers are very keen on the Physical Internet and its expected development as a powerful tool for optimisation of freight flows; however researchers do stress that «the first foundation (of the PI) is that the Physical Internet is a means to an end, not an end by itself » (Montreuil, Meller and Ballot, 2012). On its own, the European platform ALICE has also edited a roadmap for the 5 aspects of the P.I. by 2040[7].

In a literature review supplemented by the opinions of a panel of experts, Psofer et al (2016) rank the critical **success factors for synchro-modality**: trust and collaboration, sophisticated planning, ICT/ITS technologies for high quality data, physical infrastructure, legal and political framework, awareness and mental shift, and pricing/cost/service aspects. For instance, at the operational level, collaboration or competition between carriers influences the level of service, synchronisation, and performance of the system.

In terms of the ultimate objective, SteadieSeifi et al (2014) draw attention to the fact that shippers/carriers of certain time-sensitive commodities do not necessarily have a profit maximisation objective. **Multi-objective transport planning** deserves more research.

In terms of acceptability, without even mentioning the implementation of digital tools, Topp (1995) warns that: "the environmental capacity of an urban arterial road where people live will generally be less than its maximum engineering capacity and guidance encouraging even more drivers to use such roads will not be welcomed by the residents".

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7 http://www.etp-logistics.eu/wp-content/uploads/2020/11/Roadmap-to-Physical-Intenet-Executive-Version_Final.pdf

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6.2.1.5 Synthesis of input from document study

The climate emergency context tends to homogenise the objectives and the means of the planned actions. The notions of improving transhipment conditions and synchro-modality are shared by freight and passenger analysts and might be key aspects for a future MTM. In the studied documents, the question of changing behaviour (for shippers, carriers and travellers) does not appear to be very important; much more, changing passenger behaviour (in order to contain demand) is an option explicitly banned by the European Union.

Addressing the future with specific actions as expressions of collective will to achieve objectives is displayed in the Table 5, mainly relying on EU publications about mobilities for the next 30 years (cf. list of references). Main expected changes in the MTME between now, 2030 and 2050 are summarised in the Table 5.

Table 5: Main changes expected in the MTME between 2030 and 2050

	2030	2050
UAM	Introduction of first public transport drones	Vertical Automated Take-off Shuttles for urban transports
High-Speed Railway	TEN-T Core Network	TEN-T Comprehensive Network
CAV and Road Traffic	Cars connected to internet	Cooperative, Connected and Automated vehicles will be widespread; AI in traffic management
Public Transports	Autonomous vehicles at low speed in a limited number of situations	Shifting part of road public transports to air public transports
Air Transport	Initial shift to rail transport for short-medium distance (<300Km)	Airports will be multimodal hubs
Common Data Space	Shared Common Data Space	Connected Data Space managed by AI
MaaS	Growing	People will live in MaaS ecosystems

(Source: authors, according to the document study)

The document study also provides important aspects concerning future developments in freight and in traveller transportation; they need to be classified and ordered (Table 6). For this purpose, we use the analysis criteria proposed by M Godet (2007-a,-b); for the sake of clarity, we separate the criterion 'purposes' into two parts: on the one hand, the purposes for transport in general and on the other hand, the purposes for the management of multimodal traffic. We also separate the criteria appearing in the documents dealing with freight from those appearing in the documents dealing with passengers. In the end, the aspects for both of them are almost identical.

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Table 6: 2050 Target vision from the document study

	Freight	**Passengers**
Context	Climate change emergency, pollution, EU policy	Climate change emergency, pollution, EU policy, old and disabled people
General goals for transport	to contain growth and to decarbonise vehicles, sustainable and intelligent mobility, resilience	to contain growth and to decarbonise vehicles, sustainable and intelligent mobility, resilience
General goals for MTM Ecosystem	transport modes are smartly used and combined, synchromodality as enabler of greener traffic, seamless and user-centric, zero emission flows, multimodality as a green alternative to unimodality	transport modes are smartly used and combined, synchromodality as enabler of greener traffic, seamless and user-centric, zero emission flows, multimodality as a green alternative to unimodality
Major projects shaping the future	TEN-T, CAV, Physical Internet, smart interfaces	TEN-T, CAV, UAM, smart interfaces, MaaS
Shared values (within and across distinct stakeholder groups)	Green transport, improved resilience	Green and inclusive transport, high speed trains as an alternative to flights, improved resilience
Non shared values across different stakeholder groups	New business models need to be implemented to change behaviours (Alice for freight)	A change of behaviour is expected, from air traffic to rail traffic (UE references)
Collective will to achieve objectives	road maps and action plans are published	road maps and action plans are published

Source: authors, according to the document study

Two keys success factors will be fundamental to improve mobility according to the EU Commission Visions. First, an **improved governance of the multimodal transport system** where the role of all actors is defined and coordinated by accountable public authorities; secondly, the establishment of a **network of European 'living labs'** where innovative mobility solutions are introduced and tested with the direct involvement of citizens. Living labs will allow the potential users test the novelties in real life situations. Their feedback will feed into the final version of

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mobility solutions that will genuinely serve people's needs and be aligned with the values and expectations of society. Ideally, a network of such labs across Europe would allow exchange of results, for optimising utility and costs of new technologies (Joint Research Centre, European Commission 2019)

In conclusion, the evolution of technologies and the vision from the EU seem to correspond. The existing data-sharing protocols, the deployment of new Connected and Autonomous Vehicles, Urban Air Mobility, the improvement of actual infrastructure and the creation of new ones, the policies' improvement expected for the following years and the necessity to reduce GHG emissions in the transport field, may lead to think that Multimodal Traffic Management Ecosystems will be introduced, little by little, in the following years.

