Interreg CENTRAL EUROPE

Co-funded by the European Union

DREAM_PACE

D1.2.3 Co-designed solutions blueprint of integrated DRT implemented /tested through pilot activities

Final Version

09 2025

Authors and log change of the document

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2	Redmint	Gabriele Grea Anja Seyfert	Structure of the document, template for input collection	1
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2	Redmint	Gabriele Grea Anja Seyfert	Finalisation of the document	3
10	TUB	Massimo Moraglio	Review of the document	3
6	ATE	Florian Kressler	Review of the document	3a
2	Redmint	Gabriele Grea Anja Seyfert	Final proposed version	4
1	SRM	Chiara Lepori Giuseppe Liguori Dario Marchini	Edited approved version for official release	Final

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1. Summary and structure of the blueprint

DREAM_PACE aims at developing innovative Demand Responsive Transport (DRT) concepts for peripheral and rural areas, complementing regional mobility networks to improve connectivity, sustainability, inclusiveness.

From the **governance and planning perspective**, two different context-based approaches have been defined:

- for territories where comprehensive governance and planning frameworks govern composite mobility networks from a top-down perspective, with the objective of enhancing efficiency and effectiveness through the integration of services with different nature in a MaaS (Mobility-as-a-Service) logic.
- for territories where services are being designed and implemented at different governance levels, often as expression of bottom-up approaches lead by local authorities to fulfil specific needs of the citizens, with the objective of better coordinating the composite framework of direct initiatives in an inclusive model.

This document describes activities carried out in with reference to the first approach, those related to the second approach are described in Delierable D1.2.4. Project Partners have jointly designed **a modular governance and planning model blueprint for integrated DRT-public transport in a MaaS logic**.

On this basis, the tools presented in this document are meant to support the conception, implementation and scaling up of a new generation of DRT services, designed as functional and integral part of regional mobility networks, enhancing accessibility for citizens, territorial cohesion and social inclusion.

The **governance and planning model** is composed by governance, planning, financial and procurement elements/modules, designed to support the decision-making process in efficiently and effectively integrated DRT services in the existing local and regional mobility networks.

The project will improve DRT planning and delivery capacities of public authorities and operators, also by promoting the presented tools through targeted actions to influence decision makers' attitude towards change.

The model blueprint is composed by the following elements/components:

1. **Strategic planning approach for DRT in Public Transport (PT)**: a strategic guideline for the integration of DRT services in Sustainable Urban Mobility Plans (SUMPs).
2. **Recommendations on the integration of DRT services in MaaS**: a set of requirements for the seamless and effective integration of a DRT into a MaaS framework.
3. **Recommendations on how to develop a PT tendering procedure integrating DRT services**: a set of indications and recommendations for building up a mockup simulating a PT tendering procedure that includes DRT services.
4. **Business planning tool for flexible management of DRT-PT**: a calculation tool to support the operational and financial planning phase of DRT services, providing comparisons between PT and four different DRT service models, and across three conceptual scenarios ("accessibility", "intermodality", "inclusiveness").
5. **Data driven approach to DRT service expansion**: a guidance document from a Public Transport Authority (PTA) perspective on how to transform a low demand line in DRT or to create a new one; it includes practical guidance on how to design, locate and regulate DRT stops.

6. **DRT dedicated tendering procedure in new areas and regulatory frameworks, DRT as a Service**; a guidance document for the tendering of new DRT services, where the "DRT as a Service" approach – fostering the collaboration between PTOs and digital providers – is proposed.

The figure below represents the framework of the solution components, highlighting their role in the planning process, from strategic to tactical.

