Multimodal Traffic Management Cluster

Navigating Data in the Field of Traffic Management

FRONTIER FUTURE MOBILITY

Orchestra

TANGENT

DIT4TraM

MOBIDATALAB

Labs for prototyping future mobility data sharing solutions in the cloud

SYNCHROMODE

DELPHI

Acumen

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1. Introduction

To make network and traffic management truly multimodal, efficient data sharing has become significant. This policy brief, collaboratively crafted by the 4FRONT cluster (a synergy of four EU-funded traffic management projects: DiT4TRAM, FRONTIER, ORCHESTRA and TANGENT) and the MobiDataLab project, offers support for a pragmatic approach towards 2030. The insights shared here stem from a workshop held in June 2023, where the 5 projects collectively identified challenges, proposed recommendations, and outlined research gaps. The document was reviewed and validated by the new Cluster projects: SYNCHROMODE, DELPHI and ACUMEN.

Structured into four key sections, this policy brief explores various facets of the data sharing landscape:

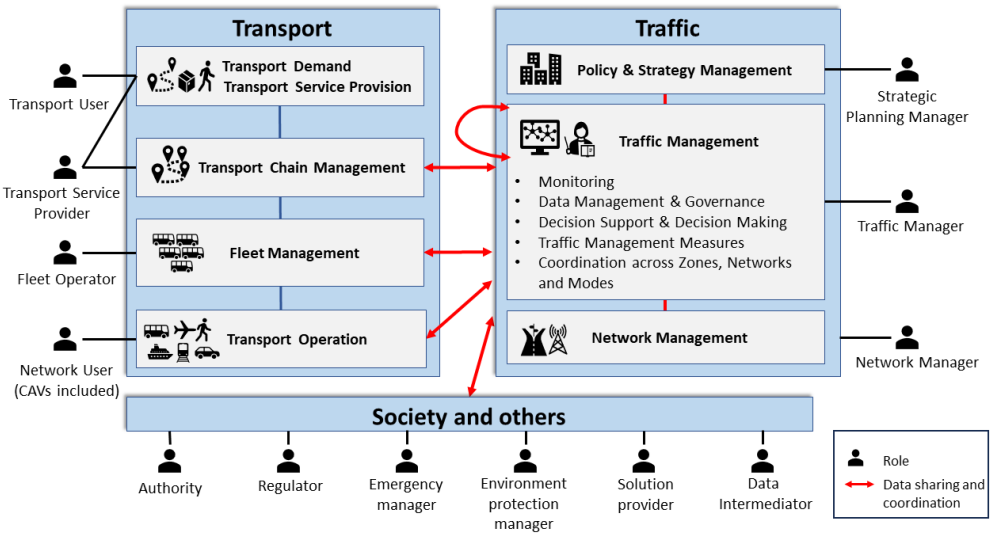
- **Data Ecosystem and Governance:** This section unpacks the intricacies of the data ecosystem in the traffic management domain and situates the role of data governance in it.
- **Regulations on Data**: Navigating the existing regulatory landscape, this section reviews current policies and highlight some gaps in the legislative framework.
- **Data Standards**: Highlighting the significance of standardised approaches, this section explores the role of data standards in ensuring interoperability and harmonising diverse data sources.
- **Data Exchange:** This section dissects challenges, presents recommendations, and unveils research gaps identified by the projects.

Collaborating is essential to reach multimodal traffic management systems that help cities achieve their mobility goals. The 4FRONT cluster aims to provide valuable support for decision-makers, traffic operators, and stakeholders, enhancing their understanding and strategic planning in the evolving landscape of network and traffic management.

2. Data ecosystem and governance

2.1 Data ecosystem: an overview of transport and traffic ecosystems

Before we dig into the content of this policy brief, it is important to go back to the basics of the transport ecosystem. It consists of two parts – transport and traffic, as depicted below.



Most data needed in future traffic management will originate from the transport side of the ecosystem. In a nutshell, this refers to the provision of passenger and freight transport services to users through one or multiple modes. These transport operations are carried out by network users (i.e., vehicles, vessels, pedestrians, etc.) who operate on transport networks (road networks, fairways, railways, and air spaces), and they need to be planned and controlled from reliable traffic data and information. Future traffic management will require more data to be shared on these transport services, for example, provided automatically by connected vehicles/vessels. Therefore, data governance and management practices must be encouraged for all modes.