6.2.2 The collective will

Some ideas from workshops and interviews enlighten some particular aspects of the 2050 target vision: control centres and disruptions management.

6.2.2.1 Control centres

The areas and the stakeholders involved in the Control centres in 2050 are wider than they were in the 2020's:

- The spatial scale of the traffic centres and the involved stakeholders, must be in line with the scale of the event.
- Due to the climate change, large-scale events had to be considered. A disruption in one place of the network can have consequences for other places of the network. Locally situated event can be managed locally, but in case of bigger events, stakeholders need a larger control system. For instance, an obstruction in the Suez Canal can affect several maritime routes and port managers who have to coordinate each other, as it happened on March 2021. The Orchestra project suggests a distribution of local control centres that are able to communicate and coordinate among themselves.

6.2.2.2 Managing disruptions

By 2050, some of the mostly recurrent disruptive situations will have been well identified all over the European continent, and analysed. All the consequences on the traffic management have been explored, and public authorities, infrastructure managers, freight forwarders, had to adapt their ways of operating in order to diminish these consequences. The Traffic Operator is able to take decision or suggest some to a control centre. For instance, it can stop the operations in time in case of extreme climatic events thanks to great prevention of extreme weather conditions. Nevertheless, climate change is now so high that the stakeholders has not been able to manage all the disruptive situations: it is too expensive to plan for all eventualities.

A resilient and multimodal traffic orchestration will support better handling of normal as well as abnormal situations (like obstructions and disasters). The resilient and multimodal traffic orchestration should ensure that goods could be transported to their destinations at the same time as abnormal situations can be handled.

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Emergency management is now eased during the disruptions due to climate change: in a dangerous situation, cargo, people and vehicles involved in accidents must be evacuated. Traffic orchestrators, who need to optimise the flows in the area and in the adjacent networks, supporting emergency vehicles and others with a role in the emergency, can now more easily cope with such a complex situation.

Emergency management can be done more effectively in 2050: in a dangerous situation, cargo, people and vehicles involved in accidents must be evacuated. Traffic orchestrators who need to optimise the flows in the area and in the adjacent networks, supporting emergency vehicles and others with a role in the emergency, can now more easily cope with such a complex situation.

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7 Conclusions

7.1 Lessons learned

D2.1 is a part of the input for the project's milestone no. 1 “First round with CoP workshops completed”. It contributes to the objective **(O1) Establish a common understanding of multimodal traffic management** (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.

This first MTME **target** vision is a made up of major goals, projects, shared values and a collective will to achieve the goals (Godet, 2007).

Main goals: By 2050, 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. In 2030, it is essentially a question of afterwards adaptation.

Major project: By 2050, technological innovations in ITS, together with great improvements of transport and data infrastructures at local (in cities) and European (TEN-T) levels are implemented by 2050. Digitisation, artificial intelligence and bio-mechanics will improve the MTM and support new transport services mixing old and new means of transport (Drones, CAVs). Thanks to standardised protocols, a traffic orchestrator is able to take or suggest decisions during disruptive situations. 2030 horizon is an experimentation step for these projects' implementation more advanced in passengers than in freight transports.

The MTME implementation relies on a **system of shared values indispensable to MTM**: the green transition suggests introducing KPI in the MTM business models. Data sharing needs trusty, liable, secure, safe and transparent data exchange and decision protocols, as well as fairness, inclusiveness and cooperation among stakeholders.

A collective will: for such MTM to work, the rules of cooperation between the stakeholders must be defined: rules of responsibility for all modes of transport and new business models. A radical mind change is expected, but it seems to be more likely to happen through passenger transport ecosystem than through the freight one.

The diversity of the spatial stretch of the MTME and the diversity of its stakeholders is such that it a centralised MTM system may not match to issues identified. Most probably, several systems will centralise the different information, which will also have to communicate with each other.

This first target vision strengthens ORCHESTRA partners to develop a polycentric distributed management system, which is the aims of WP3, WP4 and WP5.

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7.2 Future Work

Scenarios to reach the target vision will be drawn through D2.3 and D2.4. taking into account the MTM environment analysis (D2.2). Output WP 3, 4 and 5 will be provided to CoP members through other workshops (2022-23) to update and refine this first target vision.

