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BOLOGNA LIVING LAB - A study on integrating DRT services in the public transport network within a MaaS system, which includes data exchange protocols to visualize information about the service and to make reservations

Final Version

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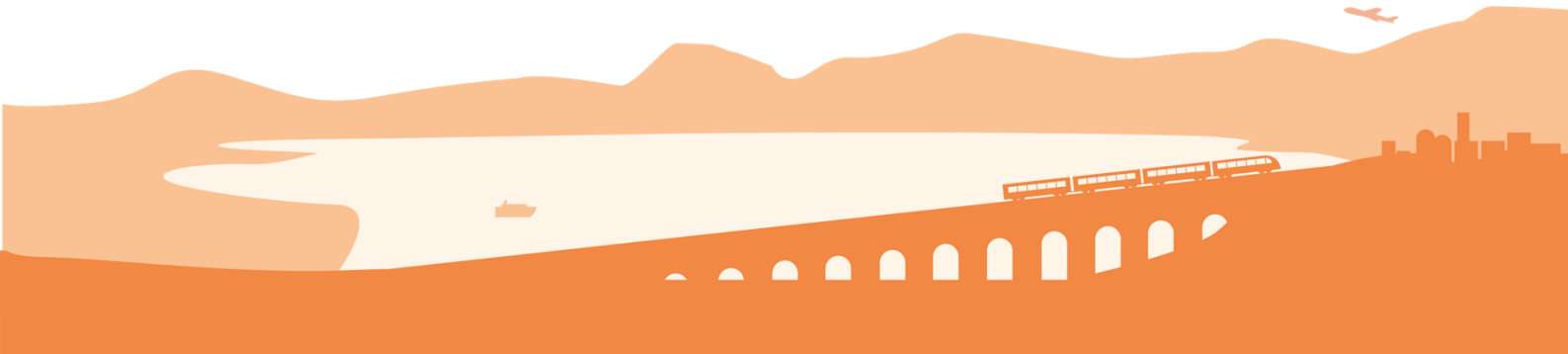

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Contents

Glossary

Name	Acronym	Description
Application Programming Interface	API	A set of rules, protocols and tools that enables different software applications to communicate with each other. APIs define the methods and data that applications can use to interact with an external system, library or service, making integration and interoperability between different software possible.
European Committee for Standardization	CEN	European body that develops and promotes common technical standards in the European Union, ensuring interoperability and quality of products, processes and services.
Data Exchange	DATEX II	European standard for the exchange of road traffic and road management data, also used to support real-time traffic information services.
deep links	deep links	A hyperlink that leads directly to a specific page or a specific function of an application.
Demand-Responsive Transport	DRT	Demand-responsive transport systems (MOD - Mobility on Demand) are services that operate on routes and timetables defined by user demand, rather than on predetermined routes.
Data Sharing and Service Repository Facilities	DS&SRF	Technological infrastructure that ensures interaction between various operators in the sector and creates a single national access point to transport and mobility data, in interaction with the NAP.
Data and Service Repository for MaaS	DSRM	Open platform to enable the development of the MaaS paradigm, harmonizing data exchange and the use of basic technology services for different stakeholders with specific needs.
Open data formats for data management	Open formats	Formats that ensure sharing and interoperability between different systems and platforms, allowing data to be used by any operator, authority or service provider.
General On-Demand Feed Specification	GOFS	Developing extension of the GTFS that harmonizes the representation of demand-responsive transport services, facilitating the integration of DRT, public transport and other mobility solutions.
General Transit Feed Specification	GTFS	Standard data format for the representation of public transport information (timetables, routes, stops), used to integrate this information into travel planning apps.
General Transit Feed Specification-Flexible Trips	GTFS-FLEX	Extension of the GTFS allowing the representation of flexible transport services (e.g., DRT), improving the interoperability of non-conventional transport data.
General Transit Feed Specification-Realtime	GTFS-REALTIME	An extension of the GTFS that enables the representation of real-time data related to public transport, such as updates on delays, cancellations, vehicle positions and service alerts.
International Organization for Standardization	ISO	International body that develops and publishes technical standards to ensure quality, safety and efficiency of products, services and processes globally.
Intelligent Transport Systems	ITS	Technological tools using telecommunications, electronics, information technology and transport engineering, capable of offering services related to traffic management and different modes of transport, including providing users with access to traffic information.
Mobility as a Service	MaaS	A global mobility concept involving the integration of multiple public and private transport services accessible through a single digital channel.
Mobility as a Service for Italy	MaaS for Italy	A national project included in the Italian PNNR, which aims to integrate the whole public transport network in a single application, facilitating user travel through the integration of static and dynamic data.
Mobility as a Service for Emilia-Romagna	MaaS4RER	It is part of the national 'MaaS for Italy', which adapts its objectives, constraints and architecture, envisaging the provision of MaaS services through specific apps in the regional territory and the availability of travel services to and from the region Emilia-Romagna.
MaaS Integrator	MaaS Integrator	Entity that acts as a transport software integrator, with the aim of systemizing various transport services for one or more MaaS Operators, facilitating data interoperability.

National Access Point	NAP	Single access point for users to road and traffic data, updated by road authorities, road operators and service providers, covering the national territory of a Member State.
National Access Point Multi Modal Travel Information Services	NAP MMTIS	National access point for multimodal travel information services, aimed at ensuring the availability of information on different means of transport and promoting integrated travel planning.
Network Timetable Exchange	NeTEx	European standard for the exchange of static timetable and route data regarding public transport, promoting the sharing of information between different operators and systems.
MaaS Operator	MaaS service operators	A digital mobility operator that adopts technological (and often self-developed) solutions to offers users the possibility of planning and doing their journeys through 'intermediary platforms', conveying multiple transport solutions in a multi-modal approach.
Mobility operators	Operators of mobility services	Companies offering and managing mobility services, from public transport to more recent and innovative forms such as sharing mobility (free-floating or station-based systems of bicycle/scooter/car sharing).
Transport operators	Transport service operators	Entities offering public transport services, such as transport by rail, sea, air, metro, road etc.
Public Service Obligations	OSP	A regulation that defines the minimum obligations to be fulfilled in public passenger transport.
Sales Platforms	PV	Digital platforms designed to integrate multiple transport and mobility operators, enabling ticketing and payment services for transport services.
Regional Access Point	RAP	Technological infrastructure designed to collect and organize mobility data at regional level, making them accessible both to end users and to the National Access Point (NAP) at national level.
Real-Time Traffic Information	RTTI	Real-time traffic information collected from sensors, monitoring devices and alerts, useful to support user travel planning and management.
Service Interface for Real-time Information	SIRI	European standard for the exchange of public transport data in real time, used to provide up-to-date information on delays, changes and availability of means of transport.
Technical Specification	Technical Specifications	A set of technical norms and standards that define the characteristics and operating modes of a system or device.
Safety Related Traffic Information	SRTI	Security-related traffic information.
Public Transport Reference Data Model	Transmodel	Reference model for public transport data.

1. Introduction

The purpose of the document is to define an operational and technical framework aimed at guaranteeing the **interoperability of DRT systems within MaaS platforms**, promoting the integration of mobility services in an interoperable ecosystem. The document offers an outline of **operational protocols and functional and technical requirements**, which guarantee operational cohesion and coordination between the various actors involved in the development of DRT systems, ensuring their interoperability, integration into the mobility network and accessibility in the MaaS system.

Interconnection between mobility actors requires common procedures and data exchange standards to ensure information sharing, unified booking management and interoperability between services at local and regional level. The objective is to facilitate planning, management and implementation of DRT services, in compliance with current regulations, through shared data exchange standards and specifications. This report supports the adoption of unified approaches for the operational and technological management of DRT, ensuring its integration within MaaS platforms.

- *Chapters 2* and 3 offer an analysis of the concept and vision of the MaaS paradigm, as deployed in the 'MaaS for Italy' and 'MaaS4RER' projects, and a description of DRT systems and how they work;
- *Chapter 4* examines the EU technical specifications, with particular attention to the interoperability standards adopted at the European level to guarantee the harmonized integration of public transport systems
- *Chapter 4.2* is dedicated to information distribution standards, with reference to DRT, also analyzing the current critical aspects of the system and the challenges to be faced in their implementation
- the study conducted in the first chapters converges in *Chapter 5*, which proposes protocols and requirements for the implementation and integration of DRT services in the public transport network, guaranteeing interoperability and continuity of services, key elements of the MaaS paradigm.
- As a general framework, Annex 'A' of *Chapter 6* provides the regulatory framework of the guidelines and operational perimeter, where the references of directive and regulatory provisions of EU and national regimes are discussed, in accordance with the examined subject.

2. MaaS Projects

"Mobility as a Service (MaaS) is a comprehensive mobility concept that involves the integration of multiple public and private transportation services accessible through a single digital channel. Through digital intermediary platforms that combine various features and provide different travel alternatives - from public transport to car sharing, bike sharing and taxis - users can plan, book and pay for multiple services according to their needs while making a single intermodal travel experience."

Applications related to Mobility as a Service concept turn out to be in line with the dictates of the digital transition and respond to the vision of the European Green Deal: in MaaS, mobility is no longer conceived as the satisfaction of the punctual need to travel from point A to point B. A new vision is introduced in which all transportation services, public and private, are integrated into a single digital platform, enabling users to plan, book and pay for multimodal trips easily and instantly. Italy has translated this vision in a Guideline for the "Maas for Italy" project (section 2.1), promoted by the Department for Digital Transformation.

Within this national program, the "MaaS4RER" project (paragraph 2.2) represents the regional application of the national project in Emilia-Romagna. MaaS4RER is configured as an experimental project and model, capable of contributing to the construction of an integrated mobility eco-system, gathering technical refinements and administrative updates that current guidelines do not address.

2.1. Maas for Italy

Mobility as a Service for Italy (MaaS for Italy) is part of the National Recovery and Resilience Plan (PNRR)[1] with the goal of reducing dependence on the private car by promoting a public and shared transportation network that is interoperable, efficient and sustainable. In this context, **the project aims to integrate all public transport services within a single application**, facilitating the satisfaction of individual mobility needs through advanced processing of static and dynamic data, thus reducing the distance between the user and the service.

MaaS for Italy is part of the National Strategic Plan for Digital Transition and Connectivity "*Italia digitale 2026*," consistent with EU regulatory principles and the "*European data strategy*," adopting the key concepts of data promotion and sharing, as well as interoperability of transportation systems, including lines of action for:

1. test MaaS projects in various territories through pilot projects, using digital platforms and new business models, **promoting data sharing and interaction between different mobility operators**, also assessing the environmental and socio-economic impact;
2. create an open platform for mobility data, i.e., a technological infrastructure capable of ensuring effective interaction between the various operators in the sector and creating a **single national access point for available data on transport and mobility** supply in the context of MaaS;
3. strengthen the digital dimension of public transport to facilitate the deployment of MaaS in selected territories by enabling **digital payment services**, user **information systems** and **travel booking solutions**.

In addition to funding experimentation in the territories, the project envisages the State taking on a **dual role**: first, as a **regulator**, defining norms, obligations, standards and rules to ensure the interaction

[1] The government delegates management and control functions to the Ministry of Technological Innovation and Digital Transition, through the Department of Digital Transformation, which is responsible for project governance, with support from the Ministry of Infrastructure and Transport

between all actors in the MaaS ecosystem; and second, as an **enabler**, through the creation of an open platform that facilitates the effective development of MaaS.

To address this need, in accordance with Delegated Regulation (EU) 1926/2017, the creation of an enabling infrastructure, the ***Data and Service Repository for MaaS*** **(DSRM)**, designed to offer useful services to MaaS Operators, transport operators, and citizens will be funded. The main objective of the DSRM is to support the operational efficiency of MaaS services by facilitating data exchange and access to basic technology services.

The project is based on the implementation of the ***National Access Point*** **(NAP)**, a centralized digital infrastructure that collects information and data related to different transport modes, with the aim of facilitating their consultation and enabling their dissemination through a single platform.

The development path of the project includes several phases, starting with experimentation in pilot cities to test the effectiveness of the system in different urban contexts, and then gradually extending to the regional level. In this context, Emilia-Romagna is playing an active role with the MaaS4RER project, aimed at the creation and consolidation of ***Regional Access Points*** **(RAPs)**, regional platforms that will collect and transmit to the NAP/DSRM real-time data on the location of buses, trains, and sharing mobility vehicles. This data will be made available by the NAP/DSRM to MaaS Operators, i.e., companies offering intermodal travel solutions, thus contributing to construction a large interoperable network.

The goal of the DSRM is to harmonize data exchange and the use of basic technology services by the following stakeholders, each with specific needs:

- ***MaaS Operators***: entities that adopt technology solutions to enable users to plan and carry out their travel in an integrated manner;
- ***Transportation Service Operators***: entities that provide public transportation services - rail, maritime, air, metro, road, etc. - often accessible through vertical apps, but with a low level of integration with other mobility actors;
- ***Mobility service operators***: an evolving sector, including solutions such as bike and car sharing, characterized by an initial phase of diffusion thanks to the adoption of connected services, but in need of greater integration with the rest of the mobility ecosystem.

The expected benefits of the “MaaS for Italy” project are relevant on several levels. On the environmental side, the project aims to incentivize the use of public and shared transportation, contributing to the reduction of harmful emissions. On the level of territorial inclusiveness, it aims to offer mobility solutions even in areas with low demand for transport, generating positive impacts in terms of accessibility. In addition, economic and social effects are expected through the creation of new business models, the enhancement of technological innovation and the generation of opportunities for businesses.

Summary of key concepts:

- **National Access Point (NAP)** defined and regulated at the EU level, it is developed to aggregate and provide data on public and private transport services at the national level, ensuring interoperability and compliance with European standards. NAPs are central nodes within the data architecture, but they can receive information either from regional platforms (RAPs) - if present - or directly from transportation and mobility operators.
- **Regional Access Points (RAP)** are not explicitly mentioned in EU regulations. They come from the practical need to decentralize data collection in complex contexts. In Italy, the Regional Access Point concept is closely linked to MaaS implementation projects, such as the MaaS4RER project of the Emilia-Romagna Region.
- **Data and Service Repository for MaaS (DSRM),** although not directly regulated by European directives, is implemented as a national infrastructure for MaaS. Under the MaaS4Italy project, the DSRM is designed as a central tool for data and service integration, according to an architecture in which:

- RAPs collect data from local operators and transmit them to the NAP, which serves as the national central point;
- the DSRM operates as an infrastructure for storing and managing data, without collecting it directly from operators, but receiving it through the NAP.

Element	Description	Main Function	Data Source	Data Recipients	Relationship with DSRM
DSRM (Data and Service Repository for MaaS)	Digital infrastructure providing processed, ready-to-use data to MaaS Operators	Delivers updated, harmonized data via APIs	Receives data from the NAP	Provides data to MaaS Operators via APIs	–
NAP (National Access Point)	Regulated national platform collecting and distributing transport/mobility data	Standardizes and makes transport/mobility data accessible	Receives data from RAPs and/or transport/mobility operators	Supplies data to the DSRM and MaaS Operators	Provides DSRM with EU-standard compliant data, making it usable for MaaS Operators
RAP (Regional Access Point)	Regional node collecting local transport data and transmitting it to the NAP	Aggregates and transmits data to the NAP	Receives data from transport/mobility operators	Sends data to the NAP	No direct interaction with the DSRM
MaaS Operator	Apps/platforms enabling users to plan, book, and pay for multimodal trips	Uses data to create integrated app services	Receives data from the NAP and DSRM	Delivers services to end-users via digital apps	Accesses DSRM data via APIs for real-time, processed information
Transport Operators	Public/private transport companies (buses, trains, metro, taxis, etc.)	Provide schedules, routes, and fares information	Send data to RAP (if present) or directly to NAP	Their data feeds the NAP (and indirectly the DSRM)	No direct interaction with the DSRM
Mobility Operators	Companies offering ancillary services (car/bike sharing, parking, etc.)	Share availability, pricing, and accessibility data	Send data to RAP (if present) or directly to NAP	Collaborate with MaaS Operators to integrate services	No direct interaction with the DSRM

Table 2-1 Element, roles and functions in the MaaS

Examples for each element defined in Table 2-1**:**

- ***DSRM (Data and Service Repository for MaaS)*** receives data such as train and bus schedules, availability of car sharing vehicles, prices and fares from the NAP. It organizes this information in a standardized format, making it uniformly accessible to MaaS apps via APIs;
- ***NAP (National Access Point)*** collects data from RAPs, if any, or directly from transportation and mobility operators. It standardizes the information received and transmits it to the DSRM for processing;
- ***RAP (Regional Access Point)*** receives data from accredited transportation and mobility operators, such as bus schedules for a particular province or area, and transmits it to the NAP;
- ***MaaS Operator*** uses data from the DSRM to develop its own services. For example, it may leverage the DSRM API to display the availability of car sharing vehicles near a train station or to provide multimodal mobility solutions to reach a destination;
- ***Transport operators*** provide key data and information about their mobility offerings, such as routes, schedules, and fares. They transmit their data directly to the NAP or RAP, if any;
- ***Mobility operators*** share data about their complementary service offerings, such as bike sharing, transmitting real-time availability to the NAP or RAP, if any.

The following subsections will analyze the *Policy Framework for "MaaS for Italy"*, which defines the vision (ref. § 2.1.1), the architecture and the role of all the actors and elements involved in the development of the project (ref. § 2.1.2 and 2.1.3)

2.1.1. Vision

MaaS vision is illustrated in the "***Policy Framework and Guidelines for the implementation of "MaaS for Italy" Project***" (hereinafter Policy Framework), with which the State aims to support the development of new large-scale mobility systems. The aim is to optimize the integration between public and private transport, making mobility more efficient, sustainable, inclusive and digital, facilitating internal travel and intermodal connections through a user-centered approach. Local public transport companies, operating in compliance with public service obligations, must be integrated and empowered to collaborate with other operators in the sector to improve the overall quality of services offered. **MaaS solutions enable the creation of a multimodal ecosystem based on user needs, improving accessibility to services through the personalization of options**. A system structured in this way would ensure efficient travel and immediate access to different mobility solutions. The goal is to push for a modal shift toward sustainable and shared forms of transportation, reducing dependence on the private car and limiting traffic-related negative externalities.

To ensure effective planning and integration of service supply, a synergistic approach is needed to coordinate policies among various mobility services and new MaaS operators. In addition, strategic use of the data generated will achieve concrete benefits for both users and governance by improving operational efficiency and optimizing service delivery in urban areas. The project takes a **multi-territory approach** to ensure continuity in the travel experience throughout the urban and intercity mobility chain, facilitating connections between cities, territories and regions. This vision aims to promote harmonization and territorial cohesion by making **MaaS services interoperable** nationwide and **including areas with low demand for transport**, through solutions targeted to their specific needs.

This multi-territorial dimension in the constructive approach, along with the personalization of transport supply, increased accessibility and balanced distribution of services across the territory, emphasizes the **"social" role of mobility as well**, conceived as an essential service for citizens.

MaaS also represents an opportunity for digital economy companies active in the mobility sector. The approach proposed by "MaaS for Italy," in addition to protecting and enhancing pre-existing investments made by public and private entities, aims to facilitate the entry of new economic operators, expanding opportunities for growth and innovation in the sector.

2.1.2. The architectural scenario

As described in the document "*Policy Framework*," the architectural scenario of MaaS envisions a system in which **multiple MaaS Operators compete with each other**, offering modular and scalable travel solutions over a wide territorial span.

To ensure efficiency and integration, the sharing of transportation data is critical. However, without clear regulation, shared standards and a central coordination, the system risks fragmentation, generating dominant positions, duplication and inefficiencies. To overcome these critical issues, the proposed model is based on business-to-business integration, which allows MaaS Operators to access data and transport services through dedicated layers, ensuring interoperability and standardization. In this context, the **National Access Point (NAP) plays the role of central hub between transport operators and MaaS Operators**, ensuring a coordinated and efficient ecosystem. The NAP acts as a technological intermediary, **preventing each MaaS Operator from having to connect separately to the various transport providers, each with different formats and modes**. Through this infrastructure, all operators send their data to the NAP, which

collects, standardizes and transmits it to the DSRM. In this way, MaaS Operators access a single data point, simplifying the integration of transport services.

In the International Association of Public Transport's (UITP) "*Policy Brief MaaS*[2]" document, this integration layer is identified with an open platform, *Open Back-End Platform*, designed to offer services to operators (MaaS model 2), according to the diagram shown in Figure 2-1. In this vision, "MaaS for Italy" entrusts public authorities and involved entities with a dual role: on the one hand, to **establish rules, obligations and standards to ensure the interoperability of the MaaS system**; on the other hand, to **facilitate MaaS Operators through digital infrastructures designed to support the development of the model through an open platform**. Delegated Regulation (EU) 1926/2017 (ref. § 6.1.3) introduced rules on data sharing in the mobility sector, but there is still no specific regulation for MaaS platforms. Indeed, these platforms are not limited to selling tickets or travel packages, but can influence the choices of users and operators, for example by suggesting routes or promoting specific solutions. The use of big data, artificial intelligence, and nudging can affect market dynamics, requiring a clear regulatory framework to ensure balance and fair competition.