In contrast, **traffic** (right column) is about the management of the traffic generated by the transport part. To reach a city's policy goals, it must be influenced, supported, and managed through policies, regulations and strategies to make it resilient, safe, and efficient while minimising negative externalities. Traffic managers monitor the traffic by using many data sources included those provided from the transport side of the ecosystem. In the near future, AI technologies such as machine learning will increasingly use data to detect occurred and upcoming situations at an early stage and support informed and pro-active decisions regarding the traffic management measures to be taken. Coordinated measures across zones in the transport network and with other transport networks and modes will facilitate an optimal transport system as a whole.

2.2 Establishing the groundwork for comprehensive data governance

Data availability and sharing are fundamental to driving innovation and collaboration in optimizing traffic operations. The ability to access and exchange data among various stakeholders within the transport ecosystem is crucial for **developing and testing innovative solutions**. However, data sources are currently managed by different data providers and made available in a plethora of heterogeneous public and private data portals. This **fragmentation** poses significant challenges to effective data sharing and collaboration.

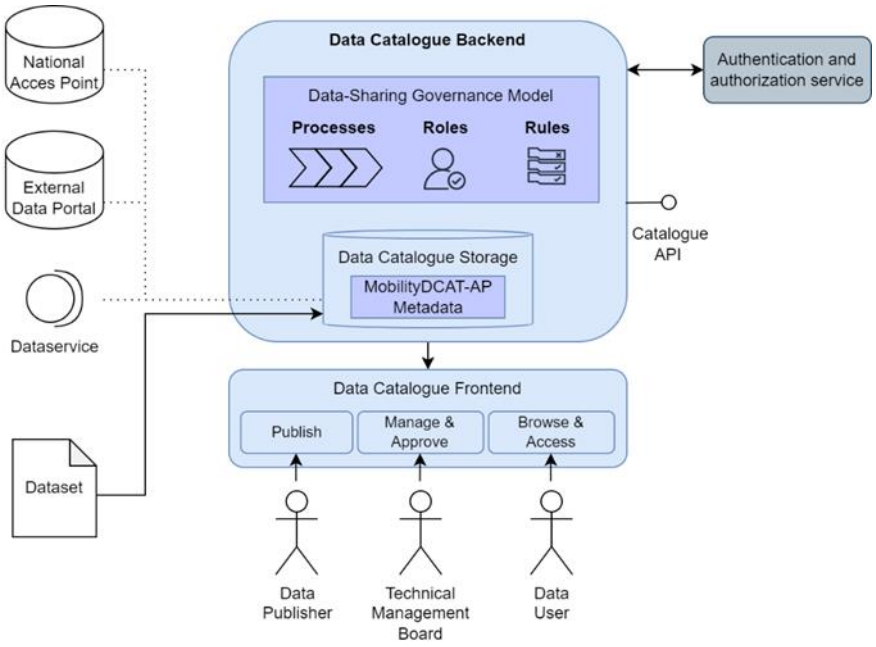
To address these challenges, it is imperative to implement **structured and effective data governance mechanisms**. Such governance practices are essential for streamlining data sharing processes, ensuring data quality, and fostering collaboration among stakeholders. Data intermediaries play a pivotal role in ensuring the quality and governance of shared data. Additionally, the concept of a **Mobility Data Space**—a unified infrastructure facilitating seamless data exchange among various stakeholders—can further support effective data sharing within the transport ecosystem

From the analysis and comparison of data governance models defined by previous European research projects (e.g., Transforming Transport[1], HARMONY[2], MOMENTUM[3], NOESIS[4], LEMO[5], SPRINT[6]) in the transport domain, the following best practices emerge:

- definition of a metadata catalogue, i.e., a digital platform supporting data sharing;
- definition of rules and establishment of a Technical Management Board for facilitating data collection, publication, and sharing;
- definition of rules to enforce compliance with European regulations on data sharing and to ensure interoperability and reuse of data and metadata;
- definition of rules to properly govern data manipulation (e.g., data harmonisation and fusion) and reuse.

These best practices have been partially adopted by the 4FRONT projects. In particular, the ***metadata catalogue*** has been recognized as a key instrument in facilitating the sharing and accessibility of distributed data sources in the TANGENT project. The metadata profile to describe data sources in the catalogue should adhere to the European recommendation for metadata interoperability (DCAT-AP[7]) in order to increase and simplify data sharing, discovery, and reusability through shared semantics. Moreover, the data catalogue should support the application of a data governance model to properly govern data processes (data publication, data access, data storage, data usage) to be addressed by different stakeholders in the transport ecosystem with different roles and following a detailed list of rules.