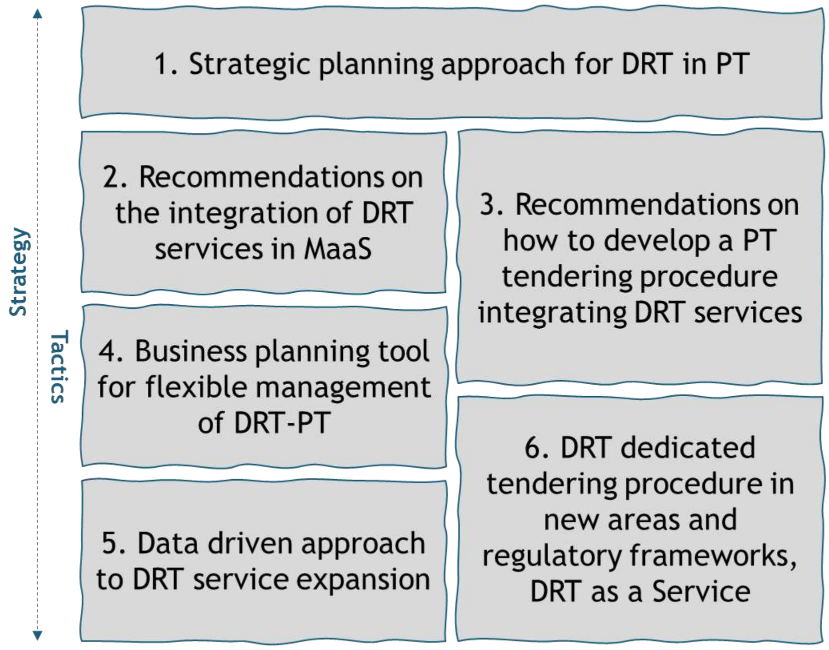

Figure 1: A modular governance and planning model blueprint for integrated DRT-public transport in a MaaS-logic

In the following chapters (2 to 7), the objectives, target groups and main functionalities of each solution component are presented.

Chapters 8 and 9 focus respectively on the expected change generated by the adoption of the described solution and on the transferability and replicability of the components, while chapter 10 highlights a set of planned targeted actions planned to influence decision makers' attitude towards change.

2. Component 1: Strategic planning approach for DRT in PT

2.1. Objective

This component, developed by SRM, consists of a strategic document for integrating DRT services in the Sustainable Urban Mobility Plan (SUMP) of the Bologna metropolitan area. For this it is necessary to identify opportunities and spaces for future implementation of DRT, ensuring that services are effectively incorporated into long-term mobility strategies and contribute to a seamless and inclusive PT ecosystem.

The core aim of this solution component is to support Public Authorities in planning and governing DRT services as a permanent part of the PT ecosystem. This involves recognizing DRT as both a tool to cover underserved and low demand areas and an instrument for achieving broader goals such as territorial cohesion, social inclusion, and sustainability.

This component directly addresses several key challenges identified by the DREAM_PACE project, in particular:

- The integration of DRT into existing PT networks, overcoming the fragmentation and "stand-alone" nature of current DRT solutions.
- Improving accessibility in low-demand or underserved areas by strategically identifying where DRT can complement traditional PT.
- Strengthening governance capacity of Local Authorities through structured planning tools, enabling better coordination of mobility services.

2.2. Target groups

The pilot 1.1 solution component no.1 “Strategic planning approach for DRT in PT”, that has the format of a strategic document composed with various contributions, lies on the following pilot actions:

- “b - Analysis of potential demand and definition of areas of weak demand at the metropolitan level (in terms of geographic, socio-economic, temporal, and inter-territorial characteristics)”.
- “c -Study on DRT costs and the possibility of their inclusion in the Public Transport Contract of Service”.
- “d - Study on potential integrations between demand assessment methodologies and parameters and city and metropolitan planning tools (i.e., SUMP)”.
- “g - Identification of potential weak demand areas by analysis and geographic visualization of the Origin / Destination (O/D) matrix starting from telephone SIM data”.

Among these actions, “d” is particularly relevant as it deals with the development of the strategic planning approach for DRT in PT: indeed, it is crucial for providing insights that directly inform and enhance the PT strategic planning process.

The provisions contained in the document **“d - Study on potential integrations between demand assessment methodologies and parameters and city and metropolitan planning tools”** can support different stakeholders, either directly or indirectly.

Direct beneficiaries include:

- Local and Regional Authorities, especially those involved in defining strategic mobility objectives and integrating flexible services into planning tools such as SUMPs. The study provides them with structured criteria and methodologies to identify where and how DRT can complement existing networks, particularly in weak demand areas.