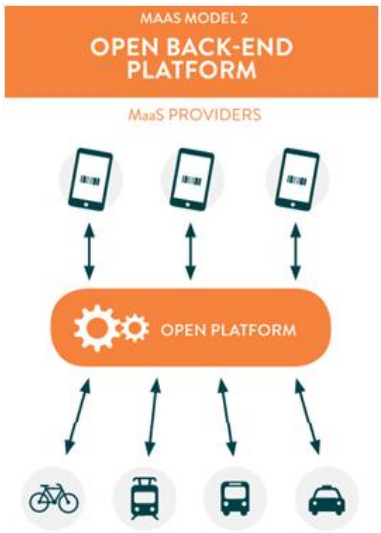

Figure 2-1 MaaS model-2 scheme

"Open platform" infrastructures must ensure interoperable data sharing, consistent with the principles set out in Delegated Regulation (EU) 1926/2017 and, in combination with the provisions of Delegated Regulation (EU) 490/2023, through standard procedures and protocols that ensure effective interaction between MaaS Operators, transport operators and authorities.

In the **MaaS for Italy** vision, the **testing phase will highlight critical issues and the possible need for specific regulations**. Thus, it is important to monitor the impact of MaaS in different contexts to ensure that the **results will guide public policies and regulations for MaaS development**.

2.1.3. Data Sharing and Service Repository Facilities

Data Sharing and Service Repository Facilities ***(DS&SRF)*** is a digital platform designed to **facilitate integration between transport operators and MaaS developers** by providing tools for data sharing and fostering interoperability between services. This infrastructure extends the functionality of the National Access Point (NAP) to the MaaS domain by introducing specific tools to support its development and ensure integration.

While the NAP collects and distributes general transport data, the **DS&SRF adds advanced opportunites to optimize the operation of MaaS apps and systems**. The integration between the NAP and DS&SRF creates a "***national digital desk***" simplifying market access for companies and facilitating the development of new services. **Through the DS&SRF, transport operators can connect with MaaS app developers**, making data such as timetables and routes available according to standards and technical specifications recognized by EU regulations (e.g., NeTEx, SIRI), thus ensuring a coordinated ecosystem. This platform is designed to test new ideas and pilot projects, funded under PNRR, Investment 1.4.6, which may form the basis of an operational nationwide MaaS system in the future.

It is useful to **distinguish the DS&SRF from the DSRM**, as the Data and Service Repository for MaaS is focused on the operational efficiency of MaaS, while the DS&SRF is an infrastructure designed to support MaaS integration and experimentation. In essence, ***the DS&SRF is a platform that helps building the MaaS, while the DSRM optimizes its operation***.

[2] https://cms.uitp.org/wp/wp-content/uploads/2020/07/Policy-Brief_MaaS_V3_final_web_0.pdf

Feature	DSRM (Data and Service Repository for MaaS)	DS&SRF (Data Sharing and Service Repository Facilities)
Main Objective	Support MaaS Operators by providing optimized and ready-to-use data	Facilitate integration between transport operators and MaaS Operators
Role	Collects data from the NAP, unifies, standardizes, and organizes information from different sources, making it easily usable by MaaS Operators	Enabling platform that provides tools for collaboration and integration of MaaS data, supporting cooperation between transport operators and service developers
Relationship with NAP	Receives standardized data from the NAP and processes it to make it usable by MaaS Operators	Extends the NAP by introducing MaaS-specific tools, such as APIs for data integration, support for multimodal navigation, and experimentation with new services
Main Function	Provides updated and harmonized data to MaaS Operators, through APIs, to facilitate integration of transportation and mobility services	Provides tools to integrate and test new mobility models, supporting pilot projects funded by the PNRR
Target	MaaS Operators (MaaS app and service developers)	MaaS Operators and MaaS app developers
Long-term Goals	Harmonize data exchange and improve data accessibility for MaaS Operators	Become the "national digital desk" for MaaS, helping companies to enter the market and develop new services

Table 2-2 Comparison of DSRM and DS&SRF

In brief:

- the **DSRM provides the basic information infrastructure** essential to any MaaS ecosystem, ensuring that all actors use a common language in terms of mobility data;
- The **DS&SRF**, on the other hand, represents a more advanced level of ecosystem maturity, it is an operational platform that, relying on that standardized data, **allows for the coordinated and centralized management of the complex interactions** typical of MaaS, from the integration of the transport supply to ticket sales.

The choice between the two frameworks is not alternative, but complementary. A mature MaaS system requires both: on the one hand, a robust open data sharing framework (DSRM/NAP) as the foundation; on the other, a shared services platform (DS&SRF) to fully implement the MaaS paradigm in a harmonized and user-friendly way.

In MaaS for Italy project, the national integration layer, represented by the "*open platform*" based on the DS&SRF, is the central element to enforce the rules and create the necessary conditions for the development of MaaS solutions. This infrastructure is designed to **ensure interoperability among operators, supporting the development of solutions and services and providing basic data and features**, as illustrated in the diagram in Figure 2-2.

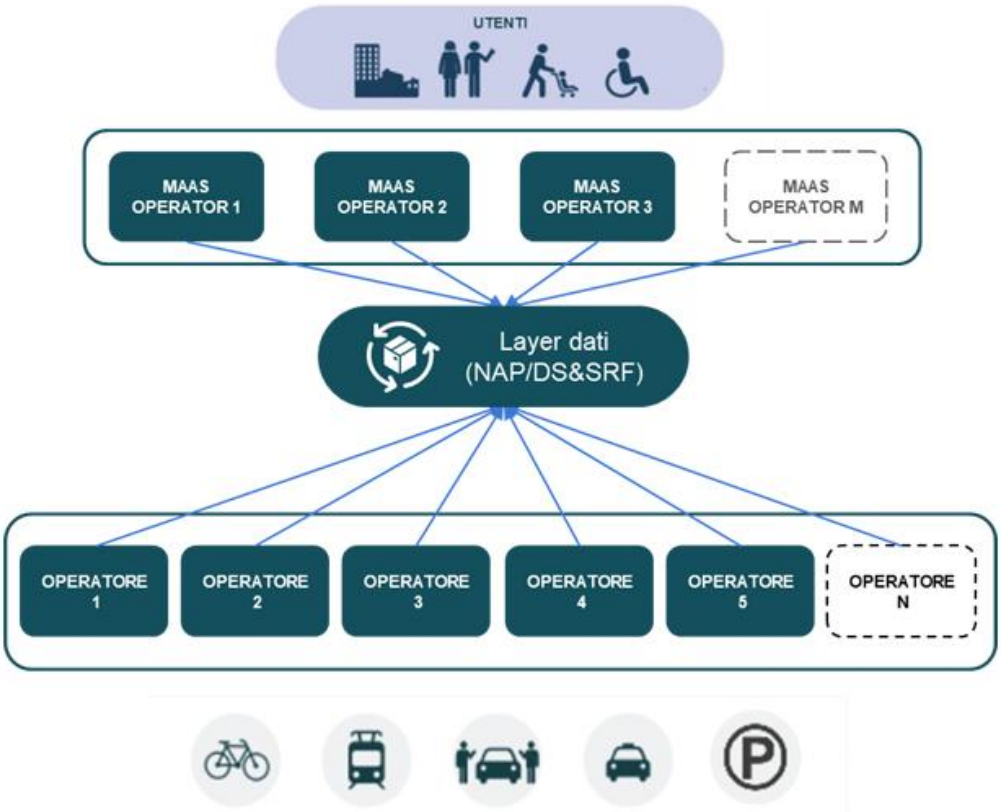

Figure 2-2 NAP/DS&SRF as enabling tools

The DS&SRF extends the NAP to the MaaS application context, adopting an integration model designed to provide:

- ***a dedicated and specialized national access point for MaaS***;
- ***an integrated support for MaaS Operators***, through a platform that combines specialized tools and services to facilitate the development of innovative and competitive solutions, simplifying the technological and organizational complexities of the industry and ensuring inclusive access to the MaaS market;
- ***an API Gateway system***, a digital interface that facilitates communication between different applications and services using APIs (Application Programming Interfaces).

APIs are IT tools that make accessible features, software or data already developed for a specific domain. These resources can be used to create new applications or services within the same ecosystem. As a gateway, the system is designed as a strategic access point for digital solutions developed by third parties, enabling MaaS players to integrate new services and features, ensuring full consistency with the national MaaS architecture and promoting an interoperable and efficient ecosystem.

Functionality of the DS&SRF:

- **uses NAP** and integrates with it to provide **dedicated and optimized access to all** static and dynamic **data and tariffs** of transport and mobility operators, obliged by regulation to expose their transport services on the NAP;
- allows all mobility operators, including those not obligated by Delegated Regulation (EU) 1926/2017, to **expose their transport services** to MaaS operators;
- **extends NAP** with the transposition of any **commercial agreements**, also keeping track of confidential ones, established between transport, mobility and MaaS Operators;
- performs functions of:

  - **extraction and navigation** of NAP **data** for MaaS Operators;

- exposure of **dematerialized sales services**, external to the DS&SRF itself and fundamental to implementing MaaS solutions;
- exposure and use of any **commercial agreements** between operators, made external to the DS&SRF, but made usable by it;
- exposure of **secure and protected communication channels** between MaaS Operators and transport and mobility operators, to facilitate and make as automated as possible the operation of defining and formalizing (consolidating) trip chains;
- **secure, safe and incontrovertible recording** of agreed and implemented trip chains;
- implementation of an efficient mechanism for the **circulation of dynamic data** on transportation services between NAPs (and thus transportation/mobility operators) and MaaS Operators, including with the possible assistance of regional or metropolitan-based systems.

The DS&SRF features listed above make it possible to:

- facilitate the opening of the MaaS market by facilitating contact between transport/mobility operators nationwide who wish to offer their services and MaaS Operators interested in intermediating them. The DS&SRF does not require the presence of pre-existing commercial agreements between the parties, but still supports the utilization of any existing agreements; it also enables the creation of **multi-operator and multi-modal trip chains** through a consensus mechanism, including temporary consensus, among all actors involved;
- constitute a potential tool for the **management of regulatory aspects,** enabling interaction among accredited actors and making such interaction and accreditation subject to compliance with a predefined system of rules;
- **define uniform national specifications**, in line with industry standards, so that each MaaS Operator uses predefined interfaces and methods to interact with transportation and mobility services;
- foster:
  - the **interregional/national dimension** of MaaS;
  - **access** to the MaaS ecosystem **even by small operators**, both on the transport/mobility services side and on the MaaS Operator side;
  - **competition among players**, even outside pre-existing commercial arrangements;
  - the **inclusion** and spread of the MaaS ecosystem even **in areas with limited transportation demand.**

Regional Access Points

The architecture based on the national open platform, developed around the DS&SRF, ensures convergence and harmonization in a broad and integrated system, within which additional actors and technological systems find their place, as an integral part of the national system.

Mobility data for different modes of transport are **provided to the multimodal National Access Point** (NAP) by transport authorities, operators, infrastructure managers and service providers**, through Regional Access Points (RAPs)**, which act as territorial aggregators. RAPs collect and structure data according to defined specifications and standards for the management and distribution of public transport information.

The implementation of Regional Access Points (RAPs) is not expressly demanded in the EU regulatory legislation, but it meets a structural need, as it allows for the harmonization, within a national vision, of resources and initiatives that in some areas are already active and in others are being developed. **RAPs collect static and dynamic data at the regional level, facilitating the participation of transport and mobility operators in the integrated NAP/DS&SRF system, including from a technological perspective.**

The role of RAPs is **strategic in the management of dynamic data**, as it allows the processing load and the large amount of data to be distributed across multiple layers, **avoiding overloads on the NAP** and optimizing the digital infrastructure of transport and mobility operators. To ensure a harmonized and efficient system, **interoperability between RAPs and NAP is ensured by compliance with the technical specifications**

established by the Delegated Regulators (EU) (ref. § 4) and their current profiling, made possible by the NAP extension developed under "MaaS for Italy".

	Regional Access Points (RAP)
Role	Aggregators and spatial integrators that collect and harmonize transportation data at the regional level;
Data source	They receive data from transport authorities, transport operators, infrastructure managers, and mobility service providers;
Data recipients	They forward data to the NAP/DS&SRF, which makes it available to MaaS Operators and other actors in the MaaS system;
Main function	- collect and structure data in standardized formats, according to technical specifications; - assist the integration of transport operators with the NAP;
Interaction with the NAP	They collaborate with the NAP/DS&SRF system, ensuring interoperability through technical specifications and standard transmission protocols;
Benefits of the RAP system	- distribute the processing load to avoid overloads on the NAP; - facilitate data integration at the national level; - support the adoption of innovative protocols, although not yet mandatory;
Reference legislation	Not mandatory under EU legislation, but planned as part of the national MaaS architecture in accordance with Delegated Regulation (EU) 1926/2017;
Role in PNRR projects	Part of the NAP extension developed in the "MaaS for Italy" project to improve data management and integration between transport operators.

Figure 2-3 Feature of RAP

MaaS Integrator, MaaS Operator and Point of sales

The "***MaaS Integrator***" is responsible for **integrating and coordinating different mobility services**, both public and private, **making them available to one or more MaaS Operators**, with the goal of providing end users with unified and simplified access to all transportation solutions through a single digital platform.

The "***MaaS Operator***" is a **digital operator that provides users with app or platform to combine different transportation solutions in a multimodal perspective**. It integrates mobility services using its own or third-party technologies, enabling travel planning, booking, and execution. It also negotiates agreements with transportation operators, aggregates MaaS offerings, ensures compliance with regulations, and collaborates with public agencies, leveraging NAP data.

MaaS Integrators play a key role in the development of MaaS for Italy, integrating mobility offerings for one or more MaaS Operators. In a DS&SRF-based MaaS system, they must leverage its functionality and adapt it to local needs, managing RAPs, administering sales platforms, and facilitating the introduction of integrated fares. The DS&SRF, as a repository of services based on an open platform, provides essential tools to MaaS Operators, which MaaS Integrators must necessarily refer to create an integrated and interconnected eco-system.

Both MaaS Integrators and MaaS Operators stand between the demand for mobility (the end users who commute) *and the supply of mobility services* (the various transport operators, public and private, with their assets and services).

Feature	MaaS Integrator	MaaS Operator
End User Contact	Has no direct contact with the end user. Works in a B2B or B2G context, supporting MaaS Operators and public institutions;	Has a direct relationship with the end user. Works in a B2C model, offering apps and platforms for accessing mobility services;
Main Functions	Integrates and organizes data and services from different transport operators, ensuring their interoperability;	Provides end users with multimodal solutions (e.g., apps to plan trips and buy tickets);
Example	Collects and organizes information from buses, metro, car sharing, etc., making it available to MaaS Operators;	Uses data provided by the MaaS Integrator to create apps that allow users to plan trips and pay for services through a single platform.

Table 2-3 Comparison of the main features of MaaS Integrator and MaaS Operator

A second group of technology-driven territorial aggregators and integrators are dematerialized "***Point of sales***" (PVs) platforms, which are designed to integrate multiple transportation and mobility operators, enabling **ticketing systems and managing the payment of mobility services**. Transport and mobility operators can make their sales services available through two modes:

- *direct access through the DS&SRF*, exposing their digital sales channels and allowing MaaS Operators to manage payments for the portion of travel provided;
- *sales through third-party platforms*, which integrate multiple operators and enable centralized management of payments.

The sales platforms involved in the national system of "MaaS for Italy", as well as the operators sales channels, must guarantee non-discriminatory access to DS&SRF-accredited MaaS Operators, ensuring the availability of their services.

In summary, Figure 2-4 depicts the conceptual architecture of the "MaaS for Italy" project, highlighting the role of the described integrators and aggregators and the participation of some transport operators in third-party or integrated sales platforms.

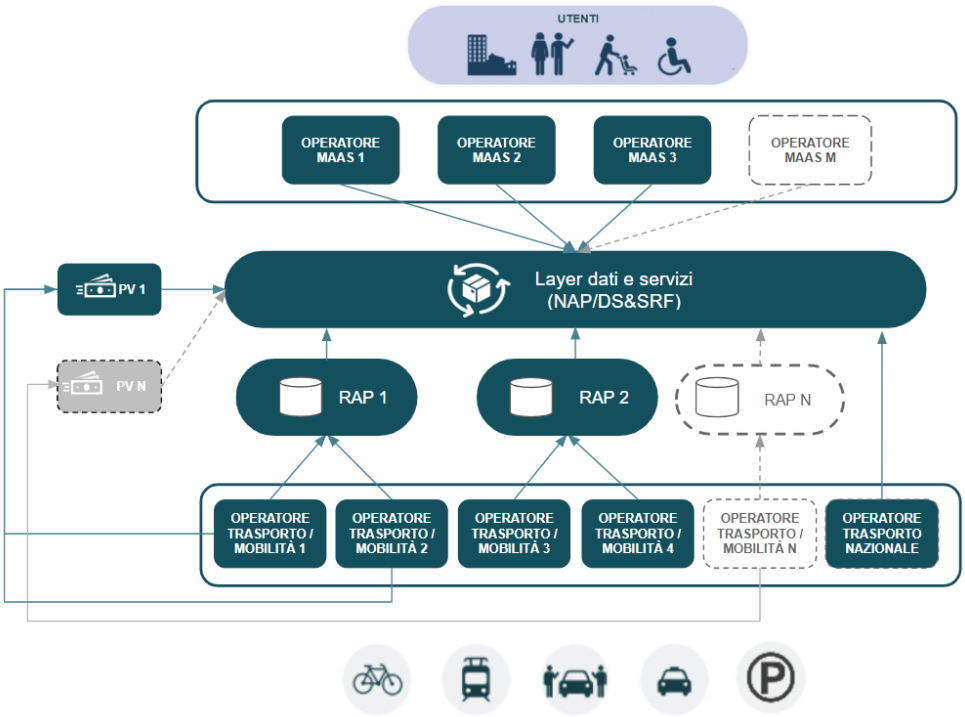

Figure 2-4 MaaS for Italy conceptual architecture

From the figure above, it is possible to detail the flow of information and actions that enable users to access and use mobility services.

1. **Transportation and mobility operators** (e.g., buses, trains, car sharing, bike sharing, parking, etc.) provide and send their data to the **Regional Access Points** (RAP) and the **Data and Services Layer** (which includes the NAP and DS&SRF).
2. The **access points** (RAP and Data and Services Layer) **collect and distribute data**:

   - **RAPs** (Regional Access Points) coordinate and manage the data collected at the regional level, ensuring **localized and accurate integration**;

- The **Data and Services Layer** (which includes the NAP) acts as **a central hub** to collect, organize, and distribute data at the national and regional levels.

3. MaaS **Operators** receive data from RAPs and the Data and Services Layer:
   - **MaaS Operators** (e.g., apps or digital platforms such as MaaS 1, MaaS 2, MaaS 3, etc.) access aggregated data from the Layer and RAPs to offer **integrated services to users**;
   - They use this information to provide multimodal mobility solutions (booking, planning, payment).
4. Interface with **Points of Sale** (PVs):
   - Points of Sale (PVs), both physical and virtual, can access data from the Layer to provide **additional services**, such as ticketing or access terminals for MaaS services.
5. **End** users **access MaaS services through MaaS Operators**:
   - Users use MaaS Operators' digital platforms to plan, book and pay for their trips in an integrated way;
   - They can combine different means of transportation (bus, train, cab, car sharing, parking, etc.) into one optimized solution.

Finally, it is worth noting that the "*Policy Framework*" represents a reference adopted by the delegated entities[3] as a summary of the shared vision on MaaS, as well as implementation guidelines for projects related to these investments. Therefore, the outline illustrated in Figure 2-4 should be interpreted as a conceptual representation, since it will be the experimentation process, through the contribution of the pilot projects supported by the DS&SRF, that will outline and specify the details and, if necessary, introduce specific technological or organizational elements for the proposed solutions, avoiding duplication of the functions attributed to the DS&SRF, the NAP and the RAPs, and without altering the model of interaction envisaged between the operators.

2.2. Maas4RER

"*MaaS4RER*" is an integral part of the national "MaaS for Italy" measure, adopting its objectives, constraints and architecture. It envisages the **development of RAP and the delivery of MaaS services through dedicated apps in the regional territory, while ensuring the availability of travel solutions to and from Emilia-Romagna**. Services should also be accessible for areas covered by transportation and mobility operators outside the region, **using the national DS&SRF system**.

Emilia-Romagna has commissioned the company Lepida to develop the RAP platform and select the MaaS Operators who will participate in the pilot. The latter will have to be able to provide mobility services according to the MaaS paradigm, including through in-house apps, adopting pay-as-you-go modes or service packages functional to the experimentation of MaaS systems. The selected MaaS Operators will operate on a competitive basis, allowing users to subscribe independently to one or more of the services offered. **Central goal of the project is the integration between MaaS Operators and mobility operators**. Through the signing of commercial agreements, the public transport companies involved will be able to make their travel tickets available to MaaS Operators. The project phases include the testing of a regional digital platform for intermodal travel, which will enable the exchange of data between different transport operators at the regional and national levels. This platform will be accessible to MaaS Operators through specific agreements, allowing them to offer intermodal mobility packages to users through dedicated apps.

[3] by the Italian Government of the Ministry of Technological Innovation and Digital Transition, with the active support and contribution of the Department for Digital Transformation and the Ministry of Infrastructure and Transport, for the implementation of Mission 1 - Component 1 of PNNR

MaaS Operators already active in the territory will be asked to collaborate in the user recruitment phase, through in-app marketing actions or email marketing campaigns aimed at their customers, with the aim of promoting membership in the "MaaS4RER" initiative.

The developed **platform will act as a RAP** and will be able to **collect and organize mobility data at the regional level, making it accessible to the National Access Point (NAP)**. Architecturally, an **infrastructure will be built to ensure interoperability between RAP, NAP and DS&SRF**, integrating static and dynamic transportation data and making mobility services usable. This infrastructure will enable direct flows with individual transport operators and the use of shared APIs among the different layers and actors in the MaaS ecosystem. Among the planned macro-functions is the MaaS Service for Users, which will enable the integration of all data into a travel planner on a regional and national scale, involving all mobility operators. This approach, in line with EU directives and included in the guidelines for implementing MaaS in Italy, is designed to provide a seamless and barrier-free mobility experience, ensuring full interoperability between regional and national services.