The following figure describes a reference architecture for a data catalogue where the key aspects (i.e., the metadata profile and the governance models) are remarked for efficient and regulated data sharing, discovery, and reuse.



RESEARCH GAPS

A structured and effective data governance could facilitate data sharing in a data ecosystem and enable the development and testing of innovative solutions for traffic management. However, legal, technical and managerial issues often make data governance difficult to define and implement. The main legal issue consists of accessing proprietary data since raw and historical data (e.g., delays for public transport) are perceived as business-critical data by stakeholders. Non-disclosure agreements (NDAs) are often needed to enable data exchange and to regulate data usage and manipulation. The main technical issue is related to data availability in heterogeneous formats, leading to interoperability issues that must be addressed by promoting data sharing in standard formats like DATEX II, NeTEx, SIRI. Managerial challenges arise from the unavailability of historical data and metadata. Data users often address the former by collecting and storing real-time data to create historical datasets necessary for tasks like training traffic prediction models. The lack of metadata presents a barrier to efficient data discovery and reuse, often stemming from data providers' manual generation of metadata. The recent introduction of mobilityDCAT-AP represents a significant step toward addressing this issue (https://w3id.org/mobilitydcat-ap/) represents a first step towards solving this issue. This standardized approach to metadata creation and management holds promise for enhancing data accessibility and interoperability within the transport sector.

3. Regulations on data

As European cities and regions strive to enhance traffic management, improve road safety, and optimise transportation systems, they are inevitably confronted with a lot of data and related practices including collecting, processing, storing, etc. This data is heterogeneous and nowadays treated as a *good with economic value*, thereby aiming to underpin a plethora of

data transactions. However, data transactions must be in line with applicable legal regimes. On the one hand, data is affected by existing legal frameworks designed in the past for different purposes and with different objects (e.g. Intellectual Property Law). On the other hand, a new wave of EU Regulations - the so-called “Data Law” (Data Governance Act, Data Act, AI Act) – seek to support the creation of a unified EU Data Economy by promoting data interoperability and access.

This legal landscape raises two challenges. Firstly, stakeholders and authorities need to **accept a transition from property-based to *governance*-based notions** related to data. Many still often-ask the question “who owns [a certain type of] data?”, demonstrating the perception that data *is or should be owned.* Such approach constitutes a barrier to data sharing. Secondly, **understanding how all the different legal regimes come together and navigating the legal patchwork that applies to data**. Sector-specific rules add an extra layer of complexity. Examples of legal regimes and the pertinent challenges are provided below. For further reading about the legal challenges of data sharing in urban mobility, MobiDataLab has prepared several publications analysing the legislative framework.

3.1 ITS Directive and RTTI Delegated Regulation

The Intelligent Transport Systems (ITS) Directive stands as a beacon while the Real-Time Traffic Information (RTTI) Delegated Regulation lays down specific requirements for the provisioning of various types of infrastructure and traffic data, in a standardised and machine-readable form, to support the creation of real-time traffic information services. The RTTI delegated regulation, revised in 2022, has seen its original geographic mandate extended from the high-level road network (mainly motorways) to all roads. Furthermore, it includes new types of data and introduces the notion of critical data sets.

In addition, the revised regulation contains two new provisions for the benefit of public authorities. Firstly, public authorities can access under FRAND (Fair, Reasonable, and Non-Discriminatory) conditions certain in-vehicle data sets for the tasks of traffic and asset management and road safety. Secondly, ITS service providers are required to take account of traffic circulation plans and regulations in their services, e.g., routing advice, provided the respective data sets are provided.

Traffic management systems operating under the realm of the ITS Directive face the dual mandate of promoting interoperability and intelligent transport systems. This regulatory framework encourages the adoption of standardised data formats and protocols to ensure the seamless exchange of information. However, translating these principles into uniform practices across diverse regions and systems can be an arduous task. Differences in interpretations and implementations of these standards pose significant challenges to the sharing of real-time traffic data, as each stakeholder may navigate the regulations through their unique lens.

3.2 GDPR

Being compliant with the **General Data Protection Regulation (GDPR)** is essential for guaranteeing trust within a data sharing ecosystem. Real-time traffic data, vehicle data and public transport data could qualify as personal data necessitating the application of the rules and principles set out by the GDPR. Mobility data more generally share some characteristics that make their sharing a potential privacy risk because they are highly *unique* and *regular. Unicity* refers to the data of different individuals being easily differentiable, meaning that each entity possesses distinct and identifiable characteristics, particularly linked to some specific locations. The starting and ending locations of users' trajectories are often their home and work locations which are highly unique and can lead to reidentification. Studies show that users' full trajectories can be uniquely recovered with the knowledge of only two locations.