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8 References

[1] ALICE, 2019. A framework and process for the development of a roadmap towards zero emission logistics in 2050, December 2019

[2] Elbert, R., Müller, J P., Rentschler, J., 2020**.** Tactical network planning and design in multimodal transportation – a systematic literature review. Research in Transportation Business & Management, 35 (2020) 100462

[3] BERKES Fikret, COLDING Johan, FOLKE Carl, "Navigating social-ecological systems ; Building resilience for complexity and change", Cambridge University Press, New York, NY, USA, 2003, cited by BRUSSET Xavier, TELLER Christoph, "Supply chain capabilities, risks and resilience", International journal of production economics, 184, 2017, pages 59-68.

[4] Busyairah S, A., 2019. Traffic management for drones flying in the city, International Journal of Critical Infrastructure Protection 26 (2019) 100310,

[5] Chen, C., Ma, J., Susilo,Y., Liu, Y., Wang, M., 2016. The promises of big data and small data for travel behavior (aka human mobility) analysis, Transportation Research Part C: Emerging Technologies, Volume 68, 2016, Pages 285-299, ISSN 0968-090X, https://doi.org/10.1016/j.trc.2016.04.005.

[6] Dellink, R., Hwang, H., Lanzi, E., & Chateau, J., 2017, International trade consequences of climate change. *OECD Trade and Environment Working Papers*.

[7] Durance, Godet, 2010, “Scenario building: Uses and abuses”, *Technological Forecasting & Social Change*, 77, pp. 1488-1492. http://en.laprospective.fr/dyn/anglais/articles/scenario-building-tfsc-2010.pdf

[8] European Commission, 2020-a, *A European Strategy for Data.* Retrieved from https://digital-strategy.ec.europa.eu/en/policies/strategy-data

[9] European Commission, 2020-b, “Sustainable and Smart Mobility Strategy – putting European transport on track for the future”, Communication from the commission to the European Parliamant, the Council, the European economic and Social Committee of the Regions, Brussels, 9.12.2020 COM(2020) 789 final, 25 p.

[10] European Commission, 2020-c. Progress on TEN-T Network. Retrieved from https://ec.europa.eu/transport/themes/infrastructure/ten-t_en

[11] European Commission, 2019-a, *Transport in the European Union - Current Trends and Issues.* Retrieved from https://www.amt-autoridade.pt/media/1934/2019-transport-in-the-eu-current-trends-and-issues.pdf

[12] European Commission, 2019-b, The future of road transport - Implications of automated, connected, low-carbon and shared mobility. Joint Research Centre.

[13] European Commission, 2018-a, *Europe on the Move: Commission completes its agenda for safe, clean and connected mobility.* Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/IP_18_3708

[14] European Commission, 2018-b, A Clean Planet for All: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0773

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 953618. This document reflects only the author’s view and the Agency is not responsible for any use that may be made of the information it contains.

[15] European Commission, 2017, *Europe on the Move: Commission takes action for clean, competitive and connected mobility.* Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/IP_17_1460
[16] European Commission, 2016, *Transport Emissions*. Retrieved from ec.europa.eu: https://ec.europa.eu/clima/eu-action/transport-emissions_en
[17] European Commission, 2013, EU Energy, transport and GHG emissions, trends to 2050, reference scenario 2013, *European Commission 2013.*
[18] European Union, 2019, Mobility 4 EU, Action Plan for the Future Mobility in Europe, *Horizon 2020, Coordination and Support Action, contract 690 732.*
[19] European Union, 2019, Green deal, *COM (2019) 640 final.*
[20] European Union, 2019, Selis, Towards a Shared European Logistics Intelligent Information Space, H2020, White Paper, 10 October 2019, Grant Agreement 690588.
[21] Fialkin, V., Veremenenko, E., 2017, Characteristics of traffic flow management in multimodal transporthub (the example of the seaport). Transportation Research Procedia 20 (2017) 205-211
[22] Godet, M., 2007 a, Manuel de prospective stratégique, Tome 1, Une indiscipline intellectuelle, L'art et la méthode, *3ème édition, Ed Dunod,*
[23] Godet, M., 2007 b, Manuel de prospective stratégique, Tome 2, L'art et la méthode, 3ème édition, Ed Dunod,
[24] Hosseini, S., Al Khaled, A., 2021. Freight flow optimization to evaluate the criticality of intermodal surface transportation system infrastructures. Computers and industrial engineering 159 (2021) 107522.
[25] Julien, P-A., Lamonde, P., Latouche, D., 1975, « La méthode des scénarios en prospective », *L'actualité économique,* vol 51, n° 2, avril-juin 1975.
[26] Kiseru I., Coosemans T., Macharis C., 2021. Stakeholders'preferences for the future of transport in Europe : participatory evaluation of scenarios combining scenario planning and the multi-actor multicriteria analysis, Futures, 127 (2021) 102690
[27] Mahdavi, M., 2018, What should managers of intermodal freight transport companies consider before adopting Intelligent Transportation Systems (ITS)? Emerging environmental technologies and health protection, (1) 2018 ISSN 2623-4874 e-ISSN 2623-4882
[28] Montreuil, B., Meller, Russel D., Ballot, E., 2012, Physical Internet Foundations, Proceedings of the 14th IFAC Symposium on Information Control Problems in Manufacturing, Bucharest, Romania, May, 23-25, 2012.
[29] Moriarty, P., Honnery, D., 2008, Low-mobility: the future of transport, Futures, 40 (2008) 865-872.
[30] Mulley, C., Yen, B, T., 2020, Workshop 6 report: better service delivery through modal integration, Research in Transportation Economics, 83 (2020) 100913.
[31] OCDE, 2017, International Transport Forum's Transport Outlook, online : https://www.oecd-ilibrary.org/sites/9789282108000-5-en/index.html?itemId=/content/component/9789282108000-5-en

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 953618. This document reflects only the author's view and the Agency is not responsible for any use that may be made of the information it contains.