A distinctive aspect of the "MaaS4RER" project is the strong active participation of users in the testing phase. Their involvement not only promotes the adoption of the platform but also enables the collection of useful feedback for its improvement. During the testing phase, 2,500 experimental users will be involved, having the opportunity to test the platform and receive incentives on the basis of the trips made, such as welcome bonuses and monthly cashback on travel tickets purchased through the app. Finally, from a scientific point of view, the University of Bologna - responsible for project analysis and evaluation - will conduct studies ex ante and ex post to measure the impacts of the activities. The analysis will involve processing the data collected during the experimentation and drafting a report with recommendations to optimize the system and evaluate its extension on a larger scale. In addition to aspects related to accessibility of transportation services, the *"MaaS4RER" project contributes to achieving the goals of "MaaS for Italy"* by feeding the National Access Point with regional data and testing replicable models in other regions of the country.

3. Demand Responsive Transport (DRT)

Demand-Responsive Transport (DRT) is a form of shared mobility that, unlike traditional fixed-route public transport, dynamically adjusts its service in real time to meet passenger demand within a clearly defined operational area. These systems sit in a hybrid position between scheduled and non-scheduled public transportation, responding to the growing consumer need for flexible transportation services capable of operating on patterns that are not rigidly predetermined, both in terms of stops and routes. When properly integrated with standard local public transport services, they can generate significant community benefits, helping to rebalance modal split in favor of public transport.

The definition of **"operational service areas**," where traditional routes give way to flexible service, opens up new perspectives in terms of integration and coordination of local mobility. In this context, the institutions involved play a central role in promoting and implementing these **new operational frameworks**, acting as prime movers of territorial needs. The adoption of transportation models based on operational flexibility requires **synergistic cooperation** between local governments, public transport operators and communities in order to ensure proper implementation and rapid user adherence. The definition of operational areas not only allows for a more effective response to local mobility needs, but also provides an opportunity to actively **involve the community in the decision-making process** through ongoing consultations and feedback, promoting a bottom up participatory approach that fosters virtuous policies for building a public transportation network tailored to local needs.

After a description on the general concepts and characteristics of DRTs, section 3.1 will explore how these services work, concluding with a comprehensive overview.

3.1. The operation of DRT

In the transportation sector, there is an intermediate category between collective and private public transport, known as **Flexible Transport Service** (FTS), of which DRTs are a component. DRTs involve the definition of a specific area and main pick-up points, offering greater flexibility in the organization of routes and stops, as well as in the choice of schedules by users, adapting to demand rather than following a fixed timetable or predetermined route.

This type of service covers the last hierarchical level of the transportation network, that is what is not already covered directly by the primary network and complementary lines. By analyzing the demand for mobility within each basin, an efficiency threshold can be identified, below which the provision of traditional services would be ineffective. In these cases, it is more appropriate to adopt DRT services, favoring flexibility in terms of both timetables and routes. As a result, traditional lines are transformed into **"operational service areas"** in which there is no longer a predetermined route, but a perimeter within which it is possible to take advantage of connections and meet one's mobility needs, in integration and support of the primary service network. These operational service areas are defined on the basis of several factors, including transportation demand, infrastructure availability, operational sustainability, and service priorities, and therefore can vary widely in size and characteristics, including both high-density urban areas and rural or suburban communities that are less served by conventional means of public transportation. The concept of **"flexibility"** is the key element of this type of transportation, allowing the service to be tailored to the specific needs of passengers based on the operational configuration established for each area.

The different configurations of flexible transportation services make it possible to respond effectively to both territorial and user needs. These services are developed along **three main dimensions**: ***"routes and times"***, ***"reservation modes"***, and ***"network types"***[4].

[4] G.Ambrosini, M.Romanazzo, *"I servizi flessibili di trasporto per una mobilità sostenibile"*. Editore ENEA, 2002

Routes and Times

This dimension describes the structure of routes and the flexibility of schedules:

- *predefined routes with partially fixed schedules*: services follow an established route, but schedules may vary partially;
- *scheduled service with detours on predefined routes in a corridor*: the vehicle mainly operates on a defined corridor, but may make detours to serve specific requests;
- *predefined stopping points within a corridor*: users can access the service at predetermined stops along a transit corridor;
- *predefined stop points within an area*: the service offers defined stops in a larger geographic area;
- *origin/destination points within an area*: users can be picked up or dropped off at any point within a predefined area;
- *combined service scenarios*: combination of different approaches to maximize efficiency and service coverage.

Reservation Mode:

Reservation mode is a key aspect in flexible transportation services:

- *reservationless travel*: direct access to the service without the need for advance planning;
- *immediate booking*: service can be requested in real time via app, phone or other digital tools;
- *wide time window - trip notification*: users book well in advance and receive confirmation later;
- *request capture - service planning*: requests are collected in a defined time window to plan the service;
- *combined modes*: integration of different booking modes to meet the needs of various users.

Network Types:

Flexible transportation networks can be configured according to the structure of routes and stops:

- *networks with fixed routes and fixed stops:* which follow a rigid pattern for operational simplicity;
- *networks with flexible routes and fixed stops*: the route adapts to the demands, but the stops remain predetermined;
- *networks with flexible routes and stops*: maximum flexibility, with routes and stops varying dynamically according to demand.

Within the operational areas, transport operations are managed through software and technologies capable of handling passenger bookings, optimize vehicle routes even in real time, and respond dynamically to the transport demand of the individual applicant. This service architecture makes it possible to offer a more **personalized and flexible alternative** to traditional bus services with fixed schedules and routes. **"Flexibility"** and **"dynamism"** allow operating areas to be updated to adapt to transportation needs, improving the service and ensuring its sustainability over time.

Operational areas, in addition to allowing internal travel, ensure connections with the first-tier network, facilitating accessibility to the major metropolitan and city hubs of attraction. Thus, scheduled public transport acquires the flexibility of non-scheduled transport, improving efficiency and attractiveness compared to the private car. DRT service can serve areas with more dispersed or less predictable demand, allowing users to connect to public transport without having to extend or densify the traditional network. Due to the absence of predetermined routes, the system adapts to users' needs, integrating with public transport and improving its offerings. This model also makes it possible to serve suburban areas during off-peak times for school and commuter traffic, supplementing or temporarily replacing LPT lines with dial-a-ride services or targeted detours, following a hierarchical local public transport network logic.

4. Technical specifications and standards for the management and distribution of public transport information

4.1. EU technical specifications for public transport interoperability

The adoption of **"open formats"** for data management is one of the fundamental principles of European policies on standardization and uniformity in information processing. Unlike proprietary formats, open formats allow sharing and interoperability across different systems and platforms, ensuring that data can be used by any operator, authority or service provider. This approach underpins the development of EU technical specifications in the transportation sector, with the aim of unifying the mobility ecosystem and making traffic management and public transport services more efficient. As highlighted in the Regulatory Annex of Chapter 6, the European Union has played a key role in promoting operational standards. The ITS Directive (EU) 2010/40 and its associated Delegated Regulations, in particular Delegated Regulation (EU) 1926/2017, have defined a clear regulatory framework for the development of ITS, imposing shared technical specifications to improve accessibility, interoperability and integration among mobility actors, ensuring continuity between systems. In line with these goals, the European Commission has launched initiatives to support the development of open standards, such as DATEX II, NeTEx and SIRI, in collaboration with international standardization bodies such as the European Committee for Standardization (CEN) and the International Organization for Standardization (ISO).

The *Public Transport Reference Data Model* (**Transmodel**) serves as a conceptual reference model and provides the theoretical framework for consistently representing public transport schedules, routes, stops, fares and infrastructure, ensuring interoperability between operators and digital platforms. Transportation operators must adapt their systems to the interoperability requirements of Delegated Regulation (EU) 1926/2017, which established the National Access Point (NAP) and mandates the use of standardized data formats:

- *Data Exchange* (**DATEX II**), a road traffic management-specific data exchange format used for sharing information on traffic flows, incidents and road conditions in real time. It is not based on Transmodel, but follows ITS standards to ensure interoperability with transportation infrastructure;
- *Network Timetable Exchange* (**NeTEx**), based directly on Transmodel, used to exchange data on public transportation schedules, routes, stops and fares, implementing the network and service definitions needed to feed multimodal travel planning platforms and enable data exchange between different transportation operators;
- *Service Interface for Real-time Information* (**SIRI**), designed to provide real-time information to users about transportation arrival times and service disruptions, using Transmodel concepts for dynamic event management and data transmission.

The **integration** between the Transmodel model and the DATEX II, NeTEx and SIRI specifications **enables** all mobility actors **to operate on a common, shared and interoperable EU-wide database, supporting the integrated management of each multimodal network system**.

As an introduction, Table 4-1 highlights the CEN standards required for data exchange with the National Access Point MMTIS, which will be analyzed in detail in sections 4.1.1 through 4.1.4.

	Transmodel (EN 12896)	DATEX II (CEN/TS 16157)	NeTEx (CEN/TS 16614)	SIRI CEN/TS 15531)
Focus	Conceptual data model for public transport	Independent of Transmodel, based on ITS standards for traffic and travel data exchange	Derived from Transmodel, used for exchange of static data related to public transport timetables and networks	Derived from Transmodel, used for real-time data exchange in public transport
Scope	Reference model for data structure, basis for NeTEx and SIRI, but does not directly perform planning	Information on traffic, accidents, and road conditions	Information on timetables, facilities, and fares of public transport services	Dynamic information: delays, cancellations, occupancy level
Real-time	The model defines dynamic data as a concept, but does not transmit it. SIRI implements real-time management	Supported, but not primary	Not applicable	Designed for real-time
Data type	Conceptual: network models, resources, scheduling	Static and dynamic (e.g., weather, incidents)	Static (schedules, networks, fares)	Dynamic (delays, route changes, arrival forecasts)
Examples of use	Basis for managing and planning transportation services	Monitoring road conditions, traffic infomobility	Multimodal travel planners, fare systems	Passenger information systems, real-time operational management
Standard format	This is a reference model, not a technical specification	XML (based on DATEX II schema)	XML/JSON for interoperability with other systems	XML, with extensions for specific needs
Interoperability	Reference basis for NeTEx and SIRI	Specific for roads and traffic, compatible with other ITS networks	Based on Transmodel, compatible with SIRI for dynamic data	Based on Transmodel, compatible with NeTEx for static data

Table 4-1 CEN technical specifications compared

4.1.1. Transmodel, the reference model

Formalized as CEN/EN 12896 standard, the *Public Transport Reference Data Model* (Transmodel) provides a consistent framework for implementing the requirements of the ITS Directive 2010/40/EU and Delegated Regulation (EU) 1926/2017, fostering the integration and interoperability of public transport systems. Transmodel provides a **baseline for the design of databases**, which are essential for storing and exchanging data between applications via standard interfaces. Transmodel is not directly usable for data exchange but provides guidelines for the development of intelligent transportation systems, it ensures consistency and interoperability between different technological solutions. Transmodel defines the **European conceptual reference model for the representation and management of network transportation data**, forming the basis for specific standards such as NeTEx and SIRI, which implement selected portions of the model for practical purposes.

Transmodel establishes a "***common terminology***", facilitating the integration and exchange of public transportation data in a consistent and structured manner. Its architecture allows for a unified description of all aspects of public transportation, from routes and schedules to fares and infrastructure information. Its main applications include:

- *public transport management*, enabling operators to plan, monitor and optimize the delivery of mobility services;
- *multimodal integration*, combining data from different operators or transportation modes into a single platform, fostering MaaS solutions;

- *trip planning*, supporting the development of applications that can provide users with accurate and comprehensive information on routes, schedules, and fares.

The CEN/EN 12896[5] technical specification is organized into thematic modules or "**Parts**," which **describe specific functional areas of public transportation**. This modular division facilitates understanding and adoption of the model by agencies, operators and transport managers interested in particular application domains, making it a flexible tool that can be adapted to different contexts. The modular architecture covers all aspects of public transportation, including the definition of routes, stops, stations, multimodal interconnections, schedules, trip planning, frequencies, and connections between routes. It also provides a framework for static and dynamic user-facing information management and fare structure modeling, promoting interoperability and integration between systems.

The main parts of the Public Transport Reference Data Model include:

1. "*Common concepts*", which defines the basic concepts and data structures used throughout the model, providing consistent terminology for the other sections;
2. "*Public transport network*", which describes the topology of the public transportation network, including routes, lines, travel patterns and scheduled stop points;
3. "*Timing information and vehicle scheduling*", which covers travel time management, vehicle scheduling, and schedule planning based on weekdays and holidays;
4. "*Operations monitoring and control*", focused on monitoring daily operations and proactive control for internal public transportation operational management, implemented through corrective decision support actions in response to detected events;
5. "*Fare management*", which includes the definition of fare structures, access fees, sales methods, validation and control of tickets;
6. "*Passenger information*", which covers the provision of both static and dynamic information for public transport passengers, including planned information such as schedules and routes, as well as real-time updates on delays or service changes. The model supports the management and distribution of this information through various channels, ensuring that passengers have access to accurate and up-to-date data for effective planning of their trips;
7. "*Driver management*", which focuses on the scheduling and management of driving personnel, including shift planning, assigning drivers to vehicles and monitoring their operational performance;
8. "*Management Information and statistics*", which collects data related to service scheduling and actual daily production, used to construct service performance indicators and other statistical analysis for continuous improvement;
9. "*Additional documentation and clarifications*", which complements the other sections of the standard by providing informational support for better understanding and implementation of Transmodel. It includes an overview of the structure of the model, a comprehensive data dictionary, a reference system for interconnecting different components, and tables illustrating the evolution of terms from the previous model to the current version;
10. "*Alternative modes*", which focuses on the integration of unconventional modes of transportation, such as carpooling, car sharing, and non-scheduled public transportation services, for route management and planning in a multimodal, interconnected, and interoperable spatial system.

4.1.2. DATEX II, the standard for road traffic management

Data Exchange (DATEX II), defined by Technical Specification CEN/TS 16157, is the European standard designed to facilitate the exchange of **traffic and travel-related data** between different entities and organizations. Characterized by a **modular structure**, it allows adaptation to a wide range of applications in the context of intelligent transportation systems (ITS). Its use is particularly prevalent in real-time traffic

[5] https://transmodel-cen.eu/

monitoring systems for road networks and in traffic control centers for infomobility services, where data are **used to optimize traffic flows, improve road safety, and support operational decisions**.

DATEX II is designed for the transmission of large volumes of structured data between different organizations. It is used by road managers, public authorities, and service providers to share information on incidents, road conditions, traffic restrictions (e.g., road closures or temporary speed limits), work in progress, and truck parking areas. With its modular architecture, DATEX II supports the **monitoring of road networks and provides data for navigation and infomobility systems**. It is suitable for various scenarios, from managing unexpected events to strategic traffic planning.

The CEN/TS 16157[6] technical specification is divided into several "Parts," each focusing on a specific aspect of data exchange:

1. "*Context and framework*", defines the general context and framework for data exchange, including the modeling approach and fundamental data structures;
2. "*Location referencing*", specifies methods for reporting geographic locations, which are essential for locating events or road conditions;
3. "*Situation publication*", describes how to represent and exchange information about events affecting traffic, such as accidents or road works;
4. "*Variable Message Sign* (VMS) *publications*", details the representation of messages displayed on variable message signs along roads;
5. "*Measured and elaborated data publications*", covers the collection and distribution of traffic data collected from sensors and other sources;
6. "*Parking publications*", provides specifications for the exchange of parking-related information, including data on availability and rates;
7. "*Common data elements*", defines data elements used across the other parts of the standard;
8. "*Traffic management publications and urban extensions*", focuses on traffic management in urban settings and related extensions;
9. "*Traffic signal management publications*", specifies how to exchange data related to traffic signal management;
10. "*Energy infrastructure publications*", covers information exchange on energy infrastructure, such as electric vehicle charging stations;
11. "*Publication of machine interpretable traffic regulations*", defines how to represent traffic regulations in machine-readable formats;
12. "*Facility related publications*", covers information on specific facilities related to transportation and traffic;
13. "*Status & Fault*", adopts procedures for identifying static device data, reporting current status, and reporting alterations and failures;
14. "*Transport Network ITS*" (TN-IS), currently under development, will facilitate the exchange of up-to-date road network data between road authorities and map and service providers, ensuring timely updating of road infrastructure information.

4.1.3. NeTEx, the standardization of public transportation data

NeTEx, an acronym for "Network Timetable Exchange", CEN/TS 16614 technical specification, is the European standard for **modeling**, **distribution**, and **exchange of static data in the context of public transport** such as detailed service timetables, including departure and arrival times, information on networks and routes with descriptions of stops and multimodal connections, and fares and fare systems, including ticketing rules. The technical specification does not handle real-time data but **allows the sharing of planned and periodically updated information**, such as schedules and characteristics of transportation networks. It is

[6] https://datex2.eu/specifications/

used to exchange data between operators and service providers, such as travel planning and ticketing systems, ensuring **uniform and standardized data for interoperable multimodal applications across Europe**.

NeTEx is divided into "parts", each covering a functional subset of the CEN Transmodel. The original core CEN/TS 16614[7] technical specification contained the first three; over time they have been updated and supplemented, to the current six parts.

1. *Part 1* describes the topology of the public transport network, including the management of stops, interchange points and their connections (CEN/TS 16614-1:2014);
2. *Part 2* deals with scheduled timetables of planned rides, specifying their validity for weekdays, holidays, or specific seasonal periods (CEN/TS 16614-2:2014);
3. *Part 3* deals with tariff information, providing the model for managing tariff data (CEN/TS 16614-3:2015);
4. *Part 4* defines the European Passenger Information Profile (EPIP) (CEN/TS 16614-4:2017);
5. *Part 5* establishes the data model and exchange rules for unconventional transportation services, such as DRT (CEN/TS 16614-5:2021);
6. *Part 6* introduces the European Passenger Information Accessibility Profile (EPIAP) (CEN/TS 16614-6:2024).

The EU-defined "Parts" of NeTEx are based on the modularity principles of Transmodel and constitute the official "*chapters*" of the European standard, defined by the Comité Européen de Normalisation (CEN). Each chapter covers a specific functional area to which all EU countries must conform, providing a common basis for interoperability and ensuring that data transmitted between countries are interpreted uniformly.

Referring to the Regulatory Annex of Chapter 6, ITS Directive (EU) 40/2010 established the legal framework for the implementation of Intelligent Transport Systems (ITS) in Europe, setting priorities and objectives for their use, with a focus on interoperability and accessibility of public transport data. The subsequent Delegated Regulation (EU) 2017/1926 established National Access Point (NAP), making their adoption mandatory in member states and specifying the NeTEx and SIRI technical standards for the harmonized publication and sharing of static and dynamic data at different national access point, ensuring their compliance and interoperability. The ITS Directive establishes, as the "*first priority action*" in Article 3(a), "*the need to prepare multimodal mobility information services throughout the European Union*", making the role of protocols for data exchange between mobility operators strategic. Within the framework of European directives, Delegated Regulation (EU) 2017/1926 recognized NeTEx as the reference standard for data exchange in public transport in all European countries, with the aim of enabling cross-border multimodal infomobility services. The Italian state implemented this EU legislation through Decree Law No. 179 of October 18, 2012, and Ministerial Decree February 1, 2013, related to the deployment of intelligent transportation systems. These measures defined the national legal framework, enabling the Ministry of Infrastructure and Transport to coordinate and support the implementation of the NAP for the transport sector, with technical support from the Ministry for Technological Innovation and Digital Transition, ensuring consistency with the national digital infrastructure, including public data interoperability platforms.

Under the supervision of the Ministry of Infrastructure and Transport, the "***Guidelines for the Compilation of the Italian NeTEx Profile v.4.1.0***," a technical note that **defines the national specifications for the interpretation and compilation of the Italian NeTEx profile, regulating data interchange between Regional Access Points (RAPs) and National Access Point (NAP)** in accordance with European provisions, were released. The guidelines also introduce the concept of "***Level***" **as an operational tool adapted to national needs**. The NeTEx protocol profile has undergone validation by the experts of the European Committee for Standardization and has been found to comply with the requirements of Delegated Regulation (EU) 1926/2017, particularly with regard to the exchange of static local public transport data.

[7] https://transmodel-cen.eu/index.php/netex/

The **European EPIP** "*European Passenger Information Profile*", defined in Part 4 of NeTEx and formalized in the EU Specification CEN/TS 16614-4:2017, updated in 2021, **forms the fundamental basis of Level 1 of the Italian NeTEx profile**. This profile ensures EU interoperability of public transport data and is the minimum requirement that all member states must comply with. Italy has also introduced additional layers to address local needs. EPIP defines a standardized subset of the NeTEx Parts 1 and 2 specifications, with the goal of simplifying and standardizing the format for the interchange of data on stops, connectivity between stops, lines, passing times, and public transport routes in Europe.