- Public Transport Authorities (PTAs), supporting them for including DRT in public service obligations.

Indirect beneficiaries include:

- Public Transport Operators (PTOs), not in terms of immediate operational design, but as recipients of clearer institutional guidelines and long-term service expectations.
- Users, especially those living in less densely populated or socio-economically fragile areas, who can benefit from enhanced mobility options and improved accessibility to essential services.

The **testing and validation** of the components and activities of the Bologna pilot directly involved the Living Lab (LL) stakeholder group[1]. Specifically, the validation of the results of pilot actions supporting the pilot 1.1 solution component no.1 were carried out as follows:

- The result of pilot action "g - Identification of potential weak demand areas by analysis and geographic visualization of the O/D matrix starting from telephone SIM data" was validated by SRM with the associated partner CMBO, confirming the zoning level.
- The studies collecting the results of pilot actions "b - Analysis of potential demand and definition of areas of weak demand at the metropolitan level (in terms of geographic, socio-economic, temporal, and inter-territorial characteristics)" and "c -Study on DRT costs and the possibility of their inclusion in the Public Transport Contract of Service" were validated were validated during the 4th and 5th Bologna Living Lab meetings, both held on 1 July 2025 at SRM's office in Bologna. Full details on them are available in the description of the pilot 1.1 solution component no.3.
- The contents of the study developed within the crucial pilot action "d - Study on potential integrations between demand assessment methodologies and parameters and city and metropolitan planning tools"" - were validated during the 6th Bologna Living Lab meetings, held online on 17 July 2025. In this specific 6th LL meeting, the composition of the stakeholder group was tailored to reflect the technical and planning-oriented nature of the activity. Indeed, in order to redesign local PT services in a hierarchical logic and integrate them effectively with DRT services, it is essential that strategic planning instruments, such as the SUMP, incorporate these directions. For this reason, the stakeholders invited to the 6th Living Lab meeting were the Local Authorities responsible for mobility planning in the Bologna metropolitan area, ensuring that the study's results and proposed guidelines could be directly discussed with, and absorbed by, the relevant planning bodies, i.e. CMBO (responsible for SUMP development and updating) and COBO.

2.3. Description and functionalities

The solution component no. 1 "Strategic planning approach for DRT in PT" builds particularly on Bologna **pilot action "d** - Study on potential integrations between demand assessment methodologies and parameters and city and metropolitan planning tools (i.e., SUMP)".

[1] The Bologna LL stakeholder group includes a broad and diverse range of stakeholders from multiple sectors and administrative levels, ensuring a comprehensive representation of the mobility ecosystem: Local Authorities, such as the Metropolitan city of Bologna (CMBO) and the Municipality of Bologna (COBO); Regional Authorities, namely Regione Emilia-Romagna (RER); National Authorities, such as Istat (Istituto Nazionale di Statistica); PTAs of the Emilia-Romagna Region; PTOs active in the Bologna metropolitan area; Enterprises and SMEs, in particular IT providers and players involved in the development and operation of DRT and MaaS solutions; General public representatives.

The purpose of this study (available as Annex “DREAM_PACE_Bologna pilot_action D_EN”) is to explore the possible integrations between advanced mobility demand analysis methods and strategic planning tools, such as the SUMP of the Bologna metropolitan area. In particular, the study investigates how the results obtained through a multi-level demand estimation approach based on data-fusion techniques – that is described in detail in document “b - Analysis of potential demand and definition of areas of weak demand at the metropolitan level” (available as Annex “DREAM_PACE_Bologna pilot_action B_EN”) and applied in chapter 2 of study “d” - can effectively support the planning and restructuring of PT services, especially in low-demand areas, with a focus on the deployment of DRT services[2].

While chapter 3 of the document “d” shows the results of applying the methodology for identifying areas with weak demand, chapters 4 and 5 represent the key foundations of the pilot 1.1 solution component no. 1, as they provide respectively the hypotheses for operational models of DRT services based on the characteristics of mobility demand (chapter 4), and the hypotheses for a remuneration model for DRT services tailored to demand characteristics (chapter 5).