[32] Pasaoglu, G., Zubaryeva, A., Fiorello, D., Thiel, C., 2014, Analysis of European mobility surveys and their potential to support studies on the impact of electric vehicles on energy and infrastructure needs in Europe, Technological Forecasting and Social Change, Volume 87, 2014, Pages 41-50, ISSN 0040-1625, https://doi.org/10.1016/j.techfore.2013.09.002.
[33] Pfoser, S., Treiblmaier, H., Schauer, O., 2016, Critical success factors of synchromodality : results from a case study and literature review. Transportation Research Procedia 14 (2016) 1463-1471
[34] Ritchie, H., & Riser, M. (2017). *CO2 and GreenHouse Gas emissions*. Retrieved from OurWorldInData: https://ourworldindata.org/emissions-by-sector
[35] Rubin, I., Baiocchi, A., Sunyoto, Y., Turcanu, I., 2019, Traffic management and networking for autonomous vehicular highway systems, Ad hoc Networks, 83 (2019) 125-148.
[36] SELIS, 2016, Towards a "Shared European Logistics Intelligent Information Space", http://www.selisproject.eu/, EC Grant Agreement N° 690588.
[37] Shibayama T., 2020, Competence distribution and policy implementation efficiency towards sustainable urban transport: a comparative study, Research in Transportation Economics, 83 (2020) 100939
[38] SteadieSeifi M., Dellaert, N.P., Van Woensel, T., Raoufi, R., 2014, Multimodal freight transportation planning : a literature review. European Journal of Operational Research, 233 (2014) 1-15
[39] Topp, H, H., 1995, A critical review of current illusions in traffic management and control Transport Policy, vol 2, n° 1, January, 33 -42
[40] Tuchen, S., 2020, Multimodal Transportation operational scenario and conceptual data model for integration with UAM. *2020 Integrated Communications Navigation and Surveillance Conference (ICNS).*
[41] UK Research and Innovation, 2021, Future Flight Vision and Roadmap, August 2021.
[42] United Nations, 1981, "United Nations Conference on a Convention on International Multimodal Transport", Held at Geneva from 12 to 30 November 1979 (first part of the session) and from 8 to 24 May 1980 (resumed session), New York, 16p, available on line: https://unctad.org/system/files/official-document/tdmtconf17_en.pdf
[43] United Nations, 2017, "Strengthening the links between all modes of transport to achieve the Sustainable Development Goals", Resolution adopted by the General Assembly on 20 December 2017, A/RES/72/212, 6p. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/72/212&Lang=E
[44] UNECE - United Nations Economic Commission for Europe, 2020, "Climate Change Impacts and Adaptation for Transport Networks and Nodes", Geneva, 216 p, online: https://unece.org/sites/default/files/2021-01/ECE-TRANS-283e_web.pdf
[45] Van Gheluwe, C., Semanjski, I., Hendrikse, S., & Gautama, S. (n.d.), 2020, Geospatial Dashboards for Intelligent Multimodal Traffic Management. *{2020 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops).* doi:10.1109/PerComWorkshops48775.2020.9156231

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 953618. This document reflects only the author's view and the Agency is not responsible for any use that may be made of the information it contains.

[46] Yesudian, A., Dawson, R., 2021, Global analysis of sea level rise risk to airports. *Climate Risk Management, 31*.