The EU-defined "Parts" of NeTEx (1, 2, 3, 4, 5, 6) define the European standard, with each part dedicated to specific aspects of public transport, from network structure to service planning and timetables. Italy reorganized these parts to ensure compliance with CEN/TS 16614 specification, structuring the Italian NeTEx profile into **national levels** (L1, L2, L3, L4, L5). These levels **introduce extensions for service contract data with operators, as well as for the definition of pricing and tariff rules**:

1. *Level 1* provides the minimum compliance basis for describing the public transport network, in line with the European EPIP Profile, including descriptions of stops (name, location, accessibility), lines (name and type of transport), routes (route covered) and connections between stops of different lines and modes;
2. *Level 2* adds information for correlating local public transport service with contractual aspects, which is of particular interest to public administrations. These data will be able to assist public authorities' monitoring of operators' performance. The document "Guidelines v.4.1.0" refers to a specific note on the structure and reference entities for this level of the NeTEx Italian Profile;
3. *Level 3* introduces pricing-related information, through the introduction of the "*CappingRulePrice*" substructure, within the "prices" structure of "*fareTables*", which combines pricing logics with the related price. This pricing rule is not present in the EU-defined Parts, but has been added in the national extension to handle fare schedules that include a maximum cost for a parking or travel ticket;
4. *Level 4* introduces information related to alternative transportation services to LPT, including soft mobility and micromobility solutions;
5. *Level 5* adds information related to the accessibility of shelters "*Quays*" in aggregations of stops "*StopPlaces*", lines "*Lines*" and rides "*VehicleJourneys*".

NeTEx's Italian profile reorganizes the EU-defined "parts" into "levels", allowing transport operators to provide data in a phased manner. It integrates fare rules and contract data to support performance monitoring by public authorities. Table 4-2 summarizes the correlation between the EU-defined Parts of NeTEx and the levels of the Italian profile.

EU-defined Parts of NeTEx	Levels of the Italian profile of NeTEx	National Adaptation Needs
Part 1 - Network Topology	Level 1 - EPIP (Passenger Information Profile)	Part 1 is integrated into Level 1, including descriptions of stops, networks, and interconnections.
Part 2 - Scheduled Schedules and Rides	Level 1 - EPIP and Level 3 (Scheduling and Ride Data Management)	Part 2 schedule management is split between Level 1 and Level 3, where specific Italian elements related to ride scheduling are added.
Part 3 - Fares	Level 3 - Fare Information	Fares, which in Part 3 of NeTEx are described at a general level, become a key component of Level 3 in the Italian profile, with the introduction of CappingRulePrice logic.
Part 4 - Passenger Information Profile (EPIP)	Level 1 - Full EPIP Profile	Part 4, which defines the European EPIP profile, is fully incorporated into Level 1 of the Italian profile, representing the minimum common basis required by Delegated Regulation (EU) 2017/1926.

Part 5 - Alternative Modes of Transport	Level 4 - Alternative Mobility	The Italian profile further specializes Part 5, which deals with alternative modes of transport (e.g., demand-responsive transport, taxis), transforming it into Level 4, with the addition of Italian specificities such as support for car sharing, bike sharing, and other forms of soft mobility.
Part 6 - Accessibility Profile	Level 5 - Accessibility and Quality of Service	Italy has expanded the concept of accessibility. It is not limited only to accessibility for people with disabilities (elevators, ramps) but it also includes comfort aspects (Wi-Fi, covered shelters, etc.), thus defining Level 5 of the Italian profile.

Table 4-2 Comparison of EU-defined "Parts" of NeTEx and "Levels" of the Italian profile of NeTEx

Related to the objectives of the study on the **operability of DRT services**, **"Part 5"** of the UNI CEN/TS 16614-5:2022 specification extends Parts 1, 2 and 3 of NeTEx to integrate data on alternative and public transportation modes, **including multimodal ticket packages and identifying interchange points**. Italy adopts this scheme by reorganizing the EU-defined Parts into Levels, ensuring compliance with European standards. In this context, **"Level 4"** transposes and adopts Part 5 of CEN/TS 16614, supporting DRT and introducing Italian specifications for car sharing, bike sharing and micromobility.

4.1.4. SIRI, real-time information on public transportation

An acronym for "*Service Interface for Real-time Information*", SIRI is the **standard for dynamic data, used for real-time information management and exchange in public transportation**. It provides updates on delays and advances, cancellations, route changes, and dynamic information on stops, arrival/departure times, and any spatial and temporal changes in transportation services. The European Technical Specification CEN/TS 15531[8] provides immediate and continuous updates to support passenger information applications, infomobility systems, trip planning and real-time monitoring of public transport fleets. This standard underpins operational solutions such as information boards at bus stops, notifications on travel apps, and real-time fleet management systems. **Together with the NeTEx standard, it enables the integrated management of a complete and accessible mobility ecosystem, combining static and dynamic information to support modern urban transportation systems and MaaS solutions**.

SIRI's CEN/TS 15531 technical specification is divided into seven parts, each covering a functional subset of the CEN Transmodel model, focusing on information management in public transport:

1. *Part 1* describes the Background and Framework (EN 15531-1:2015);
2. *Part 2* describes the Communications (EN 15531-2:2015);
3. *Part 3* describes Functional Service Interfaces (EN 15531-3:2015);
4. *Part 4* describes Functional Service Interfaces: Facilities Monitoring (CEN/TS 15531-4:2011);
5. *Part 5* describes Functional Service Interfaces: Situation Exchange (CEN/TS 15531-5:2016);
6. *Part 6* describes Functional Service Interfaces: Control Actions (CEN/TS 15531-6:2024);
7. *Part 7* describes the European Profile for Real-time Information to Passengers (SIRI) (CEN/TS 15531-7:2024)-currently under approval.

SIRI specification defines distinct **functional services**, each of which is designed to enable real-time data management and exchange in public transportation. Each service is based on a common structure and uses the same terminology, architecture and reference data:

- **SIRI-PT** "*Production Timetable Service*", enables the dynamic exchange of scheduled timetables for a specific day, including updates, using information exchanged through NeTEx. This service is used by Automatic Vehicle Monitoring Systems (AVMS) to predict and monitor vehicle performance against scheduled timetables;

[8] https://transmodel-cen.eu/index.php/siri/

- **SIRI-ET** "*Estimated Timetable Service*", unlike the "Production Timetable" service, which handles predefined schedules for a specific day, the "Estimated Timetable Service" focuses on real-time updates by supporting the exchange of estimated schedules, including variations from the scheduled schedules. This service is used by AVMS systems to predict and monitor the actual location and progress of vehicles in real time;
- **SIRI-ST** "*Stop Timetable Service*", provides information on arrival and departure times at a specific stop point "*StopPoint*". Unlike production timetables, this service focuses on detailed information for a specific stop, with the scheduled arrival and departure times of each vehicle;
- **SIRI-SM** "*Stop Monitoring Service*", like the "Stop Timetable Service" but with a stop-centric rather than vehicle-centric approach. It allows to know, for each stop, which vehicles are arriving, whether there are delays and other variations. It is used for electronic panels at stops, providing real-time information on arrivals and departures at a stop location;
- **SIRI-VM** "*Vehicle Monitoring Service*", this service provides information on the exact location of a vehicle and lets you know if it is meeting its scheduled time or if it is early or late. It monitors location and movement in real time by comparing it against the established schedule, facilitating monitoring and operational management of fleets;
- **SIRI-CT** "*Connection Timetable Service*", provides information on connecting and interchange times at a connection point between two or more transportation lines or vehicles. For example, it can provide the time when a vehicle is expected to arrive at a stop, enabling it to predict when it will connect with another service;
- **SIRI-CM** "*Connection Monitoring Service*", like the "Connection Timetable Service," but with the focus on real-time updates on actual connections, indicating whether a connection will be guaranteed or whether there will be problems, such as delays or cancellations, that may affect the interchange between vehicles;
- **SIRI-GM** "*General Message Service*", enables the exchange of general messages related to public transportation information. These messages may concern stops, lines, routes or other service elements. Typical example are overtime service alerts or notifications;
- **SIRI-SX** "*Situation Exchange Service*", facilitates the exchange of structured messages related to situations that affect public transportation services and networks, such as incidents or service disruptions, so that they can be used by Journey Planner systems to optimize routes in real time and alert users of any discrepancies in a timely manner. Information related to the SX service covers both planned events, such as maintenance work on travel infrastructure, and unforeseen events, such as traffic accidents and service interruptions. Reports on major public events that may affect the use or availability of public transportation are also included;
- **SIRI-FM** "*Facility Monitoring Service*", enables the exchange of real-time information on the status of facilities at a stop, such as elevators, escalators, and other supporting infrastructure and their availability status, including indicating whether such unavailability impacts certain categories of users, such as people with reduced mobility, providing up-to-date data that improves the experience of public transportation users.

As a conclusion, **SIRI-Lite** can be described as a simplified version of the SIRI standard, which is intended to **reduce** its **complexity** while **maintaining the essential features** required for effective communication between systems. The main difference between SIRI and SIRI-Lite services lies in the level of detail and complexity of the data exchanged, as SIRI-Lite **uses simpler and less detailed data formats, making it more useful and usable in organizations that may not need the full range of features offered by SIRI**. As a "*soft*" version, SIRI-Lite represents a compromise between the integrity and depth of detail of the EU standard and the need for solutions, while still ensuring interoperability of services and effectiveness in sharing real-time information in the public transport sector, in sync and in compliance with relevant EU dictates.

4.2. Standard for Public Transport Information

4.2.1. Brief Overview of the GTFS Standard

The *General Transit Feed Specification* (GTFS) is an **open standard** for managing public transportation route, schedule and fare data, **structured through easily shared text files**. This data, which can be used on a variety of platforms and applications, allows routes, stops and other essential service information to be represented. Widely adopted by public transportation agencies and operators, GTFS has established itself as the industry standard.

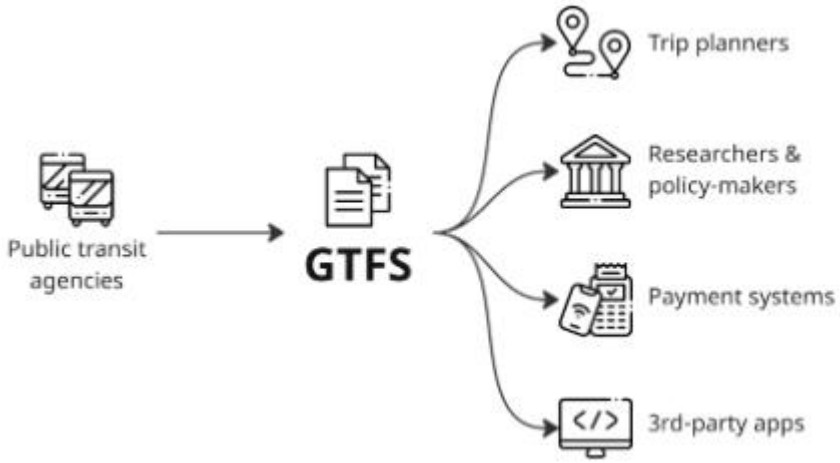

Figure 4-1 Application related to the use of GTFS

The way GTFS data is managed and distributed directly affects the quality of service because, since it is an open standard, it does not mandate the use of proprietary software to generate or share it. This eliminates any constraints with specific vendors and allows the use of any compatible tool, including simple text editors or spreadsheets, ensuring maximum interoperability. Once generated, a GTFS feed can be deployed on platforms such as Google, Apple, Transit App, Open Trip Planner, and other solutions as needed by operators. Although GTFS is primarily known for managing "static" trip planning information, particularly in metropolitan areas with fixed-route services (**GTFS Static**), there are several optional extensions that extend its functionality.

The GTFS is a standard format for organizing public transport schedules and associated geographic data, allowing services to be effectively modeled and represented. A GTFS feed consists of a series of text files organized in a ZIP file. Each file contains data formatted in lines of text with fields separated by commas to define the different components of the service. Each file is dedicated to a specific aspect of the public transportation network, such as stops, routes, frequencies, and other planned information. Key files within the dataset include:

- *agency.txt* - defines the transportation agencies whose services are represented in the dataset;
- *stops.txt* - identifies stops and stations by *stop_id* and, where available, *stop_name* to facilitate recognition. Stops can be georeferenced through the *stop_lat* and *stop_lon* fields;
- *routes.txt* - defines public transportation routes through the *route_id* and its service type (1=tram, 2=metro, 3=bus);
- *trips.txt* - specifies all trips made by each line via the *trip_id*, associated with the respective *route_id*. The *service_id* field identifies a set of dates when service is active for one or more routes;
- *stop_times.txt* - defines the arrival and departure times for each run (*trip_id*), specifying the *arrival_time* and *departure_time*. The *stop_sequence* field allows the order of stops for each route to be determined;
- *calendar.txt* - associates each *service_id* with the days of the week when the service is active, specifying the time interval defined by *start_date* and *end_date*;

- *calendar_dates.txt* - introduces exceptions against calendar.txt, allowing the service to be turned on or off on specific dates through the *exception_type* field (1 indicates that the service is added on a specific date, 2 that it is removed).

Analysis of GTFS data allows the public transportation network to be represented for each day of service, displaying the routes of the lines on a map and classifying them according to the number of daily trips and direction of travel. In addition, key performance indicators can be extracted, such as total trip lengths (mount km), travel times (mount hours), and commercial speed. The use of GTFS data also makes it possible to evaluate service levels at different time slots, analyze stop-level transit ridership, and study the organization of interchange nodes. By geolocating stops and analyzing transit frequencies, it is possible to estimate the accessibility of locations, identify any overlap between routes, and conduct targeted studies to support data-driven public transportation planning.

Figure 4-2 illustrates the interaction between the different information contained in the GTFS files/feeds listed above and their integration into public transportation planning systems:

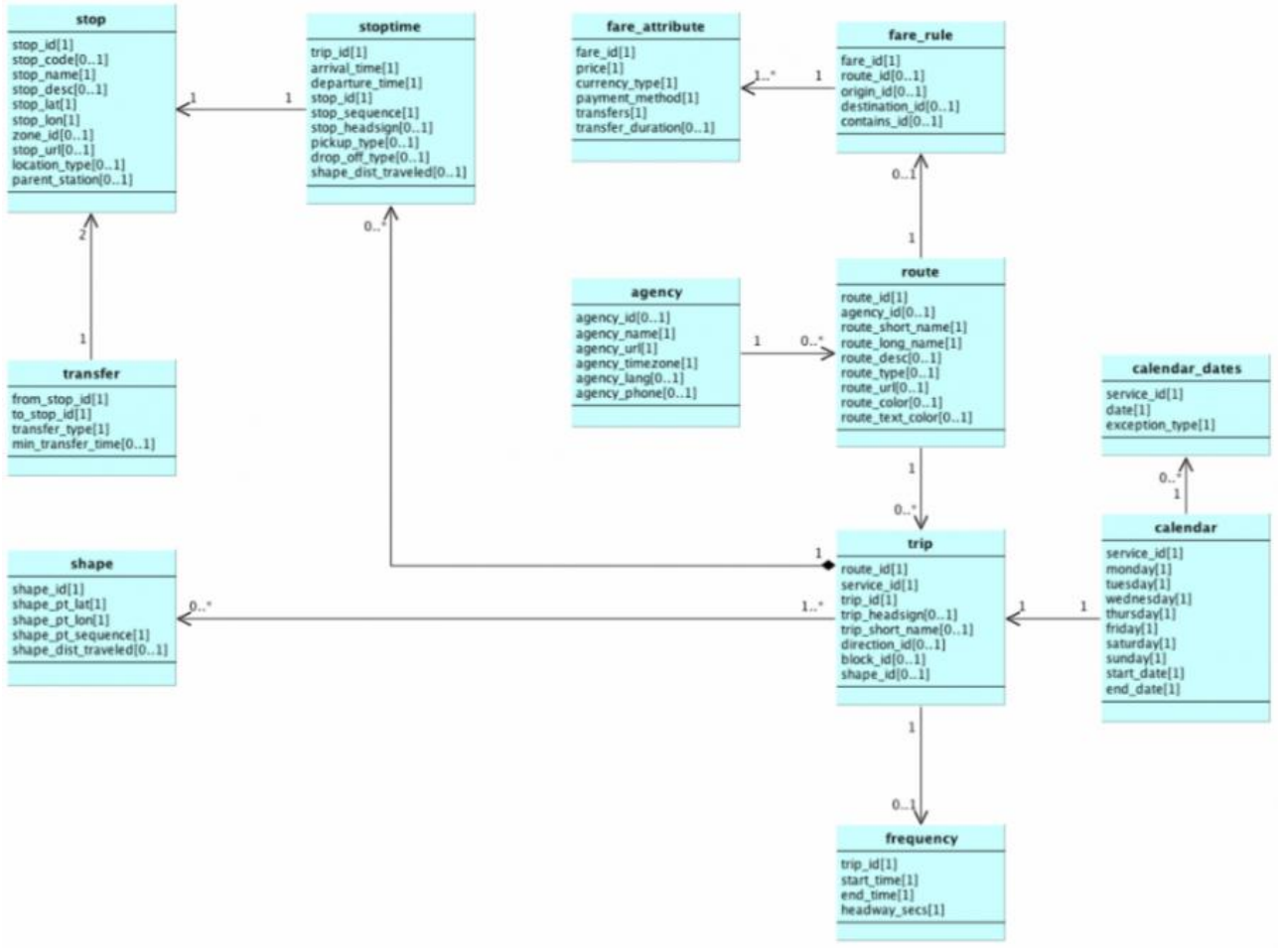

Figure 4-2 GTFS-Static feed interaction

4.2.2. GTFS RealTime

GTFS Realtime is an extension of the General Transit Feed Specification (GTFS) that enables public transportation agencies to **provide up-to-date real-time information on the status of their transport services**, improving user experience and operational management through dynamic data on arrivals, departures, vehicle locations, and service alerts. Real-time location data are continuously generated through automatic vehicle location systems, while trip arrival times are calculated using models that analyze historical

positioning data and scheduled times. GTFS Realtime supports different types of real-time data, which can be combined within a single feed[9]:

- **Trip Updates**, which is information about changes from scheduled schedules, such as delays, cancellations, or route changes. Trip Updates represent fluctuations from planned schedules, allowing an understanding of how far the actual operation deviates from the initial planning, providing an accurate picture of the current situation;
- **Service Alerts**, notifications regarding service disruptions, station closures, or other information relevant to passengers. Service Alerts provide updates whenever there is an interruption in the network. Delays and cancellations of individual trips should generally be communicated using *Trip Updates*. Service Alerts report significant problems on a specific entity and provide a textual description of the outage, including explanatory text, any URLs for further investigation, and structured data to help identify who is affected by the alert;
- **Vehicle Positions**, which provide information about the location of a specific vehicle in the transportation network, such as latitude and longitude. Each vehicle must be associated with the trip it is serving, specified via a *TripDescriptor*, and you can also add a *VehicleDescriptor*, which accurately identifies the physical vehicle whose updates are being provided. You can also provide the current trip via a *stop_sequence* or a *stop_id*, which represents a reference to the stop to which the vehicle is headed or at which it has already stopped;
- **Trip Modifications**, which enable the description of structural and planned changes affecting one or more trips, such as detours, stop cancellations, or updates to routes and schedules. Unlike the trip modifications handled by Trip Updates, which focus on temporary, operational changes such as momentary delays or cancellations, Trip Modifications directly update the planned trip in the static GTFS. Modifications do not create new or duplicate trips, but replace the original trip, ensuring consistency with static data and accurate information management.

GTFS Realtime provides up-to-date public transportation data to improve both operational management and user experience. It enables information on delays, changes, and cancellations, reducing uncertainty and facilitating trip planning. At the same time, operators can monitor deviations from planned schedules in real time and promptly manage any critical operational issues, such as resource reallocation or delay management. Because it is an open format, the data can be made available to third parties, enabling the development of up-to-date travel planning applications and infomobility services. At the technical level, GTFS Realtime uses the *Protocol Buffers* format, which enables fast and efficient data transmission, optimizing communication and update rates.

4.2.3. GTFS-Flex

At the technical level, *GTFS-Flex* represents an extension that adds specific features to the GTFS-Static format, designed to **make DRT services discoverable and accessible** by introducing the ability to define "***service areas***", "***mandatory reservation***", and "***availability windows***". DRTs, as discussed in Section 3.1, represent a transportation mode that overcomes the rigidities of routes and stops typical of scheduled services and does not follow fixed routes or schedules within the same framework used for traditional public transportation. In this context, **GTFS-Flex allows the representation of operational areas and time windows of operation**, rather than describing fixed departure and arrival routes and times.

To integrate DRT into travel planning platforms, **GTFS-Flex introduces new datasets and management files**, giving users flexible options in space and time, within **operational areas, defined as service polygons or groups of stops**, where passenger pickup and drop-off is possible. **GTFS-Flex includes files for managing reservations**, specifying minimum and maximum request times, contacts, reservation URLs, and availability windows. For full integration, data producers must provide information compliant with the new extensions,

[9] https://gtfs.org/documentation/realtime/feed-entities/overview/

such as the *booking_rules.txt* feed, which governs reservations. The combination of these new feeds with GTFS features allows the system to be adapted to different operational contexts.