However, understanding the legal implications of collecting and processing mobility data is not always evident. For example, defining data controllership (i.e. the actor mainly accountable and responsible for complying with the GDPR) can be challenging. Given the multitude of actors potentially active in a data sharing ecosystem, the correct characterisation of each actor's role under the GDPR and identifying those carrying the main responsibility can be quite challenging. Other challenges include using the appropriate legal basis, particularly managing consent, and exploring which privacy-preserving techniques could be applied without sacrificing the value of the mobility data shared.

3.3 Competition law

Data sharing may violate Article 101 TFEU by qualifying as anticompetitive information exchange. That would be the case when market players that are (actual or potential) competitors share competitively/commercially sensitive information and this action enables them to become aware of each other's market strategies. Consequently, this influences their economic conduct on the market which by definition should be determined independently. The EC recently adopted revised Guidelines providing some guidance on acceptable data exchanges. However, given the primitive status of data sharing arrangements, it is difficult to evaluate the implementation of these rules.

Article 102 TFEU, which addresses abusive practices by dominant companies, can also be applicable to data sharing practices. Abusive behaviours in data sharing may include refusal to share, discriminatory treatment, exploitation through unlawful processing, or unfair terms. However, defining dominance is an open question. For example, whether we could consider a market for data and how that can be measured.

4. Data Standards

Efficient traffic management and the exchange of quality traffic data are crucial for road network operators responsible for travel safety, road maintenance, and user information. Simultaneously, road users depend on accurate and up-to-date map data for their navigation systems. Achieving these goals heavily relies on the use of standardised data-access methods, semantics, schemas, and syntaxes.

The 4FRONT projects are pioneering innovative traffic management concepts and tools such as the TANGENT dashboard for real-time multimodal traffic monitoring and forecasting, the DIT4TraM simulation framework for network optimisation, and ORCHESTRA's decision support platform utilising information from common data spaces. In a similar way. In a similar way, FRONTIER has implemented Orion Context Broker for real-time data exchange among different traffic management and prediction components through the Autonomous Network and Traffic Management Engine (ANTME). As research endeavours, it is imperative to assess the feasibility of applying these novel approaches and their anticipated impacts on other (test) sites. Having well-established standards in place, such as those for data exchange and system integration, plays a crucial role in ensuring interoperability and facilitating the seamless migration of these innovative approaches to diverse environments with minimal effort.

In many instances, the standards employed by these projects are closely linked to groundbreaking concepts, lacking any precedent, and not building upon existing infrastructure. However, for certain concepts that do extend upon existing infrastructure, it is not only desirable but also highly recommended to **leverage existing standards** whenever feasible. Furthermore, when available, incorporating international standards can significantly enhance the scalability and applicability of these novel approaches.

Leveraging standardised message sets, such as those defined by the European Telecommunications Standards Institute (ETSI) for cooperative vehicles, is a valuable practice. DIT4TraM is building upon these well-defined and widely accepted message sets - in their case, those relating to newer traffic lights-, simplifying the migration of traffic control approaches across different test sites and environments. Utilising standardised message sets ensures consistency and ease of implementation across diverse scenarios.

Achieving true interoperability can be challenging due to differences in technology, data formats, and communication protocols used in different regions and by different organisations. In the case of autonomous networks, **a common language for receiving and broadcasting messages is essential**. FRONTIER's practice of developing an ontology as an extension of SAREF4AUTO and Smart Data Models from established standards- in their case DATEX II[1]- provides a robust foundation for clear communication and data sharing. This approach promotes standardised communication and data exchange, reducing ambiguity and improving interoperability.

Similarly, TANGENT is improving data interoperability by **developing automatic processes for data conversion towards reference standards** (DATEX II, NeTEx[2] and SIRI[3]). The TANGENT solution realises data conversion by exploiting a reference conceptual model, defined by reusing existing ontologies, and Semantic Web technologies. The data conversion through a reference conceptual model also streamlines data enrichment and integration and enhances adaptability.

[1] DATEX-II is the European standard for the exchange of traffic-related data. It is a unified XML-based format modelled with UML (Unified Modelling Language) to allow data exchange between traffic management/control centres, traffic service providers, and road and traffic operators

[2] NeTEx (Network Timetable Exchange) is a CEN standard that facilitates the exchange of complex public transport data in XML format.