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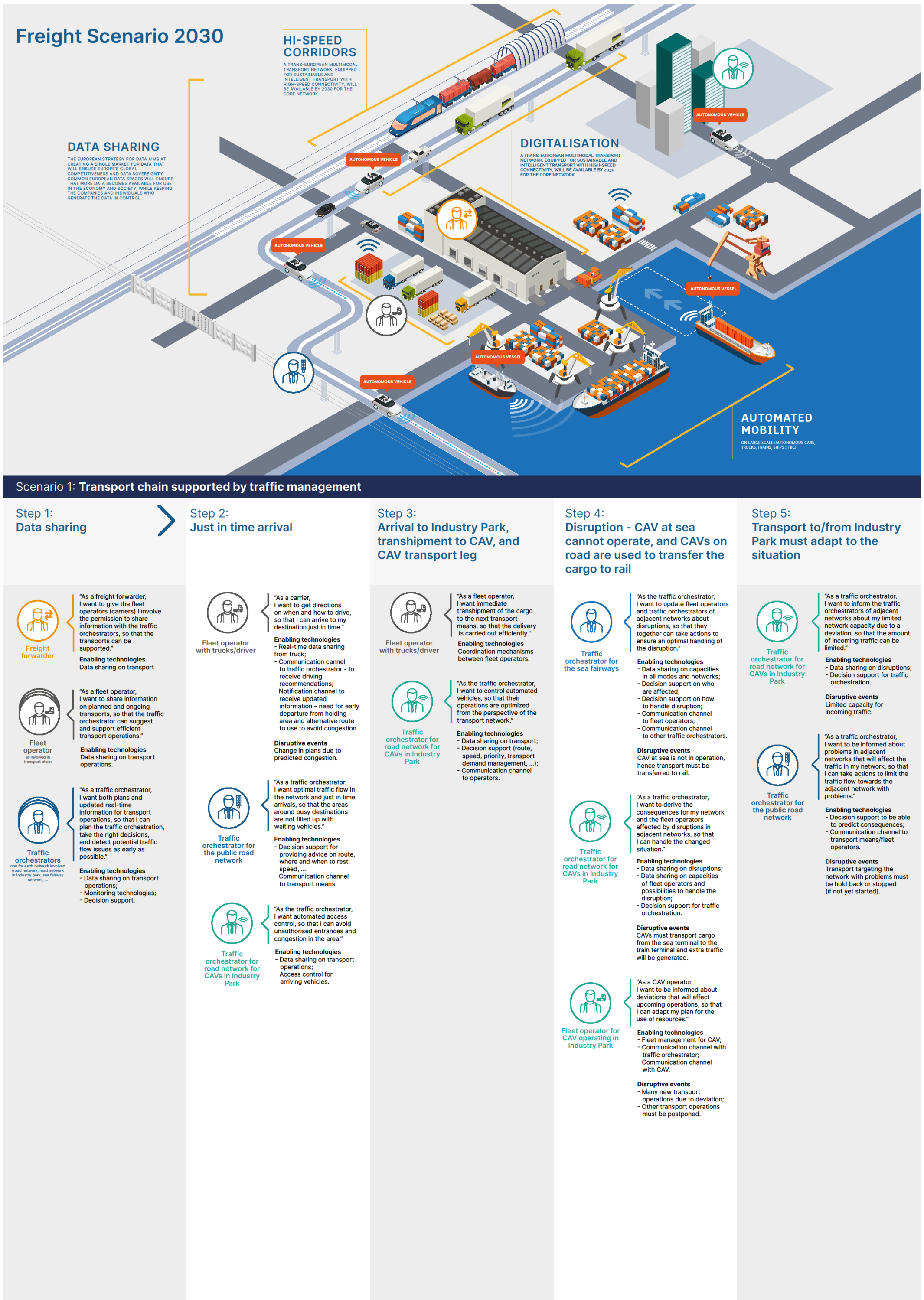
Annex A Story mappings

A.1 The story mapping 2030 freight scenario



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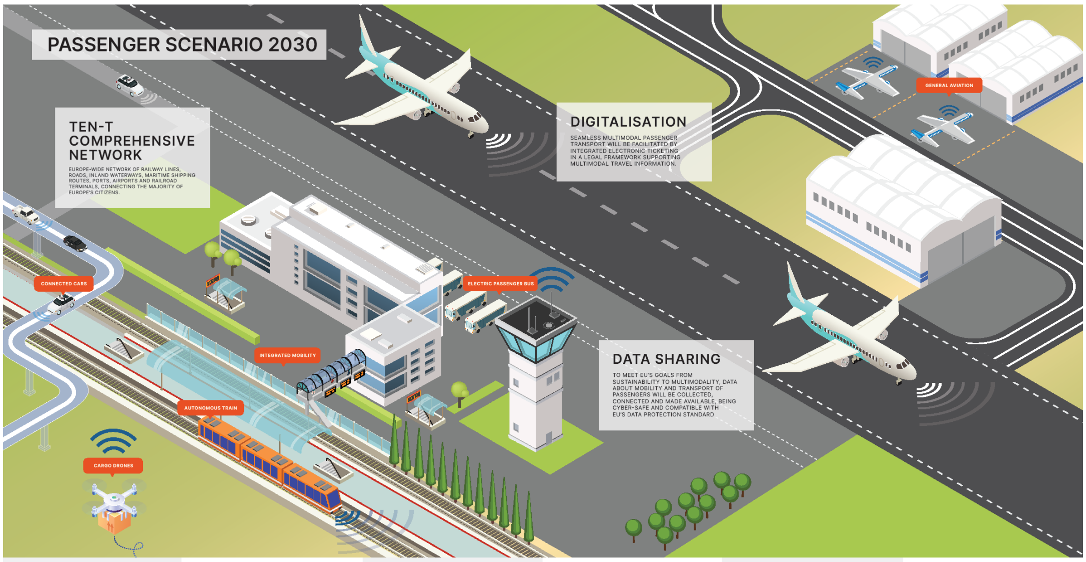
A.2 The story mapping 2030 passenger scenario