The objective of these chapters is to integrate the application of the methodology for identifying low-demand areas with the evidence gathered throughout the Bologna pilot actions, ultimately leading to a concrete proposal for the adoption of differentiated DRT service models. These models are designed to be consistent with territorial constraints while also meeting the criteria of effectiveness, equity, and sustainability.

In detail, chapter 4 targets the adaptation of DRT services to local specificities, in order to maximize operational efficiency and ensure adequate coverage of mobility needs in low-demand areas. To achieve this, it uses a classification logic, based on the integrated analysis of estimated demand (quantitative and qualitative) and the suitability of different DRT models with respect to the configuration of each area. The chapter proposes a structured logical framework developed for the Bologna metropolitan area, articulated as follows:

- Identification of four DRT operational models (chapter 4.1), each described in terms of its main functional characteristics and their suitability in different territorial, settlement, and organisational contexts - such as the level of integration with the existing PT system, particularly in relation to the metropolitan network envisaged in the SUMP. The four models are: (i) base-route service with fixed stops; (ii) base-route service with deviations and fixed stops; (iii) free-routing service between a predefined set of points; (iv) free-routing service between any set of points.
- Analysis of the mobility demand in the 23 areas (chapter 4.2) previously identified in chapter 3 through the application of the methodology. This section aims to define the key factors that influence the choice of appropriate DRT operational models. The analysis focuses on two main dimensions: the temporal structure of demand, and the spatial structure of demand. The intersection of these two dimensions supports the assignment of the most appropriate operational model to each low-demand area.
- Assignment of the DRT service model that best matches the specific characteristics of each area (chapter 4.3), ensuring contextual coherence and alignment with planning objectives.

Chapter 5 addresses the issue of DRT service remuneration, taking into account the demand characteristics that emerged from the analysis. The aim is to build a coherent framework that aligns operational models with appropriate contractual and remuneration schemes. Also, chapter 5 follows a structured logical framework, articulated as follows:

[2] It is noted that the document “d” directly addresses the recommendations of ART (Autorità di Regolazione dei Trasporti) Resolution no. 48/2017, particularly those included in Annex 1, Measure 3, which emphasize the need to match service models and levels of supply with the actual characteristics of demand in weak demand areas.

- Definition of a guide for selecting the most appropriate remuneration model for DRT services in each low-demand area (chapter 5.1). The analysis begins with a review of the main cost drivers in DRT services (detailed in document "c - Study on DRT costs and the possibility of their inclusion in the Public Transport Contract of Service" – available as Annex "DREAM_PACE_Bologna pilot_action C_EN"), then summarizes alternative remuneration models compared to the standard approach, and outlines possible criteria for assigning remuneration schemes based on the four operational service models used in chapter 4.
- Characterization of demand levels in a way that allows for a clear and immediate understanding of the potential suitability of each area for PT services (chapter 5.2). This characterization serves as a criterion to coherently associate both the operational models and the related remuneration mechanisms with the real demand conditions observed in each area.
- Assignment of DRT remuneration models to the 23 low-demand areas identified in the Bologna metropolitan area (chapter 5.3). Based on the operational model previously identified for each area and the estimated potential demand, a remuneration model is proposed for every low-demand context. This ensures consistency between the level of service required, the operational configuration, and the economic sustainability of the solution.

3. Component 2: Recommendations on the integration of DRT services in MaaS

3.1. Objective

This component, developed by SRM, provides the requirements for the seamless integration of a DRT into a MaaS framework. The activities and studies were carried out in the DREAM_PACE Bologna pilot context and started from the specific case of a MaaS that could serve both urban and peripheral areas in the Metropolitan city of Bologna.

The recommendations ground on the analysis of the existing Emilia-Romagna regional MaaS ecosystem, and consider the technological, operational, and governance dimensions of the integration of a DRT service with/in it. Their aim is to ensure that DRT services become an effective, flexible, and sustainable component of the overall mobility offering in the Bologna metropolitan area, particularly in areas underserved by conventional public transport.