[3] SIRI (Service Interface for Real Time Information) is a standard that provides a framework for exchanging real-time public transport information.

Complementary to the above, ORCHESTRA is prototyping common data spaces to support collaborative decision-making were data from trains and highways are integrated in airport operation planning. ORCHESTRA is also prototyping tools that provide improved situational awareness, utilising both data from infrastructure and connected and automated vehicles, in addition to weather forecasts.

To others facing similar challenges when innovating in traffic management, the Cluster recommends investigating strategies and tools for efficient data conversion and adaptation to standardised formats, such as DATEX II. Highlighting that emphasis should be placed on minimising divergence from established standards to ensure smooth data transition and compatibility.

RESEARCH GAPS

In the realm of traffic data standardisation, several critical research gaps emerge. Firstly, there is a growing demand for standards that can seamlessly integrate dynamic, real-time traffic information, including traffic flow updates and incident data. Additionally, research is needed to develop automated data quality assurance mechanisms, ensuring data accuracy and reliability, especially when data originates from diverse sources and sensors. As transportation systems become more integrated, the need for standards supporting intermodal transportation data sharing arises, promoting the seamless exchange of information between various modes of transport, such as buses, trains, bicycles, and shared mobility services. Privacy concerns pose a significant challenge to data sharing, necessitating research into privacy-preserving techniques and standards to protect sensitive individual information while enabling data sharing. Furthermore, the harmonisation of regional and national traffic data standards is crucial to overcome interoperability challenges across different regions and countries. Finally, enhancing semantic interoperability by aligning ontologies and taxonomies used in traffic management becomes paramount to effectively integrate and interpret data from various sources. Whilst the 4FRONT cluster is actively working and addressing some of these issues, further research and collaboration are needed to keep progressing.

5. Data exchange

Efficient data exchange is a critical aspect of traffic management systems, posing both challenges and opportunities for improvement. One primary challenge identified by the Cluster, referring to the multimodal network management of the future, involves **the adaptation of data structures and the reduction of data size**. Large datasets incur high storage costs and lengthy transfer times, necessitating continuous server operation. The key challenge is to adjust data structures, eliminate duplicated information, and choose appropriate file formats to reduce both stored and transferred data sizes. This reduction not only diminishes server resource requirements but also contributes to energy efficiency and environmental impact reduction, ultimately resulting in faster response times for system actions.

Another significant challenge is **the homogenisation of data entities**. The transport sector employs various ontologies, often based on the DATEX-II standard, to identify data entities. Despite this, there is a need for concerted efforts to unify these definitions at the EU level. Achieving homogenisation is crucial for fostering efficient data exchange and interoperability across diverse systems.

To achieve efficient data exchange in a data-based technological solution, it is necessary to **implement various services to facilitate seamless data transfer** among all components of the system, between users, and with end-users when necessary. Technologies such as Rest-API, coupled with publish-subscribe message exchange services like MQTT or Orion, prove to be effective and established approaches for ensuring robust and reliable data exchange.

RESEARCH GAPS

Within this landscape, there are gaps that necessitate further research. Notably, the sharing of data from connected vehicles with traffic operators remains a challenge. Real-time sharing of these substantial data volumes could significantly enhance network control, but issues related to data privacy and ownership must be addressed. Developing new ontologies and standards is essential to establish an efficient and secure framework for data exchange, ensuring the integration of data from connected vehicles into traffic management systems.

6. Conclusions

In conclusion, the realization of truly multimodal network and traffic management hinges on efficient data sharing, and both the 4FRONT cluster and the MobiDataLab project advocate for a pragmatic approach towards 2030.

The previous sections meticulously explore the intricacies of the data ecosystem and governance, current regulations on data, the significance of data standards, and the challenges inherent in data exchange. Each section not only outlines challenges faced by the projects but also identifies noteworthy best practices implemented to mitigate these challenges. Significantly, each section ends by bringing light to relevant research gaps, offering a guide for future initiatives and research endeavours.

An important message emanating from the Cluster is the indispensable role of collaboration in the development of multimodal traffic management systems aligning with the mobility goals of cities. The 4FRONT cluster's commitment is reflected in its aspiration to offer valuable support to decision-makers, traffic operators, and stakeholders. Through this support, the cluster seeks to enhance their understanding and facilitate strategic planning within the dynamic and evolving landscape of network and traffic management.

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