Below are the datasets included in GTFS-Flex[10]:

- *agency.txt* - which defines mobility and transportation agencies whose services are represented in this dataset;
- *stops.txt* - defines stops where vehicles pick up or drop off passengers and can also define stations and station entries;
- *routes.txt* - represents public transport routes and where a route is a group of rides displayed to users as a single service;
- *trips.txt* - trips for each route, where a trip is a sequence of two or more stops that occur in a specific time period.
- *stop_times.txt* - file extended and modified from GTFS-Static to include time windows where a vehicle picks up or drops off passengers at stops or groups/areas of DRT-managed locations. Adds *start_pickup_drop_off_window* and *end_pickup_drop_off_window* fields to define the time interval when DRT service is available or inactive at a GeoJSON[11] location, at a stop or group of stops. To link booking rules to operational service areas, stops or group of stops, *pickup_booking_rule_id* and *drop_off_booking_rule_id* fields are added, which define how and when users can book the service;
- *calendar.txt* - specifies service dates using a weekly schedule with start dates, *start_date* and *end_date* This file is mandatory unless all ser- vice dates are defined in calendar_dates.txt.
- *calendar_dates.txt* - if *calendar.txt* is omitted, *calendar_dates.txt* becomes mandatory and must include all service operating dates;
- *fare_attributes.txt* - this file defines information on available fares, such as ticket fare, method of payment (on board or in advance), and whether transfer facilities are provided; it is also useful for describing the characteristics of fares applicable to flexible or on-demand services;
- *fare_rules.txt* - file specifying "how" and "where" the fares defined in *fare_attributes.txt* apply. It can indicate, for example, whether a fare applies to a specific service area, route, or geographic area, allowing fare customization by service;
- *transfers.txt* - is used to define transfer (or "change") rules and times between two stops or stations within the public transportation network. This file allows explicit specification of connections between stops, transfer modes, and minimum times needed to make the modal or vehicle change. It provides precise instructions on line changes by specifying which stops are connected and the time required to transfer, avoiding impossible connections and ensuring that passengers have the time they need to change from a train to a bus or between different lines;
- *feed_info.txt* - contains metadata about the GTFS dataset, such as information about the dataset version or producer, instead of the transportation services described;
- *booking_rules.txt* - additional file of GTFS-Flex - specifies the rules and requirements needed to make a successful booking, providing passengers with guidance on how to request the service, including operational details for the booking;
- *locations.geojson* - additional file of GTFS-Flex - mandatory file in GeoJSON format that defines operational service areas via polygons or multi-polygons, specifying areas where passengers can request pick-up or drop-off;

[10] https://gtfs.org/community/extensions/flex/

[11] GeoJSON is an "open format," or a public domain technical specification used for describing and storing digital data, with no legal restrictions on its use. GeoJSON is employed to represent spatial geometries using the JSON format. It supports points (e.g. addresses), broken lines (e.g. roads), polygons (e.g. boundaries) and multiple collections of these types. GeoJSON geometries are not necessarily constrained to the representation of geographic entities, as they can be employed by assisted navigation software to describe the coverage area of a service.

- *stop_areas.txt* - an add-on file to GTFS-Flex - is a file that is modified to allow the grouping of GeoJSON locations and/or stops, allowing predefined groups of these features to be created. These groups can then be specified on individual lines in the *stop_times.txt file*. In practice, this modification allows stops or geographic areas to be collected into defined groups (e.g., a set of stops that belong to a specific operating area) and to use these groups to simplify and organize the data in the *stop_times.txt* file, where service timings are shown, reducing the need to repeat details for each individual stop or location;
- *location_groups.txt* - additional GTFS-Flex file - the file organizes stops into sets that can be easily used in the transportation system, allowing them to be grouped together and enabling the definition of predefined groups of these stops. These groups can be specified in the single lines of the *stop_times.txt file*, simplifying data management and precisely defining each group, indicating which stops are part of it;
- *location_group_stops.txt* - additional GTFS-Flex file - defines the mapping and relationships between groups of stops (*location_groups*) and individual *stops*, linking each group to the specific stops that are part of it.

Below in Figure 4-3 it is represented the interaction between the different information of the GTFS files/feeds listed above:

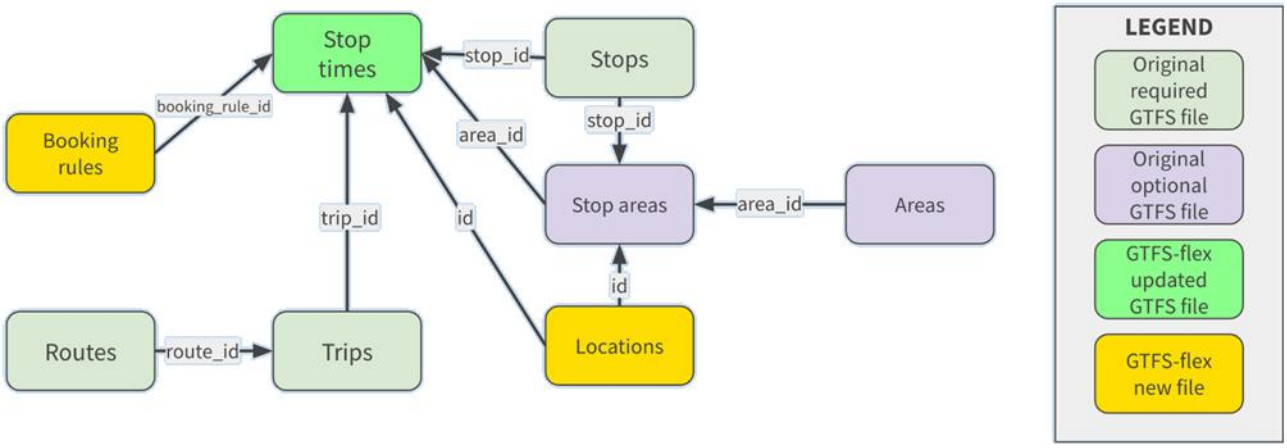

Figure 4-3 GTFS-Flex Feed Interaction

Below, Table 4-3 shows the adaptation of the standard GTFS feeds for DRT management in GTFS-Flex, while Table 4-4 lists the new GTFS-Flex-exclusive files that are essential for DRT and flexible services:

File	Description	Adaptability for GTFS-Flex
agency.txt	Transportation agency information	Used to describe the operator of the on-demand service, no interpretive changes to the agency.txt feed are needed
stops.txt	List of stops and their coordinates	With GTFS-Flex, "service areas" can be used instead of fixed stops, so it can be used to define "collection points" or "access points" to the system
routes.txt	List of routes or services	The "routes" of an on-demand service are not fixed, but the route_type = 715 field can be used to describe the on-demand bus service
trips.txt	List of scheduled trips on each route	For DRT, the "trips" are flexible. The file can be used to represent "blocks" of time during which the service is available
stop_times.txt	Arrival/departure times at stops	DRT services do not have fixed times, GTFS-Flex uses the concept of "time windows" to define when the service is available
transfers.txt	Definition of transfer rules	This file is useful if the service is integrated with traditional transportation, with respect to exclusive DRT service it finds no use
calendar.txt	Days of service	Defines the days and hours when the DRT service is available

calendar_dates.txt	Exceptions to service days defined in calendar.txt	Used to indicate special days such as holidays or special events when DRT service is available or suspended
feed_info.txt	GTFS feed information	Important for defining the validity of the GTFS feed and providing details about attributes of its dataset

Table 4-3 Adaptability of GTFS Feeds in GTFS-Flex

File	Description	Function in GTFS-Flex
booking_rules.txt	Booking rules for flexible services	Essential for defining how and when passengers can book the service, specifying access modes (app, phone) and any booking timeframes (e.g., advance notice required)
locations.geojson	Geographical data defining service areas or access points	Essential innovation for DRT management as it allows service areas to be graphically represented on a map
stop_areas.txt	Areas grouping stops or collection points	Defines groups of nearby stops, such as an urban area or location served by a reservation point
location_groups.txt	Logical groupings of locations (such as stops or service areas)	Organize flexible stops and service areas into groups that can be used to define service rules, such as rates or reservation arrangements specific to certain areas or sets of stops
location_group_stops.txt	Associations between groups of stops and individual stop locations	Needed to link physical stops and pickup points, to logical groups defined in location_groups.txt

Table 4-4 Features of new feeds unique to GTFS-Flex

In its static version, GTFS supports fixed-path transport services. With the integration of GTFS-Flex, several types of flexible services can be modeled, including:

- the **dial-a-ride service**, in which the vehicle operates within an operational zone or area, allowing passengers to be picked up and dropped off during specific service hours;
- the **route deviation service**, in which the vehicle follows a fixed route with an ordered sequence of stops, but may deviate to pick up or drop off a passenger between stops;
- the **point deviation** or **checkpoint service**, in which a passenger may board at a fixed stop and alight at any point within an unordered list of stops, with the driver serving only the required stops;
- **point-to-zone service**, in which the passenger can board at a fixed stop and alight at any point within a predefined area, with scheduled departures coordinated with other services.

Adoption of GTFS-Flex can improve the accessibility of public transportation services and, if well integrated into travel planning applications, can provide users with different transportation options to meet specific travel needs.

4.3. Compatibility and comparison between technical specifications and operational standards

Feature	NeTEx (CEN/TS 16614)	SIRI (CEN/TS 15531)	GTFS (General Transit Feed Specification)	GTFS-RT (Realtime)	GTFS-Flex (Flexible Trips)
Focus	Exchange of static timetable data and public transport networks	Exchange of real-time data for public transport	Specification to represent static public transport data	Extension to represent real-time data	Extension to represent flexible transport services
Scope	Schedules, facilities, and fares of transportation services	Delays, cancellations, occupancy	Schedules, routes, stops, and fares	Updates on delays, cancellations, vehicle locations	Flexible services such as demand-responsive transportation

Real-time	Not applicable	Designed for real time	Not applicable	Designed for real time	Not applicable
Data type	Static: schedules, networks, fares	Dynamic: delays, forecasts, cancellations	Static: schedules, routes, stops, fares	Dynamic: delays, cancellations, vehicle locations	Static with flexible services information
Standard format	XML/JSON format for interoperability with other systems	XML with specific extensions	CSV (comma-separated text)	Protocol Buffers (binary format)	CSV (comma-separated text)
Examples of use	Multimodal trip planners, fare systems	Passenger information systems and real-time operational management	Global trip planning applications	Real-time updates for apps and operational monitors	Representation of services such as dial-a-ride transportation
Compatibility	Based on Transmodel, compatible with SIRI for dynamic data	Based on Transmodel, compatible with NeTEx for static data	Not based on Transmodel, requires conversion for interoperability with NeTEx/SIRI	Not based on Transmodel, compatible with GTFS	Compatible with GTFS, requires mapping for integration with NeTEx/SIRI
Main Goals	Interoperability between public transportation systems	Provide dynamic, real-time updated data with a high level of detail	Standardize static data in a universally readable format	Provide dynamic, real-time updated data in a compact format	Extend support for demand-responsive transport (DRT) services
Technical implementation	Requires compatible tools for processing data in XML and JSON	Based on XML, with modular configuration for dynamic data	Easy to implement using CSV files	Uses Protocol Buffers for fast and lightweight data transmission	Extends GTFS structure to represent flexible data
Applications for MaaS	Integration of networks and static schedules into MaaS systems	Real-time updates on delays, changes, and operational alerts	Enabling applications for trip planning and management	Real-time data for operational management and monitoring apps	Representation of flexible services such as on-demand transportation

Table 4-5 Comparison of technical specifications and operating standards

4.3.1. Conversion between different formats

- **NeTEx and SIRI to GTFS/RT and Flex**: NeTEx and SIRI allow direct conversion of static and dynamic data to formats compatible with GTFS and its extensions, through tools that can map the XML structures of NeTEx and SIRI to the tabular formats of GTFS.
- **GTFS/RT and Flex to NeTEx and SIRI**: reverse conversion is more complex, as data in GTFS format may have a lower level of detail than NeTEx and SIRI requirements. This process therefore requires enrichment of the source data with additional information, so as to comply with the more articulated structures inherent in NeTEx and SIRI.

Middleware software can play a key role in the conversion between the different formats, acting as a "*bridge*" between systems. It is important to distinguish middleware from APIs, since the latter represent specific interfaces that allow one system to access another directly, as in the case of an app that queries a database to obtain a bus schedule. Middleware, on the other hand, translates and combines complex data between heterogeneous systems, organizing it and, if necessary, including APIs to facilitate communication between platforms.

A practical example of this approach is the "*GTFS to NeTEx Converter*", a middleware that enables data translation between GTFS and NeTEx, ensuring compatibility between different systems.

5. Protocols and requirements for the implementation and integration of DRT Services in the public transport network and MaaS platforms

This document constitutes an analysis of interoperability between different modal public transportation systems, conducted through the study of the technical specifications for data exchange that enable the integration of operations and features. In accordance with current regulations, the objective is to provide an operational framework for the proper planning, management and implementation of DRT services, ensuring compliance with applicable regulatory constraints.

This chapter defines **protocols and requirements related to the planning and management of DRT services**, with a specific focus on functional and technical specifications that can be integrated within the broader context of the MaaS4RER project. These guidelines should be able to support all stakeholders in the process, including:

- **Region and Local Authorities**, responsible for coordinating and supervising the integration of DRT services in the territories and setting reference standards;
- **LPT Agencies**, for the definition and monitoring of public service contracts;
- **Software manufacturers**, for the development and management of platforms dedicated to the operation of DRT services;
- **Transportation Operators**, for the implementation and operational management of DRT services;
- **MaaS operators**, to ensure interoperability and data sharing by integrating platforms and trip booking functions.

To implement **efficient and interoperable DRT** systems within **MaaS** platforms, it is necessary to adopt **standards and technical specifications** that can ensure data uniformity, **compatibility between systems**, and **real-time updates** for users and operators. The integration of DRT with MaaS platforms is a strategic step, combining the flexibility of DRT with the benefits of an integrated mobility ecosystem. Essential to the achievement of this goal is the use of standardized protocols and secure authentication systems, such as *OAuth 2.0*[12], that ensure effective and secure exchange of information. Adoption of these standards and specifications not only improves the user experience, but also strengthens interoperability between operators, optimizes operational management and helps build more efficient, accessible, and inclusive mobility networks.

5.1. Integration via Deep Link

Integration of DRT services with MaaS platforms via deep links is an **immediate and easy-to-implement solution that is particularly suitable for rapid integrations**. A "*deep link*" is a hyperlink that provides direct access to a specific DRT application page or function, while maintaining the context of the journey. Currently, this approach is the most widely used both nationally and internationally. This methodology simplifies integration between systems, allowing DRT providers to maintain direct control over their application. However, it should be noted that switching between different applications can compromise the smoothness of the user experience and does not guarantee full MaaS integration. The limitations of deep link-based integration include:

- *fragmented user experience*, as switching to an external application breaks the continuity of the process, forcing the user to interact with different interfaces;

[12] https://datatracker.ietf.org/doc/html/rfc6749

- *reduced functionality*, as deep links do not support advanced features such as real-time tracking or unified payment and reservation management;
- *technology dependency*, as deep link requires the DRT app to be compatible and up-to-date, making the integration vulnerable to any changes or disruptions;
- *lack of aggregate data*, as MaaS platforms cannot directly access data for analysis or optimization, as control remains primarily within the DRT app.

5.2. Integration through API

Application Programming Interfaces (APIs) enable deeper and more comprehensive integration by facilitating two-way communication between DRT services and MaaS platforms. Through APIs, platforms can query DRT systems to **obtain real-time data on availability, fares, and routes, enabling users to book and pay directly from the same MaaS interface**. This type of solution provides a smoother and more consistent user experience than deep links, eliminating the need to switch between applications, as APIs support advanced features such as real-time tracking and dynamic updating of service information. It should be considered, however, that adoption of this solution requires significant technical development and may vary depending on the specifics of MaaS integration platforms and DRT service technology providers.

The most widely used API standards are listed below:

Common API Standards	Description
REST API	Flexible HTTP-based protocol for requests and responses in JSON/XML
GraphQL	API query language that enables targeted and flexible requests
OAuth 2.0	Standard for secure authentication and authorization management
MQTT	Lightweight protocol for real-time messaging
WebSocket	Protocol for real-time two-way communication

Table 5-1 commonly used API standards

5.3. Current critical issues and challenges to be addressed

The **GTFS-Flex** standard reduces the isolation of DRTs services by **integrating them into scheduling systems**. This allows passengers to access coordinated information, improving service accessibility and system efficiency. Currently, DRT operators use their own apps for fleet management and reservations, which are often not integrated with LPT apps. This forces users to use multiple platforms, preventing coordinated trip planning. Similarly, current trip planning apps also have limitations, as they only display fixed-route services without combining travel times between scheduled and DRT services. This situation reduces the visibility and effectiveness of flexible services, leaving many users unaware of their availability.

In this context, the GTFS-Flex introduces a key integration that **allows flexible services to be displayed alongside traditional services within trip planners**, providing an estimate of travel time that includes both modes. This not only improves the visibility of DRT services but also ensures a broader and more **integrated spatial coverage**, again with a view to mobility conceived as a service and not just as a means or series of means of transportation, a principle underlying MaaS policies.

A concrete example of the integration of GTFS-Flex with DRT systems can be found in Switzerland, where a national profile[13] has been developed to ensure standardization of DRT data. As of April 2024, DRT operators began publishing their feeds in accordance with this profile, made accessible through the official *Open*

[13] GTFS Profil Switzerland 0.17 Cap. 12 Extension under Development: GTFS-Flex - https://www.tp-info.ch/sites/default/files/2024-12/GTFS_Profil_Switzerland_Version_0_17_en.pdf

Transport Data[14] platform. However, while this is an important step forward, the availability of DRT offer data still does not translate into effective integration with other transport modal systems, limiting the potential for interoperability and accessibility of services for users.

From a technical point of view, in terms of transferring data and information needed for promotion and access to DRT systems, GTFS-Flex is a significant development in the management of flexible services, but it still has some limitations that reduce its potential. For example, it does not cover all aspects related to on-demand services, such as some booking methods or specific fare details, making further extension necessary. To this end, the **GTFS-On-Demand**, called the *General On-Demand Feed Specification* (GOFS), is **currently under development**, designed to fill current information gaps and provide more comprehensive tools for integrating flexible transportation into mobility networks. The GOFS project aims to develop a shared standard that unifies the representation of on-demand transportation, facilitating the integration of DRT, public transportation, and other mobility solutions, such as taxi services. **This standardization** is not limited to improving the experience in urban areas but is primarily intended to **support** those residing in remote or rural areas, more generally in **areas with low demand for transport, where demand-responsive transportation can be a viable option for meeting travel needs**. GOFS will need to ensure a uniform representation of on-demand services, including user-oriented transactional data such as availability and reservation management. Starting with the GTFS-Flex format and integrating other extensions, including GTFS-Vehicles and GTFS-Fares v2, the project will need to maintain a simple and functional structure, making the specification accessible to a wide range of services and collaborating with other existing initiatives in the field. The goal is to develop a "**minimum functional specification**," capable of concretely representing real-world use cases for demand-responsive transportation, with a focus on trip planning. This first level of standardization will enable not only a better representation of on-demand services, but also greater interoperability between different actors in the industry.

5.3.1. Lack of integration of DRT services into MaaS

DRT services are often developed as stand-alone entities, without real integration with the existing public transport network. This choice, while aimed at avoiding overlap with scheduled transportation, has technical and economic consequences that need to be carefully evaluated.

Effective integration of DRT with scheduled services is essential to ensure optimization of the public transport network. A **lack of interoperability** reduces operational efficiency and generates problems in operator management and user demand response, **compromising the travel experience and the overall effectiveness of the public mobility system**. In summary:

- ***from the perspective of transport operators***, the absence of a centralized platform for the simultaneous management of DRT and scheduled services limits operational flexibility and hampers network coordination, compromising the ability to respond to daily needs in a timely manner;
- ***from business perspective***, duplication of in-vehicle hardware and software results in high installation and maintenance costs, impacting operational resources and complicating the management of a fragmented technology environment;
- ***from the user perspective***, the requirement to use multiple applications to access DRT services, scheduled services, and other shared mobility solutions (micromobility, car sharing) generates confusion and worsens the overall travel experience, with the risk of alienating users from the service and achieving an effect opposite to the principles of the MaaS model.

In many realities, the lack of integration between DRT and LPT services leads to the creation of isolated systems that are complex and unintuitive for users, limiting the deployment of integrated solutions and

[14] Open Transport Data is the Swiss national platform dedicated to the collection, management and dissemination of open data on public transport and mobility (https://opentransportdata.swiss/en/)

reducing the overall effectiveness of the network. This approach leads to increased operational costs for the public administrations responsible for financing public mobility, without bringing efficiency benefits. The absence of hierarchical network planning can lead to duplication of services, with competing lines increasing operating costs without improving service quality. In contrast, integration between DRT, public transport, shared mobility, and micromobility can avoid unnecessary costs, simplify administrative management, and improve the user experience. In this context, intermodality is central to the implementation of the MaaS model, as it enables services that are adaptable to the real needs of passengers, ensuring a more efficient and accessible mobility ecosystem.

Benchmark

As part of the investigations conducted for the benchmark analysis, models for integrating DRT services into MaaS were investigated in depth, with the involvement of industry players and those active in implementing such solutions:

- the analysis showed that, **currently, there are no established developments involving full integration of DRT systems into MaaS platforms**.

In the contexts in which DRT services have been implemented, their operation appears to be integrated into the operation of local public transport with an operational support role over specific geographic areas, and the management of interaction with users continues to be delegated to proprietary channels, such as dedicated applications reachable at most through deep links, without structural integration into MaaS models.

This configuration results in limited benchmark relevance for the scope of analysis, highlighting how ***the integration of DRT services into MaaS systems still represents an area of experimentation, lacking established benchmarks or established operational best practices***.

5.4. Protocol for integration of DRT services in LPT networks and MaaS platforms

This protocol establishes **technical and operational criteria** to ensure the **interoperability of DRT in LPT and MaaS**. It defines **standards and reference specifications** for the implementation and regulation of services, ensuring **effective integration with public transport networks and digital mobility platforms.**

DRT services are a strategic solution to serve territories characterized by low transport demand, peripheral areas and contexts where traditional public transport would be ineffective or economically unsustainable. **In order to ensure its full utilization, DRT must be integrated into both Local Public Transport networks and MaaS platforms.**

The integration of DRT involves compliance with specific requirements in two main areas:

- **§ 5.4.1** ***Requirements for integration of the DRT into LPT networks***, which concern coordination with public transport services, in order to ensure complementarity between services, continuity in routes, and interconnection at interchange points;
- **§ 5.4.2** ***Requirements for integration of DRT within MaaS***, relating to the inclusion of DRT in digital multimodal mobility platforms, allowing users to plan, book and pay for the service in a way that is seamlessly integrated with other available public transport modes.