This component directly addresses several key challenges identified by the DREAM_PACE project, in particular:

- Territorial disparities in accessibility and mobility: by focusing on the integration of DRT into MaaS, the component supports the reduction of gaps in service availability between urban centres and rural or peripheral areas. It contributes to a more balanced and equitable mobility system.
- Lack of integration in DRT planning and operations: traditionally, DRT services have often been implemented as stand-alone solutions. This component seeks to overcome such fragmentation by aligning DRT governance, planning, and operation with the MaaS ecosystem.
- Need for scalable and innovative solutions: the integration of DRT into a MaaS environment enables scalable, data-driven, and user-focused services. This component supports the design of interoperable systems and governance models that allow DRT to evolve from pilot experiences into structural mobility solutions.

3.2. Target groups

The pilot 1.1 solution component no. 2 “Recommendations on the integration of DRT services in MaaS”, that has the format of a guideline/checklist, lies on a study on the integration of DRT services into the public transport supply and MaaS system. Within the DREAM_PACE project, this study corresponds to the Bologna pilot action **“a - Study on the integration of DRT services into the public transport supply and into a MaaS system”** (available as Annex “DREAM_PACE_Bologna pilot_action A_EN”).

The guidelines provided by the document can support a wide range of stakeholders throughout the integration process, including:

- Local and Regional Authorities, responsible for coordinating and supervising the integration of DRT services in the territories and setting reference standards.
- Public Transport Authorities (PTAs), 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.
- Public Transport Operators (PTOs), for the implementation and operational management of DRT services.

- MaaS operators, to ensure interoperability and data sharing by integrating platforms and trip booking functions.
- Users, who benefit from the integration of DRT services with other mobility solutions within a single MaaS platform, eliminating the need for multiple applications and improving clarity, usability, and convenience for a seamless travel experience.

The **testing and validation** of the components and activities of the Bologna pilot directly involved the Living Lab (LL) stakeholder group[3].

Specifically, the validation of the study developed as a result of Bologna pilot action "a" - corresponding to the solution component no.2 - was carried out during the 3rd Bologna LL meeting, held online on 4 April 2025. The composition of the stakeholder group for this meeting was deliberately shaped around the technical nature of the activity, with the goal of bringing together different expertise and perspectives. The stakeholders involved were:

- Local and Regional Authorities: CMBO, COBO and RER.
- PTAs (Mobility Agencies) of the Emilia-Romagna Region[4].
- PTOs active in the Bologna area.
- MaaS Integrator: Lepida, the in-house company of the RER responsible for managing digital infrastructures and services for the public administration. Its role is particularly relevant within the Bologna LL as it represents the Region's Regional Access Point (RAP) in the context of the MaaS4RER[5] initiative.
- IT players operating in the DRT and MaaS sectors[6].

3.3. Description and functionalities

The solution component no. 2 "Recommendations on the integration of DRT services in MaaS" lies on Bologna pilot action "a - Study on the integration of DRT services into the public transport supply and into a MaaS system".

The purpose of this study (available as Annex "DREAM_PACE_Bologna pilot_action A_EN") is to define an operational and technical framework for guaranteeing the interoperability of DRT services with the public transport and within the MaaS platforms, promoting the integration of mobility services in an interoperable ecosystem. The study offers an outline of operational protocols and functional and technical requirements, which guarantee operational cohesion and coordination between the various actors involved in the

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[3] The Bologna LL stakeholder group includes a broad and diverse range of stakeholders from multiple sectors and administrative levels, ensuring a comprehensive representation of the mobility ecosystem: Local Authorities, such as the Metropolitan City of Bologna (CMBO) and the Municipality of Bologna (COBO); Regional Authorities, namely Regione Emilia-Romagna (RER); National Authorities, such as Istat (Istituto Nazionale di Statistica); PTAs of the Emilia-Romagna Region; PTOs active in the Bologna metropolitan area; Enterprises and SMEs, in particular IT providers and players involved in the development and operation of DRT and MaaS solutions; General public representatives.

[4] Tempi Agenzia Piacenza, S.M.T.P. - Società per la mobilità ed il trasporto pubblico di Parma, AMI - Agenzia Mobilità Impianti Ferrara, Agenzia Mobilità Reggio Emilia, aMo - Agenzia per la mobilità di Modena, and AMR - Agenzia Mobilità Romagnola.