Multimodal Traffic Management Point of View

Step 1: Receiving travel plans	Step 2: Disruption	Step 3: Monitoring flows, exchanging data	Step 4: Coping with the disruption	Step 5 Offering options	Step 6 Overcoming of the disruption
	Malpensa Express, after an on-time departure from Milano Centrale, faces an unexpected disruptive event: a train breakdown near Castellanza train station.				
All the actors involved (Rail Transport Provider, Airport), thanks to new legislations (European Common Data Spaces) and the Traffic Orchestrator Tool, receive Passengers' travel plans and information of a passenger travelling to Paris, departing from Milano Centrale, through Malpensa Airport.	The Rail Transport Provider makes sure that the information related to the train breakdown and the passengers on board is correctly achieved by the Traffic Orchestrator.	The Traffic Orchestrator Tool alerts the Airport about the ongoing disruption, the number of passengers involved, their destination. The Traffic Orchestrator Tool displays the traffic conditions on the railway network. The Rail Transport Provider consults the Traffic Orchestrator Tool to identify useful information for passengers.	The Airport Operator together with the ANSP takes the necessary actions to minimize the impact on flight delays and maximize the service to the passengers. The Rail Transport Provider organises the solution to cope with the disruption by inputting data in the Traffic Orchestrator Tool.	The Traffic Orchestrator tool, through the travel planner app, offers different trip options: a delay of 15 minutes in arriving at the airport taking another train from Castellanza Station or having the flight rescheduled, according to the seats availability on the same booking class.	The disruption is overcome. People flows are monitored to verify how the train breakdown will influence the next flows to the airport.

Passengers Point of View

Step 1: Travel planning	Step 2: Disruption	Step 3: Waiting	Step 4: Receiving information	Step 5 Choosing options	Step 6 Overcoming of the disruption
	Malpensa Express, after an on-time departure from Milano Centrale, faces an unexpected disruptive event: a train breakdown near Castellanza train station.				
The Passengers organise their trip through the Travel Planner App, accepting the data sharing, protected by European Common Data Spaces legislations. They input their data: > starting point (home), > arrival (Paris – Charles De Gaulle Airport), > constrains (means of transport) Based on the preferences chosen by the passenger, the Travel Planner App suggests him to take the Malpensa Express to reach Malpensa Airport, departing from Milano Centrale.	Malpensa Express, after an on-time departure from Milano Centrale, faces an unexpected disruptive event: a train breakdown near Castellanza train station.	The passengers on the train are now waiting, feeling emotions related to uncertainty: stress, anxiety, anger. Their need for information brings them to ask insistently the Train Manager when they will have the solution.	The passengers are informed through the Travel Planner App that the Rail Transport Provider and the Airport Operators are coordinating to help the passengers take the flight minimising delays.	On the Travel Planner App, Passengers can choose between taking another train arriving 15 minutes late, departing from Castellanza Station, or rescheduling the flight, according to the seats availability on the same booking class.	Passengers have taken their decision and they are now reaching the airport.

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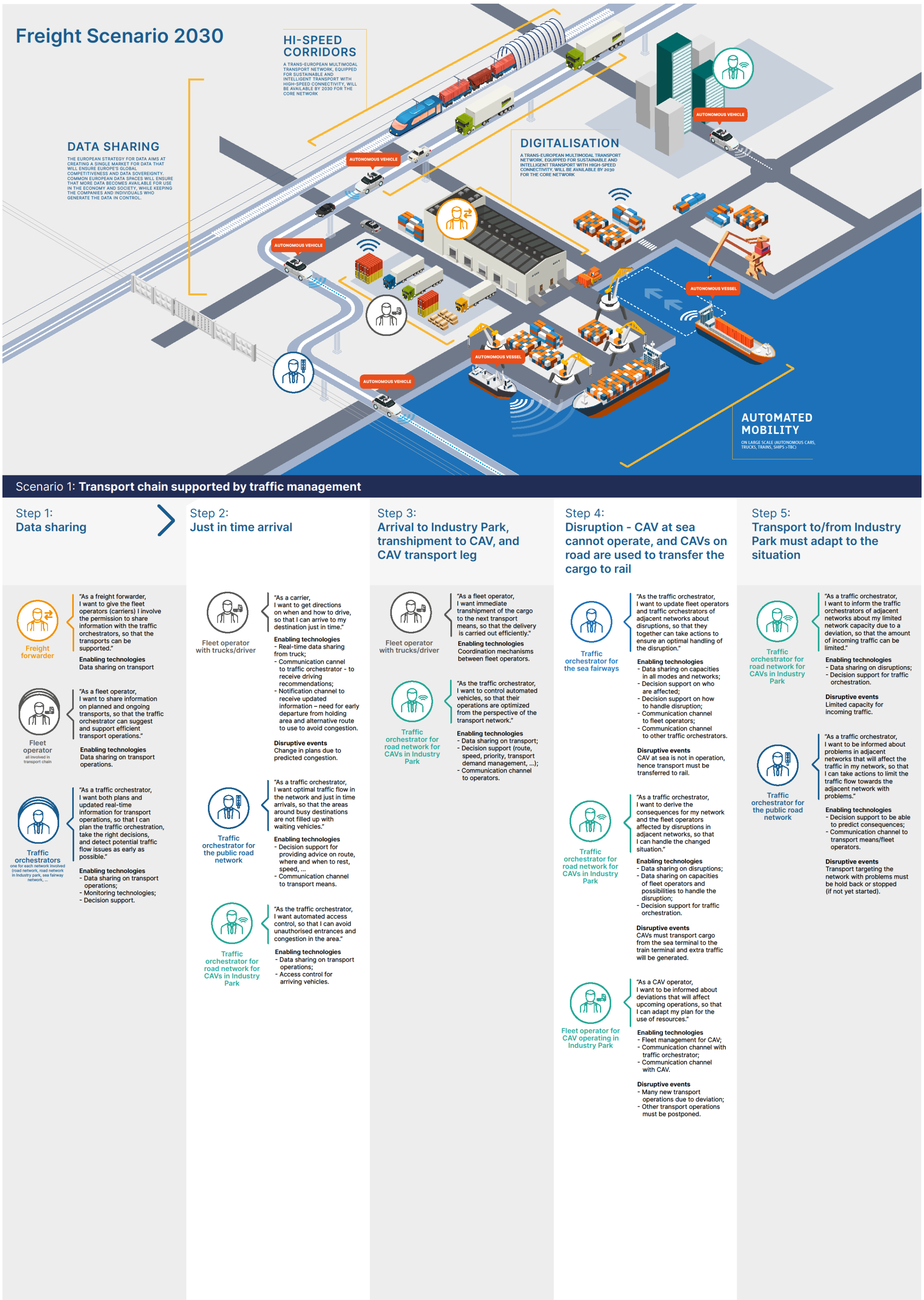
A.3 The story mapping 2050 freight scenario