Before developing the areas of DRT integration with LPT networks and MaaS, it is necessary to point out that **to ensure** the proper functioning of **this integration**, the **MaaS** system must be technologically **prepared to accommodate DRT services**. Consequently, in addition to DRT integration requirements, **technological prerequisites must be defined to enable full interoperability** between transportation services and digital platforms:

- **data management and standardization**: MaaS must be able to receive, process and make available data from DRT services according to recognized formats (*GTFS-Flex, NeTEx, SIRI*), ensuring full interoperability within the system;
- **accessibility to data management layers:** MaaS architecture must be compatible with data management structures (*NAP, DS&SRF, RAP*) to ensure uniform and integrated access to information;
- **secure and scalable technology infrastructure:** MaaS system must ensure security, data protection, and compliance with cybersecurity standards and privacy regulations (*GDPR, national regulations*).

These prerequisites define the ***compliance obligations that the DRT service operator must meet as part of the procurement process, ensuring full compatibility with the MaaS system architecture and adhering to established data standards and specifications***.

DRT provider is required to transmit **service data according to the required standards** (*GTFS-Flex for static data and GTFS Real-Time for real-time updates*), **in accordance with the structure, frequency, and format of the data defined by the contracting authority** and detailed in the technical annex to the MaaS architecture. The operator shall ultimately ensure the transmission of data to the MaaS management layers, such as the RAP where available or, in its absence, the NAP/DS&SRF, in accordance with the procedures specified in the technical tender documentation.

5.4.1. Requirements for integration of DRT into LPT networks

The **integration of Demand Responsive Transport (DRT) into the Local Public Transport (LPT) network** is aimed at ensuring that the service aligns coherently and complementarily with the existing transport system, avoiding inefficiencies or overlap.

DRT is a solution to serve areas with low transport demand, peripheral territories and contexts where traditional public transport offerings may not be sustainable or adequate to the needs of the population. To maximize its effectiveness and efficiency, the service must comply with criteria for **coordination with the LPT network**, avoiding the overlap with existing lines and ensuring optimal connections between different levels of transportation.

The integration of DRT into TPL is based on two main dimensions:

- **Functional requirements** that define the essential rules and conditions for the DRT to coordinate with the LPT at the level of routes, interchange points, and complementarity with existing services;
- **Operational requirements** that govern the management of the DRT service in terms of fares, reservation arrangements, resource optimization and performance monitoring.

Functional requirements

The functional requirements define the **essential principles and conditions** to integrate DRT into the public transport system without creating overlaps with existing lines, ensuring **continuity in routes and interchange points** between different levels of service.

This section establishes the rationale for integration of the DRT in three key aspects:

- **Spatial location,** defining where to activate the service based on mobility demand;
- **Consistency with the LPT network**, avoiding overlaps and optimizing resources;
- **Interconnection between transportation levels**, ensuring efficient exchange points between different types of services.

Requirement	Description	Purpose of Integration	Application Criteria
Demand Analysis	Identification of areas with low demand for transport through O/D analysis, Big Data, and traditional surveys (CATI)	Implementation of the DRT and definition of its operational service areas in contexts with low transport demand	LPT planning based on updated data
Integration of DRT service into the TPL network	The DRT should be designed to complement the TPL system without generating overlaps with existing lines	Optimizing the use of resources, avoiding competition with traditional public transport lines	Integration should be assessed through transport supply analysis
Integration of the DRT service between hierarchical levels of transport	The DRT must ensure efficient connections between hierarchical levels of service, avoiding dispersion of demand and improving accessibility	Foster continuity and coherence of the public transport network, ensuring connections between services at different spatial scales	Interchange points and mobility centers must be identified according to the hierarchical function of the service

Table 5-2 Functional requirements for the integration of DRT into TPL networks

Operational requirements

Operational requirements set out **how the DRT is to be managed, regulated and monitored** to ensure:

- **Fare integration** with the LPT, avoiding separate payment systems
- **Service optimization**, to reduce waste and improve the user experience
- **Monitoring and scalability**, to adapt the service to actual needs.

Requirement	Description	Purpose of Integration	Implementation Criteria
Unified fare	The DRT service must be integrated into the LPT fare system (season tickets, single tickets), avoiding separate payment systems	Avoiding the need for users to purchase separate tickets for DRT and LPT, ensuring a single, integrated fare system	Define rules for integrating the DRT fare with existing fare systems
Capacity regulation and trips optimization	The system should include the use of pooling algorithms to optimize routes and reduce waiting times, maximizing vehicle fill rates	Avoid inefficient rides and ensure optimal use of available resources	Vehicle allocation should be based on demand analysis and dynamic capacity adjustments
Performance monitoring	Performance indicators (punctuality, utilization rate, user satisfaction) must be defined to assess service effectiveness	Ensure continuous service improvement through performance monitoring	Data must be collected regularly and analyzed for possible corrective action
Spatial scalability	The service must be able to be expanded or modified according to changes in mobility demand	Adapting the service according with territorial changes or variations of citizens' needs	Service expansions must be evaluated regularly through the analysis of data and local needs

Table 5-3 Operational requirements for the integration of DRT into TPL networks

As a corollary to Section 5.4.1, the ***selection of a single provider or centralized coordination for the management of DRT services at the regional level is recommended***. Following the example of the MaaS4RER project, which adopted a single MaaS platform for the entire territory of the Emilia-Romagna Region, adopting a similar strategy for DRT services would optimize costs, simplify integration, and ensure greater consistency across the entire territory. The regional-scale approach favors more effective governance, uniformity in technological solutions and greater scalability of services, adapting them to the different mobility needs of the territories involved.

5.4.2. DRT integration requirements with MaaS

The MaaS model aims to **simplify access to mobility** by enabling users to **plan, book and pay** for their trips in an **integrated way**, without having to go through multiple separate applications or systems. For the DRT to be fully interoperable with MaaS, it is critical to ensure **data standardization, real-time availability of information, and technological compatibility with digital mobility platforms**.

The integration of the DRT into MaaS has three levels:

- **Functional requirements**, which define the conditions for the DRT to be accessible and usable within MaaS systems;
- **Technical requirements**, establishing the standards for data exchange and interoperability between DRTs and platforms;
- **Operational requirements**, which govern the management of the DRT service in relation to the MaaS platform, including how performance is booked, paid for, and monitored.

Functional requirements

Functional integration establishes the characteristics necessary for DRT services to be **accessible, interoperable**, and usable by users within a MaaS system:

- **Data standardization**: the DRT must be compatible with the data exchange formats adopted in the MaaS;
- **Real-time availability**: users must be able to view the availability of the service and book it directly from MaaS platforms;
- **Integration into multimodal trips**: the DRT must be able to be combined with other means and modes of transportation in MaaS trip planners;
- **Centralized booking and payment management**: users must be able to book and pay without external steps.

Requirement	Description	Purpose of Integration	Application Criteria
Compatibility with standard data formats (GTFS-Flex, SIRI, NeTEx)	The DRT must be compatible with data exchange formats used in MaaS to represent routes, virtual stops, service availability, and fare information	Enable interoperability between the DRT and MaaS platforms, avoiding closed or fragmented systems	The DRT system must generate data in formats readable by MaaS trip planners, supporting dynamic updates
Real-time display and booking	Users must be able to view DRT service availability and to know their waiting times	Make the DRT as accessible as any other public or shared transportation within MaaS	The DRT must transmit up-to-date data on availability and schedules via real-time feeds (SIRI-VM, SIRI-ET)
Integration into MaaS trip planners	The DRT must be included in MaaS multimodal solutions	Ensure that the DRT is offered to users as a travel option when it is convenient	The system must allow the generation of intermodal routes with the DRT alongside buses, trains, shared mobility, etc.
Integrated booking and payment	Users should be able to book and pay for DRT service directly from the MaaS platform, without having to access separate systems	Avoid fragmentation in the user experience and ensure a uniform booking flow	MaaS should manage payment centrally, integrating DRT costs into multimodal fares

Table 5-4 Functional requirements for the integration of DRT into MaaS

Technical requirements

Technical integration is referred to the **interoperability of digital systems** so that the DRT can communicate smoothly with platforms and ensure **real-time updates, digital reservations and integrated payments**.

Technical requirements define the specifications necessary for:

- **Standardization of data exchange formats**: the DRT must support standards and technical specifications to ensure compatibility and accessibility with MaaS;
- **API infrastructure for two-way communication**: the DRT must be able to receive and send data to MaaS platforms in real time;
- **Static and dynamic data management**: the system must distinguish between planned information (e.g., operational service areas, rates) and real-time updates (e.g., vehicle location, availability);
- **Scalability and security**: platforms must be able to handle multiple DRT operators, ensuring compliance with GDPR and data protection standards.

Requirement	Description	Purpose of Integration	Application Criteria
Support for GTFS-Flex	The DRT must generate GTFS-Flex data to represent virtual stops, service areas, and reservation requirements	Standardize DRT service modeling in MaaS trip planners	The format must be compatible with trip planning systems and updated periodically
Compatibility with SIRI for real-time updates	The DRT must transmit dynamic updates (vehicle location, delays, service availability) via SIRI-VM, SIRI-ET, SIRI-SM feeds	Ensure that users receive up-to-date and reliable information about the DRT service	The system must be able to send frequent updates to the MaaS platform with minimal latency
Two-way API infrastructure	An API interface must be implemented to enable data exchange between DRT and MaaS (reservations, status updates, payments)	Enable smooth management of the DRT service directly from the MaaS platform, without manual steps	The infrastructure must support booking requests, cancellations, payments, and travel data synchronization
Managing static and dynamic data	The DRT system must distinguish between planned data (e.g., schedules, areas covered) and real-time data (e.g., available vehicles, route changes)	Avoid discrepancies between information provided to users and actual service availability	Static data should be exportable to NeTEx, while dynamic data should be transmitted via SIRI or GTFS-Realtime
Scalability and security	The DRT's digital infrastructure must be able to handle multiple operators and increasing numbers of users while meeting data protection standards	Ensure continuity of service and protection of sensitive user information	The system must comply with GDPR and implement advanced security measures for data protection

Table 5-5 Technical requirements for the integration of DRT into MaaS

Operational requirements

Operational integration is referred to the **rules for management and operation** of the service within a unified digital ecosystem, establishing ways to:

- **Performance monitoring and service quality**: performance indicators must be defined to assess the effectiveness of the integration of the service into MaaS;
- **User interaction management**: the service must ensure a clear and up-to-date information flow for users, including real-time notifications.

Requirement	Description	Purpose of Integration	Criteria for Implementation
Performance Monitoring	Performance indicators (punctuality, utilization rate, user satisfaction) must be defined to assess service effectiveness	Ensure continuous service improvement through performance monitoring	Data must be collected regularly and analyzed for possible corrective action

Real-time Notifications and Updates	Users must receive information on reservations, waiting times, service changes, and cancellations through MaaS	Improve transparency and service reliability for users	The system must send synchronized push notifications with SIRI-ET and SIRI-SM-based updates

Table 5-6 Operational requirements for the integration of DRT into MaaS

6. ANNEX "A" - Regulatory Framework

This Chapter develops an in-depth analysis of the regulatory framework related to mobility and transportation data management and distribution, with a focus on interoperability of services in the context of the "*mobility as a service*" paradigm. MaaS represents an integrated model of mobility that involves the combination of different transportation services, both public and private, made accessible through a single digital channel. MaaS intermediary platforms aggregate information, facilitate travel planning, and offer integrated travel alternatives.

The Chapter is organized along two main sections:

- in section 6.1, EU legislation is analyzed, with reference to the relevant Directives and Delegated Regulations in the field;
- in section 6.2, the process of transposition and adaptation of legislation at the national level is explored.

6.1. EU References

This section introduces the main regulatory provisions and strategic initiatives adopted by the European Union to regulate and harmonize data management in the mobility and transport sector, defining objectives and tools to address current and future challenges. In particular, the focus will be on the principles behind European policy directions to promote intermodality and foster the adoption of digital technologies for the implementation of interoperable EU-wide Intelligent Transport Systems (ITS).

6.1.1. Regulation on public service obligations (PSOs)

Regulation (EC) No. 1370/2007 of the European Parliament and of the Council of October 23, 2007 establishes the framework for the regulation of public passenger transport to **ensure the provision of services of general interest through public service obligations** (PSOs). These obligations are imposed by competent authorities to meet mobility needs not covered by the market, providing for measures such as public service contracts that allow financial compensation or exclusive rights to be awarded to the operators in charge. The objective is to ensure that public transport services meet criteria of safety, efficiency, accessibility and quality, particularly in contexts where the economic market balance would not allow for adequate supply. The Regulations stipulate that public service obligations, defined as requirements imposed by competent authorities to satisfy mobility needs not otherwise guaranteed by the market, are to be formalized through public service contracts, which set out the responsibilities of operators, how financial compensation is to be calculated, and, if necessary, the allocation of exclusive rights to operate specific lines, networks or geographical areas.

Among the key principles outlined in Regulation (EC) No. 1370/2007, the criteria of "**transparency**" and "**proportionality**" in the processes of awarding public service contracts are particularly highlighted. Contracts may provide for financial compensation, designed to cover the costs incurred by operators in fulfilling public service obligations, as well as to ensure a reasonable profit margin. The methodology for calculating compensation must be rigorous to balance the economic sustainability of the service with efficient use of public resources, avoiding overcompensation and distortion of competition. In addition to economic aspects, the regulation allows for the possibility of granting exclusive rights to operators, limiting other parties' access to certain lines or geographic areas. This tool is essential in contexts where market opening could compromise the efficiency of the service or its territorial sustainability, particularly for "*areas with low transport demand*".

The scope of Regulation (EC) No. 1370/2007 extends to all modes of road and rail public transport, including innovative solutions such as Demand Responsive Transport (DRT). The regulation is thus a key regulatory device for promoting inclusive and sustainable mobility patterns, aimed at ensuring accessibility to public

transport by reducing territorial disparities and promoting more equitable socio-economic integration. In parallel, establishing strict criteria for regulating financial compensation and exclusive rights ensures that public resources are used transparently and efficiently, helping to structure mobility policies that are consistent with economic, social and environmental objectives.

Although the regulation primarily focuses on regular transportation services, it includes prominent provisions for DRT, recognizing its essential role for mobility in areas with low transportation demand. Article 2(e) defines the concept of a **public service obligation** as "*a requirement defined or determined by a competent authority in order to ensure public passenger transport services in the general interest that an operator, if it were considering its own commercial interests, would not assume or would not assume to the same extent or under the same conditions without reward*." This principle allows authorities to set specific requirements for public transport operators who would otherwise not offer certain services, particularly in areas of reduced demand or for less profitable time slots. Unlike traditional scheduled services, DRT offers greater flexibility and can be shaped to meet the mobility needs of specific categories of users, such as the elderly, students, and people with disabilities. DRT services also contribute to intermodality, particularly when they are integrated with advanced digital solutions that enable the Mobility as a Service (MaaS) paradigm. The design of such services requires coordinated governance among different actors, as well as appropriate regulation of available resources. The Transportation Regulatory Authority (ART) recognizes that DRT services are a particularly suitable mode of public transport for fulfilling public service obligations in areas of reduced demand, serving as a tool for guaranteeing the right to mobility even in the most peripheral areas or in low-density residential settings.

Another key aspect of the Regulation (EC) No. 1370/2007 concerns the granting of financial compensation and exclusive rights to public transport operators for fulfilling public service obligations. In this regard, it states that "*competent authority decides to grant the operator of its choice an exclusive right and/or compensation, of whatever nature, in return for the discharge of public service obligations, it shall do so within the framework of a public service contract*", and by way of derogation from previous paragraph "*public service obligations which aim at establishing maximum tariffs for all passengers or for certain categories of passenger may also be the subject of general rules. The competent authority shall compensate the public service operators [...] in a way that prevents overcompensation*".

6.1.2. ITS Directive

As a preamble to the discussion of the EU Directive, it is good to specify its object of provision whereby **Intelligent Transport Systems** (ITS) are defined as technological tools using telecommunication technologies, electronics, in-formation technologies and transport engineering, capable of offering services with regard to traffic management and different modes of transport, including in such a way that users can freely access them to obtain necessary information on the traffic status of networks and usability of transport services.

The application of information technology's own technologies to the road transport sector, as well as to interfaces with other modes of transport, in addition to facilitating travel by reducing distances between user and service, contributes significantly to the improvement of environmental performances, increased efficiency, including energy efficiency as well as road transport safety. Thus, the use of such tools enables **optimization and efficiency in the planning, design, and management of transportation systems**. Concrete applications include systems for monitoring passenger numbers and locating public vehicles (automatic vehicle location), which allow the service supply to be adjusted to actual demand, but also the introduction of smart traffic lights and electronic panels for communicating real-time traffic information. Further applications in an urban context can be adopted for the implementation of:

- *intermodal trip planning* tools that allow planning a route by combining private cars, public buses, bike or car sharing;

- "*fare system*" platforms for calculating the cost of an intermodal trip including the tickets of different means of transportation;
- *MaaS* (Mobility as a Service) *platforms* that integrate different mobility services (car and bike sharing, buses, taxi) into a single application.

In this context, the **Directive of the European Parliament and of the Council of July 7, 2010, No. 40**, subsequently amended by Directive of the European Parliament and of the Council of November 22, 2023, No. 2661, establishes a regulatory framework for the **coordination and implementation of Intelligent Transport Systems**. These systems are based on open and public standards, they are interoperable and accessible on a non-discriminatory basis to all providers and users of applications and services in the road transport sector, with a focus on interfaces with other modes of transport. Directive (EU) 40/2010 aims to establish the general conditions necessary for the coordinated and coherent support, deployment, and use of ITS systems by providing for the development of specific actions in **four** well-defined **priority areas**:

I. optimal use of road, traffic and travel data;
II. continuity of traffic and freight management ITS services;
III. ITS road safety and security applications;
IV. Linking the vehicle with the transport infrastructure.

In relation to these priority areas, Article 3 of Directive (EU) 40/2010 lists **six priority actions**, of which the first three are strictly relevant to this analysis study:

a) the provision of EU-wide multimodal travel information services;
b) the provision of EU-wide real-time traffic information service;
c) data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users.

These include the definition of specifications for **interoperability and continuity of ITS services**, **standardization in data collection and data sharing**, and the implementation of real-time traffic and travel information. Directive (EU) 40/2010, in its entirety, provides precise definitions for each of its constituent elements, emphasizing key concepts such as "*continuity of services*", i.e., the ability to ensure uninterrupted services on transport networks by ensuring compatibility between national and European ITS systems, while also promoting cooperation between public and private entities, transport operators, and other stakeholders. Article 6 emphasizes that the European Commission is responsible for adopting the technical specifications necessary to ensure compatibility, interoperability, and continuity in the deployment and operational use of ITS, initially for priority actions. In conjunction with Articles 17 and 18, the Member States transpose the adopted text by establishing their obligations in monitoring and evaluating the effectiveness of implemented ITS systems, submitting periodic reports to the Commission on the progress made in the deployment of actions, activities and national projects concerning the priority areas.

The EU competence provided by Directive (EU) 40/2010, through the Delegated Regulations supplementing the ITS Directive, also produces results in favor of vehicle and driver safety, with measures that prioritize road safety objectives. **Delegated Regulation (EU) 886/2013**, concerning data and procedures for free communication to users, provides the universal minimum road safety-related traffic information and, for the "*provision of road safety-related minimum universal traffic information free of charge to users*", specifies that "*the national access point can take the form of a repository, registry, web portal or similar […] road safety-related traffic data […] are collected, formatted, and made available for exchange and reuse*". Similarly, through **Delegated Regulation (EU) 885/2013** on the provision of information services on safe parking areas for trucks and commercial vehicles, it is taken into account that "*static data shall be accessible through a national or international access point*" and "*for dynamic data, Member States (or national authorities) shall be responsible for setting up and managing a central national or international point of access referencing all individual single points of access of each truck parking operator and/or service provider on their territory in the interests of users*".

Complementing Directive (EU) 40/2010, the **European Commission's Delegated Regulation (EU) 2015/962 of December 18, 2014** provided for real-time traffic information services throughout the Union. This regulation emphasizes that accessibility to static and dynamic road data, as well as accurate and up-to-date traffic information, is essential for providing real-time traffic information services throughout the EU. Relevant data are collected and stored by road authorities, road network managers, and real-time traffic information service providers. To facilitate the exchange and reuse of these data, road authorities, road operators, and service providers make the data, corresponding metadata, and quality information available through a ***National Access Point*** **(NAP)**. This access point can take the form of a directory, registry, web portal, or similar, depending on the type of data. Member states are encouraged to group existing public and private access points into a single point, allowing access to all available relevant data types that fall within the scope of the specifications.

In order to enable road authorities, road operators, service providers, and digital map producers to effectively source and use relevant data in a cost-effective manner, Delegated Regulation (EU) 2015/962 establishes the specifications necessary to ensure the accessibility, exchange, reuse, and update of road and traffic data by road authorities, road operators, and service providers in order to prepare real-time traffic information services throughout the European Union. This regulation applies to the entire trans-European road network, as well as to highways not included in this network and to priority areas identified by national authorities where these authorities deem it relevant. *Article 3* of the regulation specifies that **each Member State shall establish a National Access Point (NAP), which shall be a single point of access for users to road and traffic data**, including updates provided by road authorities, road operators, and service providers relating to the territory of a given Member State, also enabling appropriate search services for users. In this regard, the various actors involved, in cooperation with digital map producers and service providers, must ensure the provision of appropriate metadata in order to enable users to find and use the datasets accessible through national access point.