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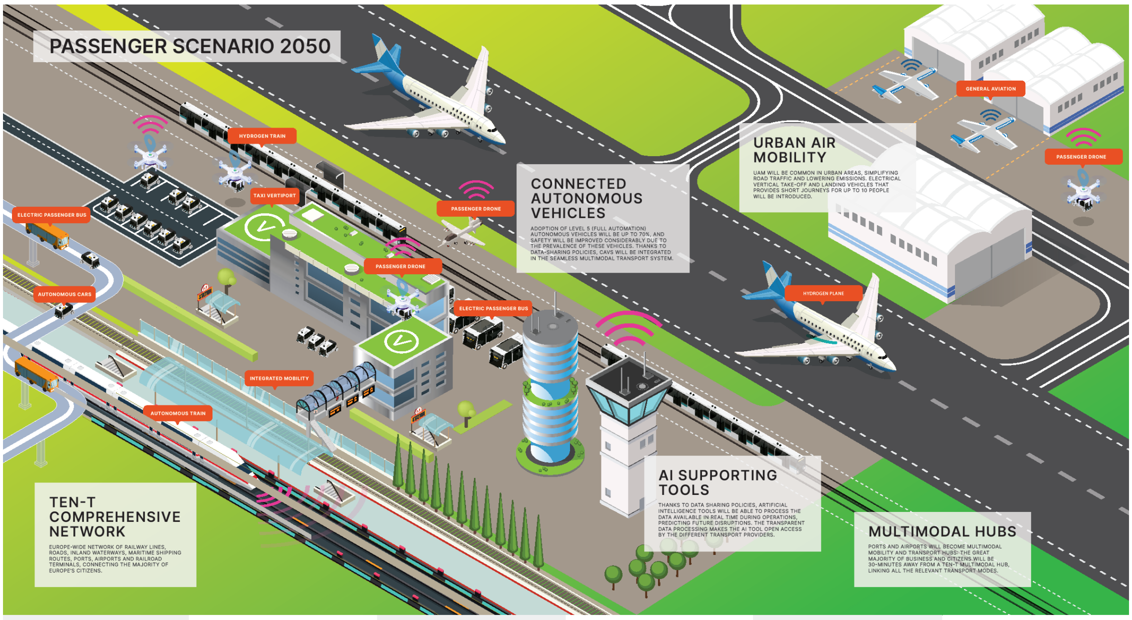
A.4 The story mapping 2050 passenger scenario



Multimodal Traffic Management Point of View

Step 1: Travel Planning	Step 2: Disruption	Step 3: Coping	Step 4: 2nd disruption	Step 5 Coping	Step 6 Just-in-time arrival
Thanks to information and real time data sharing among all the transport actors, the Traffic Orchestrator (TO) receives the travel plans of the passengers departing from home and directed to Milan Malpensa airport. The TO confirms the selected service to the users: a CAV to reach MXP from their own homes, located in Milan city centre.	Thanks to the continuous monitoring of traffic and weather conditions on the transport network, the Traffic Orchestrator alerts the passengers of a disruption through the MaaS app used for the travel booking: traffic on the highway to Malpensa is congested due to a car accident, so the Traffic Orchestrator recommends a switch to an eVTOL (electrical Vertical Take-Off and Landing drone) to reach the airport, based on flight departure time, service availability of all the transport modes and passengers' profile and preferences. The switch is accepted by the passengers.	The Traffic Orchestrator reschedules the travel plans and sends to passengers' houses the number of CAVs needed to bring them to Milano Cadorna air taxi vertiport .	Due to bad weather conditions, the Traffic Orchestrator forecasts possible delays in UAM service: through the MaaS App, Traffic Orchestrator suggests the passengers the available alternatives to reach the airport on time.	Based on the option selected by each of the passengers involved in the delay,the Traffic Orchestrator organises a remote security check and a biometric fast track on board the drone. Live updates are given on the tMaaS App.	Overcoming of the disruption: thanks to the Traffic Orchestrator, all passengers arrive at the vertiport on time and quickly reach the airport gate to take their flights.