Accessibility is further specified in Articles 4 and 5 of the regulation. *Article 4* relates to the exchange and reuse of static road data: to facilitate the provision of real-time traffic information services throughout the EU, road authorities and road operators shall provide the static road data that they collect and update according to defined temporal and spatial parameters, in a standard format or any other format readable by a computing device. *Article 5* refers to the exchange and reuse of dynamic road status data: in order to facilitate the provision of compatible, interoperable and continuous real-time traffic information services throughout the EU, road authorities and road operators shall provide the dynamic road status data they collect and update them in *DATEX II* format (as defined in technical specification CEN/TS[15] 16157 and subsequent updates) or in any other format readable by a computing device that is fully compatible and interoperable with DATEX II. This European technical specification, known as DATEX II, is a standard for the exchange of traffic and road data, used to ensure interoperability and uniformity in the sharing of information between ITS systems throughout Europe, and has been fully implemented by the Italian Standards Authority (UNI). In conjunction, both static and dynamic road data, together with the corresponding metadata, including quality information, must be accessible for exchange and reuse by any digital map producer or service provider within the territory of the Union: on a non-discriminatory basis, according to a timeline that allows for the timely provision of traffic information services in real time and through the National Access Point (NAP). Finally, Delegated Regulation (EU) 2015/962 stipulates that the real-time traffic information services shall be based on updates of static road data, dynamic road status data, and traffic data, or a combination of them. All data is updated regularly by road authorities, road operators and service providers in accordance with specific provisions carefully regulated by the EU dispositions.

[15] **CEN:** Comité Européen de Normalisation; **TS:** Technical Specification

Italy's adoption and transposition of the ITS Directive and its Delegated Regulations are discussed in Section 6.2.1 below, which is devoted to national measures to comply with EU guidelines.

6.1.3. Data standardization and interoperability

Complementing the Directive of the European Parliament and of the Council of July 7, 2010, No. 40, on the "framework for the deployment of Intelligent Transport Systems in the field of road transport and interfaces with other modes of transport," the **European Commission's Delegated Regulation No. 1926 of May 31, 2017**, establishes technical specifications for the "*provision of EU-wide multimodal travel information services*". This regulatory legislation is closely related to the concept of Mobility as a Service (MaaS), as it *provides a framework for the integration of transport data, their interoperability and access through unified digital platforms*. In this context, it is central to the implementation of MaaS because it:

- establishes a standardized and interoperable infrastructure for data collection and sharing
- promotes open and non-discriminatory access to data by fostering the development of integrated platforms, such as MaaS, by public and private operators
- defines clear technical requirements, such as the use of standardized *NeTEx* and *SIRI* formats, to ensure that information is easily integrated and usable.

Overall, Delegated Regulation (EU) 2017/1926 establishes the necessary legal framework for implementing mobility-as-a-service (MaaS) policies, providing detailed guidelines for data standardization and interoperability. This includes the establishment of National Access Point (NAP), the definition of technical standards, and the principle of neutrality in information usage. These provisions enable the development of digital architectures where MaaS platforms can operate, offering users personalized mobility planning and laying the operational foundations for multimodal mobility information services. This sets the regulatory groundwork for an interconnected, accessible, and interoperable transportation system. Article 1 clarifies the regulation's main objective, applicable to the entire European Union transport network, stating that it "*establishes the necessary specifications in order to ensure that EU-wide multimodal travel information services are accurate and available across borders to ITS users*". This principle is central to MaaS implementation, ensuring that mobility information is uniform, reliable, and accessible, overcoming the fragmentation that often hinders multimodal itinerary planning. One of the main tools introduced by Delegated Regulation (EU) 2017/1926 is the National Access Point (NAP), described in Article 3, where "*each Member State shall set up a national access point. The national access point shall constitute a single point of access for users to at least the static travel and traffic data and historic traffic data of different transport modes*". This centralized system allows platforms to collect and integrate data from multiple operators, who must provide appropriately standardized data, thus ensuring a fully integrable and interconnected view of transport services. Anticipating such standardization and technical specifications, to ensure that such information is always effectively usable, Article 4 of the Regulation sets specific requirements for the availability and sharing of data by transport authorities, transport operators, infrastructure managers, or on-demand transport service providers. They must provide static mobility and traffic data through the National Access Point, in the required formats, including information on the availability of transport services, fares, and estimated travel times, stating that "*relevant static travel and traffic data [...] shall be provided using [...] standards and technical specifications such as NeTEx and DATEX II*". Similarly, Article 5, in conjunction with point 2 of the Annex to Delegated Regulation (EU) 2017/1926, addresses the issue of "*dynamic mobility and traffic data*", such as timetables, travel itineraries, and auxiliary information like disruptions. It also requires that real-time updated information, such as delays, cancellations, or vehicle availability, be made accessible through the NAP. Regarding the sharing of both static and dynamic data, the regulation stipulates that "*APIs that provide access to static travel and traffic data listed in the Annex via the national access point shall be publicly accessible allowing users and end-users to register to obtain access*". Articles 4 and 5 together ensure that MaaS platforms have access to uniform and updated data, necessary to provide users with a seamless and personalized experience. Another fundamental aspect for MaaS functionality is transparency and neutrality in data usage, principles enshrined in Article 8, stating that "*mobility and traffic*

data [...] are accessible for exchange and reuse within the Union on a non-discriminatory basis [...]", and "*shall be reused in a neutral manner and without discrimination or bias*". These provisions ensure that all operators, both public and private, can access the information necessary to develop integrated solutions, promoting an open and competitive ecosystem. Delegated Regulation (EU) 2017/1926 is accompanied by an Annex, referenced in detail within the articles, which specifies standardized data formats (e.g., NeTEx for static data and SIRI for dynamic data), as well as the information contained in the required data for static data (such as schedules, fares, and routes) and dynamic data (estimated travel times, vehicle availability, real-time traffic conditions). These constitute the operational data foundation of MaaS platforms, enabling the planning of intermodal journeys, managing bookings and payments, and responding in real-time to user needs.

The Delegated Regulation (EU) 2017/1926 *introduces the National Access Point (NAP) for providing Multi-Modal Travel Information Services (MMTIS)*, a tool designed to centralize and facilitate access to data related to multimodal travel information services, thereby promoting "interoperable" transport aligned with EU directives.

This platform simplifies the work of sector operators, offering greater transparency in delivering information to citizens, enhancing operational efficiency, and increasing the attractiveness of transport systems. Each Member State establishes its own NAP MMTIS, configured as a digital platform that collects and distributes both static and dynamic data. Static data includes information such as schedules, fares, and details about routes and available services, while dynamic data focuses on real-time updates like delays, cancellations, traffic conditions, and other operational changes. This duality provides travelers with a comprehensive and continually updated overview, enabling informed and efficient travel planning. While the regulatory framework defines the platform's application at the national level, it should be viewed in integration with the European Union's cross-border networks, pursuing operational uniformity and service continuity through harmonized information. The primary objective of the NAP MMTIS platform is to foster the development of interoperable digital services capable of operating beyond national borders, offering travelers an integrated experience. To ensure this level of interoperability, *Delegated Regulation (EU) 2017/1926 mandates that data be provided in standardized formats: DATEX II, NeTEx, and SIRI*, which represent the European technical specifications standards for exchanging traffic and multimodal mobility information. The innovative approach adopted by the Union lies in the fact that the NAP MMTIS should not be limited to covering a single mode of transport but must include all types, both public and private, reflecting the vision of mobility as a service and embracing the broader concepts of MaaS.

Additionally, Delegated Regulation (EU) 2017/1926 fits within the legal framework of Directive (EU) 40/2010 to ensure uniform and interoperable access to public transport data, promoting the realization of European-level travel planning platforms and strengthening the regulatory framework for providing multimodal transport information services. The operational aspects of the regulatory norm are the National Access Point (NAP), through which data holders are required to make available static information such as schedules and routes, as well as real-time vehicle position dynamics. To guarantee standardization and territorial uniformity in handling the matter, Delegated Regulation (EU) 2017/1926 prescribes the use of specific technical formats, including NeTEx for static data and SIRI for real-time information. The convergence of these standards with the Transmodel conceptual model ensures information consistency at the cross-border level, thus ensuring full interoperability of data and multimodal travel information services.

6.1.4. Diffusion of ITS in the road transport sector and interfaces with other modes of transport

The European Commission's Communication to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions dated December 9, 2020, SWD 331 final, titled "*Strategy for Sustainable and Smart Mobility: Putting European Transport on the Right Track for the Future*," identifies the deployment of Intelligent Transport Systems (ITS) as a key action to achieve connected and automated multimodal mobility. This approach aims to transform the European transport system

to achieve efficient, safe, sustainable, smart, and resilient mobility, aligning with the ambitious targets of the European Green Deal. As part of the "Strategy for Sustainable and Smart Mobility," a revision of Delegated Regulation (EU) 1926/2017 was announced for 2022 to mandate access to dynamic data sets. This includes assessing the need for regulatory action concerning the rights and obligations of multimodal digital service providers, along with an initiative on ticketing, including rail tickets. In this context and reform scenario, **Directive (EU) No.2661 of the European Parliament and the Council of November 22, 2023**, amending and supplementing Directive (EU) 40/2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport, ensures that ITS applications in the road transport sector allow seamless integration with other modes of transport, such as rail or active mobility. This facilitates the shift to these modes where possible, improving efficiency and accessibility.

Directive (EU) 2023/2661 primarily addresses the clarification and redefinition of the four priority areas outlined by Directive (EU) 40/2010 for the development and use of specifications and standards, updating their scopes of action:

I. ITS services for information and mobility;
II. ITS services for travel, transport, and traffic management;
III. ITS services for road and transport safety;
IV. ITS services for cooperative, connected, and automated mobility.

Considering the need to digitize road transport, enhance road safety, and reduce congestion, it is appropriate to further develop the deployment and use of intelligent transport systems and services on roads within the trans-European transport network. This aligns with policies promoting digitization and innovation in road transport, creating employment opportunities through the development of new projects in the sector. In the context of implementing Commission Delegated Regulations (EU) No. 885/2013, No. 886/2013, 2015/962, and 2017/1926, which supplement Directive (EU) 40/2010, Member States have established National Access Points (NAPs) to organize access to and reuse of transport-related data. This contributes to providing end-users with interoperable ITS services on mobility and traffic at the EU level. The NAPs, along with any Regional Access Points (RAPs) present in Member States, constitute an important component of the common European mobility data space within the context of the European data strategy and should be relied upon, particularly concerning data accessibility. Although NAPs are operational in all Member States, there remains a need to improve data availability regarding many types of data deemed crucial to support the development of essential services that provide necessary information to end-users. In this paradigm, as provided by Directive (EU) 2023/2661, such transport data should be made available in a machine-readable format through an automated device.

The Directive extends the scope of application of ITS to ensure seamless integration with other modes of transport, such as rail transport or active mobility, facilitating the shift to these modes where possible to improve efficiency and accessibility. This also strengthens the strategic policy framework aimed at enhancing road safety by integrating the concepts of the so-called "Vision Zero," with the objective of achieving zero fatalities across all modes of transport in the EU by 2050. To this end, various actions within the adopted provisions contribute to road user safety, such as the electronic emergency call service (eCall) and traffic information services related to road safety.

Directive (EU) 2023/2661 also emphasizes the growing importance of multimodal automated and connected mobility to intelligent traffic management systems through a strong digitization of systems. The goal is to increasingly support new sustainable mobility and transport services that can improve urban travel, reduce road congestion, and associated pollution, thereby enabling the transition to green and zero-impact transport modes. In this context, the directive also stipulates that certain information regarding alternative fuel infrastructures should be made available and accessible through a national access point.

A central aspect of the regulatory framework is the improvement of data sharing, recognizing the growing need to make the best use of available sources, with greater coordination of the ITS framework in the mobility, transport, and logistics sectors from a multimodal perspective. Directive (EU) 2023/2661

introduces other innovations, such as "*Cooperative Intelligent Transport Systems*" or "C-ITS," defined as intelligent transport systems that enable ITS users to interact and collaborate by exchanging secure and reliable messages without any prior mutual knowledge and in a non-discriminatory manner. Communication in C-ITS occurs through standardized protocols, such as:

- V2V (Vehicle to Vehicle): involves the exchange of information between vehicles (e.g., sudden braking, speed);
- V2I (Vehicle to Infrastructure): communication between vehicles and infrastructures (e.g., intelligent traffic lights, speed limits);
- V2X (Vehicle to Everything): a broader communication that includes pedestrians, bicycles, and other road elements.

These systems therefore improve road safety through preventive warnings about accidents, roadworks, hazardous weather conditions, optimize traffic by reducing road congestion through dynamic traffic flow management, making the use of road infrastructures more efficient, and also enabling communication with connected infrastructures such as charging parks for electric vehicles and information on available parking spaces.

6.1.5. Improving the accessibility and sharing of mobility-related data

Within this regulatory framework, data continues to serve as the contextual foundation for the development of multimodal mobility information services, as outlined in the European Data Strategy, presented in the European Commission Communication to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions on February 19, 2020 (COM No. 66 final), titled "*A European Strategy for Data*". This strategy underscores the critical importance of increasing data availability to address social, climate, and environmental challenges.

The strategy document highlights the benefits of data-driven innovation for citizens and proposes the creation of interoperable common data spaces at the EU level in strategic sectors, including a European common mobility data space. In this regard, Delegated Regulation (EU) 2017/1926 plays a crucial role in improving accessibility and data sharing for multimodal mobility, ensuring that an increased volume of dynamic datasets becomes available in alignment with the objectives of the European Data Strategy. The widespread adoption of Intelligent Transport Systems (ITS) across the EU requires continuous support in the form of expanded and uninterrupted access to existing and new mobility-related data relevant to multimodal travel information services. Historical data on mobility and traffic, particularly average delay calculations, observed delays, cancellations, and parking availability information, should be made accessible to enhance multimodal mobility information services and facilitate passenger movement.

To support these principles, **Delegated Regulation (EU) 2023/490 of November 29, 2023**, which amends Delegated Regulation (EU) 2017/1926, introduces new provisions for the establishment of multimodal mobility information services across the EU. It defines the necessary requirements to ensure the accuracy and availability of multimodal mobility information for end-users.

This new framework defines:

- "***Multimodal mobility information***" as information derived from static, historical, observed, or dynamic mobility and traffic data, or a combination thereof provided through any communication medium, covering at least two modes of transport and allowing comparison between transport options.
- "***Mobility information services***" as ITS services, including digital maps, offering data users and end-users mobility and traffic information related to at least one transport mode.

These refinements clarify the regulatory compliance structure and the intended scope of the directives. Under Delegated Regulation (EU) 2023/490, each Member State is required to establish a National Access Point (NAP), which acts "*a single point of access for data users to the static, historic, observed and dynamic*

travel and traffic data of different transport modes, including data updates, as set out in the Annex, provided by the data holders within the territory of a given Member State".

Regarding **accessibility**, exchange, and reuse of static, historical, and observed mobility and traffic data, the new regulation mirrors previous provisions on technical specifications by adopting standardized formats to ensure data standardization and interoperability. These include one of the recognized technical standards or any digitally readable format compatible and interoperable with these standards, such as Transmodel, NeTEx, and DATEX II. The APIs providing access to static, historical, and observed mobility and traffic data listed in the annex, available through the established National Access Point, are publicly accessible to data users. Similarly, for dynamic mobility and traffic data, data holders must provide access via the National Access Point, ensuring compliance with SIRI for real-time information exchange.

Delegated Regulation (EU) 2023/490 does not replace Delegated Regulation (EU) 2017/1926 but modifies and updates it to align with the EU's evolving goals in multimodal and sustainable mobility. The regulation represents a regulatory upgrade aimed at improving the quality and comprehensiveness of multimodal mobility information services, introducing several key innovations, including:

- *expanding the list of datasets* required to be accessible through National Access Points, incorporating new static, historical, and observed data;
- *mandating access to dynamic datasets*, facilitating data sharing and use to support real-time travel information services;
- *promoting the creation of interoperable common data spaces at the EU level*, including a European Common Mobility Data Space, in accordance with the European Data Strategy.

6.1.6. INSPIRE Directive

To enhance mobility, safety, and sustainability in transport, the ITS Directive sets the framework for the development and adoption of Intelligent Transport Systems aimed at ensuring the operational continuity of mobility services. It establishes the regulatory reference framework for Delegated Regulations, which comprehensively define data-related specifications for mobility, multimodal travel, traffic management, and real-time transport information services, ensuring uniform data sharing among public authorities, transport operators, and digital service providers.

In parallel, the European regulatory framework recognizes **Directive 2007/2/EC of March 14, 2007,** known as **INSPIRE** (*Infrastructure for Spatial Information in Europe*), which aims to establish a European spatial information infrastructure, fostering the sharing of geospatial data among public administrations and private entities. The INSPIRE framework consists of three core components:

- *Metadata*;
- *Spatial datasets*;
- *Network services*.

These elements, as defined in Chapter II of Directive (EC) 2007/2, describe spatial datasets and related services, enabling users to search, catalog, and utilize such data. Spatial data includes all geographic information related to a specific area, such as addresses, transportation networks, elevation models, and land use classifications.

The "*interoperability of spatial datasets and related services*", defined in Chapter III of the INSPIRE Directive, is established through rules ensuring that spatial data and related services remain compatible and consistently usable across EU Member States. These implementation rules, developed in collaboration with Member States, are designed to meet user needs and align with existing national and international initiatives. To guarantee accessibility and interoperability, the infrastructure incorporates network services and technologies, as well as data-sharing agreements for access and usage.

The connection between the ITS Directive and the INSPIRE Directive becomes evident when considering the need to represent and manage spatial networks (geographic infrastructure) within transport systems, which

are essential for territorial planning and environmental management. Road, rail, air, and waterway networks, along with their associated infrastructure, form the intersection between the two directives. Geospatial data on road infrastructure, as defined by INSPIRE, serves as the foundation for ITS, as regulated by the ITS Directive and its Delegated Regulations. Together, the ITS Directive and the INSPIRE Directive create an integrated regulatory system, where mobility and territorial management converge. Their complementary relationship is evident in the shared use of mobility and spatial data, with INSPIRE providing the static geospatial foundation, including maps, boundaries, and road networks, while the ITS Directive governs both static and dynamic transport data, such as timetables, stops, routes, real-time traffic conditions, and estimated arrival and waiting times. A key aspect of this integration is the role of ITS in managing rendez-vous points between interconnected multimodal transport systems.

The ability to coordinate real-time multimodal connections is fundamental for passenger mobility planning, ensuring seamless transitions between different modes of transport, optimizing waiting times, and enhancing service efficiency. Journey planning applications rely on both INSPIRE's spatial data and ITS's dynamic mobility data to offer integrated travel solutions. In this synergy, INSPIRE's territorial information is seamlessly integrated with ITS real-time data, enabling the development of advanced Mobility as a Service platforms.

6.1.7. eIDAS Regulation

The **Regulation (EU) No. 910/2014 of the European Parliament and the Council**, adopted on July 23, 2014, concerning "*electronic identification and trust services for electronic transactions in the internal market*" (eIDAS), represents a cornerstone for the implementation of Mobility as a Service (MaaS). It provides the foundational framework for ensuring security, interoperability, and reliability in digital interactions. At the core of this system is the definition of "*electronic identification*", as set forth in Article 3, which states that electronic identification is *"the process of using person identification data in electronic form uniquely representing either a natural or legal person, or a natural person representing a legal person*". This mechanism is essential for MaaS, as it allows users to access multiple services with a single credential, simplifying the user experience and enabling a centralized management of personal information.

In terms of electronic identification, Article 6 further reinforces the concept of interoperability and mutual recognition, stating that *"when an electronic identification using an electronic identification means and authentication is required under national law or by administrative practice to access a service provided by a public sector body online in one Member State, the electronic identification means issued in another Member State shall be recognized in the first Member State for the purposes of cross-border authentication for that service online […]",* This principle of mutual recognition is fundamental for integrated mobility systems, as it allows users to access mobility services in any EU Member State without the need for additional registrations or authentication steps, ensuring continuity and uniformity in cross-border mobility experiences, fully aligning with the foundational principles of the EU Treaties.

Regarding transaction security, Article 24 of Regulation (EU) 910/2014 sets out the requirements for qualified trust service providers, specifying that they must *"use trustworthy systems and products that are protected against modification and ensure the technical security and reliability of the processes supported by them*". This guarantees that MaaS platforms can protect transactions—such as ticket purchases or vehicle bookings from unauthorized access or fraud, thereby strengthening user trust in the system. Within this framework, Article 25 grants full legal validity to qualified electronic signatures, establishing that *"a qualified electronic signature shall have the equivalent legal effect of a handwritten signature*". This provision ensures that contracts, booking confirmations, and any other transactions conducted through MaaS platforms carry the same legal weight as traditional paper-based agreements, thus streamlining and accelerating authorization processes for service usage.