Passengers Point of View

Step 1: Travel planning	Step 2: Disruption	Step 3: Coping	Step 4: 2nd disruption	Step 5 Trip	Step 6 Just-in-time arrival
Based on their needs (e.g. comfort, number of luggage, etc.) and on the flight departure time, passengers choose the CAV to reach Milan Malpensa Airport from home, located in Milan city centre, and plan their trip through the MaaS Application installed on their smartphone.	The MaaS App notifies a congestion on the highway and the passengers choose to accept the suggested alternatives	CAVs bring without further instructions the passengers to Milano Cadorna air taxi vertiport.	The MaaS App notifies bad weather and the passengers accept the recommended alternatives, among which the preferred one is staying on the drone.	During the trip on the drone the passengers are subjected to security checks and can see on the Travel Planner App the live updates about how the system is coping with the delays.	The passengers arrive on time at the airport and, directly from the vertiport, they can reach the gate T take the plane on time.

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Members of the ORCHESTRA consortium

ITS Norway	**ITS Norway** c/o Tekna – Teknisk-naturvitenskapelig forening Postboks 2312 Solli NO-0201 Oslo Norway its-norway.no	**Project Coordinator:** Runar Søråsen runar.sorasen@its-norway.no **Dissemination Manager:** Jenny Simonsen jenny.simonsen@its-norway.no
SINTEF	**SINTEF AS** NO-7465 Trondheim Norway www.sintef.com	**Technical Manager:** Marit Natvig Marit.K.Natvig@sintef.no
TU Delft	**Technische Universiteit Delft** Stevinweg 1 2628 CN Delft The Netherlands	**Evaluation Manager:** Alexei Sharpanskykh O.A.Sharpanskykh@tudelft.nl
ROSAS	**ROSAS Center Fribourg** Passage de Cardinal 13B Halle bleue CH-1700 Fribourg Switzerland info@rosas.center	**Contact:** Lucio Truaisch lucio.truaisch@rosas.center
CERTX	CERTX AG Route de l'Ancienne Papeterie 106 CH-1723 Marly Switzerland	**Contact:** Samuel Rieder samuel.rieder@certx.com
IKEM	**Institut Fur Klimaschutz Energie Und Mobilitat-Recht, Okonomie Und Politik Ev (IKEM)** Magazinstraße 15-16 10179 Berlin Germany	**Data Manager / Legal, Privacy and Policy Issues Officer (LEPPI) officer:** Anne Freiberger anne.freiberger@ikem.de
IOTA FOUNDATION	**IOTA Foundation** c/o Nextland Straßburger Straße 55 10405 Berlin Germany	**Contact:** Michele Nati michele@iota.org Siddhant Ghongadi siddhant.ghongadi@iota.org

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SEA Milan Airports	**Societa Per Azioni Esercizi Aeroportuali Sea (SEA)** Presso Aeroporto Linate 20090 Segrate MI Italy	**Contact:** Massimo Corradi massimo.corradi@seamilano.eu
deepblue consulting & research	**Deep Blue Srl** Via Ennio Quirino Visconti, 8 00193 Roma Italy	**Innovation Manager:** Alessandra Tedeschi alessandra.tedeschi@dblue.it
République Française Cerema	**Cerema** 25 Avenue François Mitterrand 69500 Bron France	**Contact:** Sylvain Belloche Sylvain.Belloche@cerema.fr
FS Technology Gruppo Ferrovie dello Stato Italiane	**FSTechnology SpA** Piazza della Croce Rossa, 1 00161 Roma RM Italy	**Contact:** Jessica Bonanno jessica.bonanno@it.ey.com
Information Sharing Company	**Information Sharing Company Srl (ISC)** Via di Tor Pagnotta, 94/95 00143 Roma Italy	**Contact:** Antonio Martino a.martino@gruppoisc.com
APPLIED AUTONOMY	**Applied Autonomy AS** Kirkegardsveien 45 NO-3601 Kongsberg Norway	**Contact:** Olav Madland olav.madland@appliedautonomy.no
HERØYA INDUSTRIPARK www.heroya-industripark.no	**Herøya Industripark AS** Hydrovegen 55 NO-3936 Porsgrunn Norway	**Contact:** Tone Rabe tone.rabe@hipark.no
enav	**ENAV SpA** Via Salaria, 716 00138 Roma Italy	**Contact:** Patrizia Criscuolo Patrizia.Criscuolo@technosky.it
Statens vegvesen Norwegian Public Roads Administration	**Statens vegvesen** Rynsengfaret 6A NO-0667 Oslo Norway	**Contact:** Elisabeth Skuggevik elisabeth.skuggevik@vegvesen.no

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