The structural framework outlined in Regulation (EU) 910/2014 promotes cooperation between Member States, fostering the interoperability of trust services within a collaborative approach that is crucial for the

creation of a unified MaaS ecosystem at the European level. This enables different national platforms to operate seamlessly. Furthermore, eIDAS establishes a framework for electronic identification and trust services, governing secure electronic transactions through mechanisms such as electronic signatures, electronic seals, timestamps, certificates, and authentication services. This collaborative approach is essential for developing a fully integrated European MaaS ecosystem, ensuring full compatibility between electronic identification and authentication systems, and enabling mutual recognition of electronic signatures and seals across different platforms.

6.1.8. Open Data Directive

The **Directive (EU) 2019/1024 of the European Parliament and the Council of June 20, 2019,** commonly referred to as the "*Open Data Directive*", establishes the legal framework for reusing information held by public bodies or publicly owned enterprises, including geographic, cadastral, statistical, and legal data, as well as publicly funded research data. Its primary objective is to *unlock the socioeconomic potential of public sector information, making it more accessible to startups and SMEs, increasing the availability of dynamic datasets and high-value data series, and enhancing competition and transparency in the information market*. This overarching goal has significant implications for MaaS, particularly in the management of open data, as it provides a legal foundation for reusing public sector information as a strategic resource for innovation. By promoting data openness and interoperability, the directive facilitates system integration and operator collaboration, creating a unified, user-oriented mobility ecosystem, which is central to the MaaS vision.

The Directive (EU) 2019/1024 is based on the principle that public data and publicly funded data should be reusable for commercial or non-commercial purposes. To this end, public bodies and publicly owned enterprises must make documents available in any pre-existing language or format and, where possible, electronically in open, machine-readable, accessible, discoverable, and reusable formats, along with appropriate metadata. EU Member States must facilitate effective reuse of documents, including providing information on rights under this directive and offering assistance and guidance. Dynamic data must be made available immediately after collection via an Application Programming Interface (API). The Directive states that reuse of documents must be open to all market participants, with any applicable conditions being non-discriminatory.

The core structure of Directive (EU) 2019/1024 focuses on data availability, as highlighted in Article 5, which establishes that "*public sector bodies and public undertakings shall make their documents available in any pre-existing format or language and, where possible and appropriate, by electronic means, in formats that are open, machine-readable, accessible, findable and re-usable, together with their metadata*". Moreover, "*public sector bodies and public undertakings should make this available for re-use immediately after collection by ways of suitable APIs and, where relevant, as a bulk download*". These provisions ensure that mobility-related data such as timetables, fares, and vehicle availability is accessible in standardized formats. This is a critical requirement for MaaS platforms, as it enables seamless integration of information from multiple sources, facilitating trip planning and mobility management.

Beyond data accessibility, the directive also regulates data reuse mechanisms. Article 6 introduces a "*principle governing charging*" stating that the reuse of documents shall be free of charge. However the "*recovery of the marginal costs incurred for the reproduction, provision and dissemination of documents as well as for anonymization of personal data and measures taken to protect commercially confidential information may be allowed*" Additionally, the adoption of standardized formats is essential to integrating data from different operators, ensuring uniform and seamless information exchange. The Annex I of Directive (EU) 2019/1024 classifies mobility data as high-value datasets, outlining appropriate publication and reuse methods. The directive also emphasizes interoperability as a key factor in ensuring that data management planning aligns with scientific best practices, promoting the **FAIR principles** (Findable, Accessible, Interoperable, and Reusable). By fostering an open data environment, the directive enables the development of platforms that integrate and use standardized data, ensuring accessibility and data provenance. For MaaS,

this means the ability to establish a single access point for mobility services, integrating public transport, shared mobility, and other modes, including on-demand transportation systems, within a single digital interface. This guarantees a secure, informed, and fully digital user experience.

6.2. National Regulatory References

In this section, we examine the national adoption of EU directives and how the country's regulatory framework responds to these requirements to operationalize a coherent political vision.

6.2.1. Urgent measures for National Growth

Italy has transposed Directive (EU) 2010/40 (see § 6.1.2) into its national legislation through amendments to Article 8, paragraphs 4 to 9, of **Decree-Law No. 179 of October 18, 2012**. These amendments establish the necessity of ensuring the widespread adoption of Intelligent Transport Systems (ITS) at the national level, guaranteeing efficiency, rationalization, and economic sustainability in line with the EU regulatory framework. Through a ministerial decree issued by the Minister of Infrastructure and Transport, in consultation with the competent ministers, specific guidelines have been adopted to define the requirements for ITS deployment, design, and implementation. These guidelines ensure free access to basic transport information, regular updates of infrastructure data and traffic conditions, and the coordinated, integrated, and coherent development of ITS across the national territory, in alignment with ongoing national and EU policies. To give concrete implementation to the legislative provisions of Decree-Law No. 179/2012, the **Ministerial Decree of February 1, 2013** (published in Official Gazette No. 72 of March 26, 2013) introduced key measures for the nationwide deployment of Intelligent Transport Systems in Italy, including:

- the establishment of a national ITS telematics platform, aimed at fostering ITS development and creating new professional roles for system design, management, and maintenance;
- mandatory provision of traffic event data by the "Traffic, Road, and Safety Information Coordination Center" (CCISS), making the Traffic Events Data Dictionary publicly available via the DATEX protocol;
- a national traffic database, with georeferenced models and real-time traffic data, including a Public Index of Infrastructure and Traffic Information, which centralizes both public and private data on mapping, infrastructure, traffic, and road conditions;
- the use of ITS for multimodal passenger transport to enhance service interoperability;
- technical specifications for vehicle-to-infrastructure communication, fostering ITS applications for speed monitoring on urban and interurban road networks with high traffic flow.

In accordance with Directive (EU) 2010/40 and subsequent Delegated Regulations (EU) 885/2013, 886/2013, 962/2015, and 1926/2017, Italy has designated the CCISS as its National Access Point (NAP). This designation assigns the CCISS the responsibility of centralizing, managing, and providing access to data on traffic, road safety, and multimodal mobility, ensuring full interoperability with EU systems.

As outlined in previous regulatory sections, ITS-related data is categorized into two main data types as "static" and "dynamic". The first is information on road networks, infrastructure, road attributes, and speed limits, and the second real-time updates on accidents, weather conditions, road works, and temporary restrictions. The NAP's multimodal mobility component (MMTIS), established under Delegated Regulation (EU) 2017/1926, integrates real-time transport data with multimodal transport options, including timetables and intermodal connections across public, private, and active mobility services. To ensure cross-border interoperability with EU Member States, the CCISS adopts standardized data formats as outlined in §§ 6.1.3 and 6.1.5 and Chapter 4.1 for further technical details. This includes DATEX II for real-time traffic information and NeTEx and SIRI for multimodal transport data. Using these standards ensures data uniformity, allowing ITS service providers to seamlessly integrate CCISS data into their platforms while maintaining compliance with EU regulatory frameworks for standardization and interoperability. As Italy's designated NAP, CCISS is not only responsible for data collection, distribution, and updates but also plays a role

in real-time traffic monitoring at a national scale, cooperation with local and national authorities in road emergency management, public awareness campaigns for road safety. Providing transport users with accurate and timely information through official channels, mobile applications, and telephone services. It is important to note that road safety and transport security are among the four priority areas established under Directive (EU) 2010/40, later revised in Directive (EU) 2023/2661. The activities carried out by CCISS directly contribute to these priority actions, ensuring the availability of Real-Time Traffic Information (RTTI) and Safety-Related Traffic Information (SRTI). By making these datasets widely accessible, CCISS facilitates the creation of a digital, integrated, and sustainable transport system, fully aligned with the EU's objectives for interoperability and innovation.

6.2.2. Digital Administration Code (CAD)

Legislative Decree No. 82 of March 7, 2005, established the Digital Administration Code (CAD), serving as the national regulatory reference point to guide the digital transformation of Public Administration. It provides useful guidelines for citizens and providers for the proper management of electronic documents and digitized administrative processes. Additionally, it functions as the main instrument through which Italian Public Administrations can digitally implement the principles of cost-effectiveness, efficiency, impartiality, publicity, and transparency, as outlined in Article 1 of Law No. 241 of August 7, 1990, concerning administrative procedures and the right of access to administrative documents.

It is important to highlight the nature of Legislative Decree No. 82/2005, configured as a "Code," meaning a consolidated text that systematically gathers and organizes regulations related to digital citizenship rights, as well as other technical and strategic normative provisions. However, the CAD was not conceived as a static element in the legislation; over time, it has been continually enriched with integrations that have incorporated technical rules and operational principles. These updates aim to strengthen its regulatory and applicative function, adhering to European legislative updates and subsequent technological evolutions, ensuring a modern and flexible legal infrastructure to promote administrative efficiency and digital inclusion.

One of the key principles of the CAD is the concept of "***once only***," also reiterated in the National Recovery and Resilience Plan (PNRR) and central to investment 1.3 on data and their interoperability, as will be discussed in the following section 6.2.3. This principle is explicitly stated in Article 50-ter of the Code, which "*promotes the design, development, and implementation of a National Digital Data Platform (PDND) aimed at enhancing the knowledge and use of the information assets held […] consists of a technological infrastructure that enables the interoperability of information systems and databases of public administrations and public service providers […] The sharing of data and information occurs through the provision and use, by accredited entities, of application programming interfaces (APIs). These interfaces […] in compliance with the AgID Guidelines on interoperability, are collected in the "API catalog*".

In relation to our context of integrating MaaS policies, this principle is particularly relevant as it allows for the creation of a digital ecosystem where information provided by users, such as payment credentials or travel preferences, can be automatically shared and reused among different mobility services. This not only benefits the user experience but also significantly reduces administrative burdens, promoting a more efficient and integrated management of information.

Supporting the "*once only*" principle, in addition to the emphasis on interoperability that permeates the Code throughout its provisions, Article 1 defines the concept of application cooperation as "*part of the Public Connectivity System aimed at the interaction between the information systems of participating entities, to ensure the integration of metadata, information, processes, and administrative procedures*". The combination of these factors leads us to establish that systems must facilitate the exchange and reuse of data through information systems designed to ensure interoperability and application cooperation. In this regard, the State and Public Administration must endeavor accordingly. This assumption reinforces the fundamental elements of MaaS, as it provides for the construction of a shared infrastructure where data is

easily accessible and compatible across various platforms and administrations, thus ensuring a continuous flow capable of supporting the planning and management of movements. Always with a view to simplification and unified access, access to digital services is further simplified by Article 60, which establishes the public system for managing digital identities (SPID) to "*promote the dissemination of online services and facilitate access to them by legal entities, including in mobility*", and by Article 64-bis, concerning telematic access to Public Administration services. Through this public system, users can access a variety of services with a single credential without the need for repeated authentications, promoting uniformity in the digital experience and ensuring simplicity. Similarly, reflecting EU dictates, the CAD also places particular emphasis on the quality, security, and integrity of the data processed, especially from the perspective of data reliability. This is one of the basic requirements for the implementation of all those policies that integrate external data sources at a unified platform/collector level, where the reliability of the data that becomes information for the user is the core support of the entire platform itself.

Digital Administration Code provides a broad and varied regulatory framework that enables the development of IT platforms that process data in an integrated manner, as occurs in MaaS systems. Thanks to adherence to the "once only" principle, as well as system interoperability, application cooperation, and unified management of digital identity, the Code allows for the adoption of advanced technological solutions aimed at improving administrative efficiency and offering citizens a new interface for accessing the world of Public Administration and its connected systems.

6.2.3. National Recovery and Resilience Plan (NRRP)

Through **EU Regulation No. 241 of February 12, 2021**, the "*Recovery and Resilience Facility*" (RRF) was established. The PNRR, acronym for *National Recovery and Resilience Plan*, as per Decree-Law No. 59 of May 6, 2021, converted with amendments by Law No. 101 of July 1, 2021, and subsequent amendments, is the strategic document that the Italian Government has prepared to access funds from the Next Generation EU program.

Italy's PNRR was definitively approved by **Council Implementing Decision No. 10160 of July 13, 2021**, which adopted the proposal for the approval of the plan's assessment SWD No. 165 of June 22, 2021. The National Recovery and Resilience Plan aims to:

- revitalize the Country after the COVID-19 pandemic crisis, stimulating ecological and digital transition;
- promote a structural change in the economy, starting with addressing gender, territorial, and generational inequalities.

Divided into six main Missions, the PNRR outlines investment priorities over a five-year period, from the second half of 2021 until completion and reporting expected by the end of 2026, aiming to recover the country's economic and social structure by focusing particularly on the levers of digitalization, ecological transition, and social inclusion.

PNRR is developed along 16 Components, functional to achieving the economic and social objectives defined in the Government's strategy; these components are grouped into the main Missions where, for each Mission, the necessary reforms for a more effective implementation of the interventions are indicated. There will be 63 reforms in total, divided into the following types:

- *Horizontal (or contextual) reforms*, which involve structural changes in the legal system that transversely influence all the Plan's Missions, through structural innovations aimed at improving the country's equity, efficiency, competitiveness, and economic framework;
- *Enabling reforms*, which include measures for simplification and legislative rationalization, as well as initiatives to promote competition, functional to ensuring the Plan's implementation and generally to removing administrative, regulatory, and procedural obstacles to improve the national economic context and the quality of services provided;

- *Sectoral reforms* (contained within the individual Missions), which are regulatory innovations related to specific areas of intervention or economic activities, intended to introduce more efficient regulatory and procedural regimes in their respective sectors;
- *Concurrent reforms*, which are measures not directly included in the Plan but necessary for achieving the general objectives of the PNRR.

These reforms are essential not only as a fundamental component of national plans but also as a driving force for their implementation. At the sectoral level, the reforms concern specific regulatory innovations for certain sectors or economic activities, introducing more efficient regulations and procedures in their respective reference areas.

Mission 1: Digitization, innovation, competitiveness, culture and tourism

The PNRR envisages a digital modernization of the country system through which to carry out a structural transformation of management and accessibility to public services, thus responding, on the one hand, to the delay accumulated in the technological transition and, on the other, to promoting greater competitiveness of the productive system and broader accessibility to services by citizens and businesses. Mission 1 of the National Recovery and Resilience Plan therefore represents the heart of the project to relaunch the competitiveness and productivity of the country system, in a vision that is both strategic and integrated. To achieve these results, the guidelines underlying the Plan provide for a series of interrelated "***components***", each equipped with a well-ordered series of "***investments***" into which the Plan's actions are channeled. This appropriate Plan architecture allows for agile operational capacity in identifying financial resources dedicated to the various components of the missions. Mission 1, in its generality, is based on three key elements:

- widespread and advanced connectivity for citizens, businesses, and Public Administration;
- a modern, digital Public Administration oriented towards simplifying the lives of citizens and companies;
- enhancement of cultural and tourist heritage, not only as an economic resource but also as an emblem of the "Italy brand".

In this general vision, digitalization becomes an asset of every action, every investment, every component of the Mission, not representing only a sectoral reform theme but a real transversal need that will require continuous technological updating of the data network processes connected to every sectoral area and that is shareable in the exchange of information, through a unified and coordinated approach that aims not only to intervene on the Public Administration and the productive system but to create a lasting impact on private investments and Italy's attractiveness in the global context. The Mission is structured on three main project components and a strategy of regulatory interventions, which look at the digital transition of every area of the Public Administration and where **Component 1 aims to deeply transform the Public Administration through a strategy centered on digitalization**.

Component 1 focuses interventions on improving digital infrastructures and creating a Public Administration capable of promptly responding to needs in terms of efficiency, transparency, and accessibility, particularly articulating its first four "investments," which are complementary and able to systematically address the technological criticalities of public administrations, aiming to build an integrated platform of services for citizens and to promote the transition towards innovative governance models.

Investment 1.1: Digital infrastructure

This represents the technological basis of the PA's digitalization, concentrating a series of actions and interventions that aim to strengthen digital infrastructures to develop a centralized and secure system, capable of supporting the interconnection and management of data on a national scale. The digital transformation of the PA follows a "***cloud first***" approach, oriented towards migrating data and IT applications of individual administrations to a cloud environment. This process will allow for the rationalization and

consolidation of many data centers currently distributed across the territory, starting with the less efficient and secure ones.

Investment 1.2: Enabling and facilitating cloud migration for local administrations

This investment aims to extend the benefits of digitalization to local public administrations by facilitating their migration to cloud services and is part of a broader strategy to modernize Italy's public administration by leveraging cloud technology to create a more efficient, secure, and user-friendly public sector. The transition to the cloud will standardize the technologies used by public administrations, enhancing operational efficiency and reducing infrastructure management costs. The goal is to establish a scalable and interoperable system that enables local administrations to share data and services, thereby simplifying and standardizing administrative practices for more streamlined resource management.

Specifically, this initiative supports local administrations in transferring their data and applications to secure cloud environments, making them accessible anytime and anywhere. A support program will guide these administrations through the migration process, including the identification and certification of qualified cloud service providers. This program aims to improve service quality and security, ensure cost savings, enhance transparency, and increase energy efficiency in public administration infrastructures.

Investment 1.3: Data and interoperability

This investment focuses on creating a digital ecosystem where data can be shared and reused among various public administrations, eliminating the need for citizens and businesses to provide the same information multiple times in different administrative contexts. The “once only” principle aims to simplify administrative procedures, reduce bureaucratic burdens, and enhance transparency. Data interoperability is crucial for the efficiency of public administration, enabling the exchange of information between different systems through standardized platforms. A “National Digital Data Platform” will be established, offering administrations a centralized catalog of automatic connectors (APIs) that are consultable and accessible via a dedicated service, in compliance with European privacy laws. This will prevent citizens from having to provide the same information multiple times to different administrations. The implementation of this platform will be accompanied by a project to ensure Italy's full participation in the European Single Digital Gateway initiative, which will harmonize procedures and services across all Member States and fully digitize particularly relevant processes. This infrastructure will not only improve the management of public services but also lay the groundwork for integrating mobility-related data, making it essential for developing solutions like Mobility as a Service.

Investment 1.4: Digital services and digital citizenship

This investment focuses on enhancing services offered to citizens by creating a unified access platform for digital services, consolidating various initiatives, and simplifying interactions with public administration. The project includes developing integrated portals, user-friendly applications, and tools that ensure universal accessibility. To manage these services smoothly and coherently, there are plans to strengthen the digital identity system, incorporating existing solutions like SPID and CIE, with the goal of converging towards an integrated model that further simplifies access to digital services while ensuring security and ease of use.

In this context, the investment includes specific experiments in the field of mobility, with **Mobility as a Service** (MaaS) considered an opportunity to develop and revitalize the supply of mobility services. MaaS integrates all public transport services both conventional (such as subways, railways, bus lines, and taxis) and innovative (such as on-demand transport and sharing mobility services) into a single digital application, providing users with a unified platform to plan, book, and pay for their journeys.

The digital infrastructure developed through previous investments, particularly in interoperable capabilities based on the “once only” principle, ensures a continuous flow and integration of data necessary for efficient

MaaS. This unified platform will enable integrated payments and simplified access to all urban transport services, representing the convergence point between public administration digitalization and sustainable mobility needs. The digital transformation of public administration is based on strategic interventions aimed at strengthening the fundamental elements of technological architecture, such as cloud infrastructures and data interoperability, integrating them with initiatives aimed at significantly improving the digital services offered to citizens. This approach aims not only to modernize the internal functioning of public administrations but also to ensure a simple, secure, and inclusive *user experience* for all users. Finally, the strategy outlines a structured initiative to enhance the user experience of digital platforms, prioritizing both accessibility and interaction quality, with the goal of ensuring a unified and inclusive experience for all.

Webography

Title	Link	Descrizione
UITP Policy Brief (2020)	https://cms.uitp.org/wp/wp-content/uploads/2020/07/Policy-Brief_MaaS_V3_final_web_0.pdf	Introduction to Mobility as a Service (MaaS) concepts
Transmodel	https://transmodel-cen.eu/	European data model for public transportation
DATEX II	https://datex2.eu/specifications/	European standard for traffic and travel data exchange
NeTEx	https://transmodel-cen.eu/index.php/netex/	CEN standard for the exchange of planned data in public transport
SIRI	https://transmodel-cen.eu/index.php/siri/	Protocol for real-time management of public transport information
GTFS Example Feed	https://gtfs.org/getting-started/example-feed/	GTFS Static feed, useful for understanding the data standard format for public transport
GTFS Realtime - Feed Entities	https://gtfs.org/documentation/realtime/feed-entities/overview/	Extension of GTFS, real-time data feed for public transport
GTFS-Flex	https://gtfs.org/community/extensions/flex/	Extension of GTFS for flexible and on-demand transportation services
GOFS-lite	https://github.com/GOFS-lite/GOFS-lite	GOFS extension in development for on-demand transportation services
GTFS Fares v2	https://gtfs.org/documentation/schedule/examples/fares-v2/	GTFS extension for advanced fare modeling
GTFS Profil Switzerland	https://www.tp-info.ch/sites/default/files/2024-12/GTFS_Profil_Switzerland_Version_0_17_en.pdf	Swiss GTFS profile, the national profile of the GTFS-Flex extension is laid out in Chapter 12 of the document
Open Transport Data	https://opentransportdata.swiss/en	Swiss national platform dedicated to the collection, management, and dissemination of open public transport and mobility data
REST API	https://www.ibm.com/it-it/topics/rest-apis	Introduction to HTTP-based REST APIs with JSON/XML
GraphQL	https://graphql.org/	API query language that enables targeted and flexible queries
OAuth 2.0 - RFC 6749	https://datatracker.ietf.org/doc/html/rfc6749	Framework for secure authentication and authorization management
MQTT	https://mqtt.org/	Lightweight protocol for real-time messaging, ideal for IoT (Internet of Things), referring to the set of devices connected to the Internet for data collection and exchange
WebSockets	https://websockets.spec.whatwg.org/	Specification for real-time two-way communication over the Web