[5] MaaS4RER (Mobility as a Service for Emilia-Romagna Region) project is part of the national MaaS4Italy initiative. It aims to integrate various transportation services into a single digital platform, allowing users to organize, book, and pay for their journeys through a dedicated app.

MaaS4RER: https://mobilita.regione.emilia-romagna.it/piani-programmi-progetti/maas

MaaS4Italy: https://innovazione.gov.it/progetti/mobility-as-a-service-for-italy/

[6] Padam Mobility, Instant System, My Cicero (Pluservice), SHOTL, Nemi, Ioki, VIA, Open Move, Optibus, and MAIOR

development of DRT systems, ensuring their interoperability, integration into the mobility network and accessibility in the MaaS system. It includes:

- An overview of the types of integration between DRT services and MaaS platforms, specifically addressing the use of Deep Link solutions and API-based integration approaches.
- An analysis of current critical issues and challenges, with a particular focus on the data standards required for successful DRT integration. Special attention is given to the GTFS-Flex standard.
- A final section dedicated to the protocols for the integration of DRT services into PT networks and MaaS platforms.

In particular, chapter 5 of the study is the core of this pilot component no.2, as it provides the guideline for the integration of DRT services in the public transport network and in the MaaS platforms. It contains an analysis of the various kinds of integrations, and the current critical issues and challenges to be addressed, and finally presents a protocol for the integration of DRT services in local PT networks and MaaS platforms, detailing the functional and operational requirements for such an integration in both cases:

- 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.
- 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.

It is noted that, as part of the study, 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 highlights how the integration of DRT services into MaaS systems still represents an area of experimentation, lacking established benchmarks or established operational best practices. Therefore, this DREAM_PACE pilot 1.1 component no.2 introduces as innovative element the operational and technical framework that enables the structured integration of DRT services since their planning phase, ensuring compliance with applicable regulatory constraints.

4. Component 3: Recommendations on how to develop a PT tendering procedure integrating DRT services

4.1. Objective

This component, developed by SRM, consists of indications and recommendations for building up a mockup simulating a PT tendering procedure that includes DRT services. The activities and analyses were carried out within the context of DREAM_PACE Bologna pilot, taking as a reference the specific case of the tendering process at the Metropolitan city level, where DRT services are currently not included in the existing Contract of Service.

The main objective of this component is therefore to lay the groundwork for the formal integration of DRT services into future public transport tenders, thus also enabling their inclusion in the PT Contracts of Service.

This component directly addresses several key challenges identified by the DREAM_PACE project, in particular:

- The integration of DRT into existing PT networks, overcoming the fragmentation and the "stand-alone" nature of current DRT solutions.
- Enhanced connectivity in areas with low demand where traditional PT is not viable, promoting equitable access to mobility for all citizens.
- A more inclusive and resilient regional mobility system, which responds flexibly to diverse territorial needs.

4.2. Target groups

The pilot 1.1 solution component no.3 “Recommendations on how to develop a PT tendering procedure integrating DRT services” lies on the following pilot actions:

- “b - Analysis of potential demand and definition of areas of weak demand at the metropolitan level (in terms of geographic, socio-economic, temporal, and inter-territorial characteristics)”.
- “c -Study on DRT costs and the possibility of their inclusion in the Public Transport Contract of Service”.

These studies are particularly relevant as they represent the strategic documents in the construction of a tender for DRT services. In particular, they are crucial in providing the demand-side justification and cost-based feasibility essentials for drafting a realistic DRT tender.

The guidelines provided by the document “**b - Analysis of potential demand and definition of areas of weak demand at the metropolitan level**” can address a wide range of stakeholders, either directly or indirectly.

The stakeholders directly addressed are:

- Local and Regional public authorities, responsible for defining service levels (including DRT) in weak demand areas, based on territorial, socio-demographic, and economic characteristics
- Public Transport Authorities (PTAs), for planning and contractual decisions, particularly when evaluating the inclusion of DRT services in the overall public transport offer.

The stakeholders indirectly addressed are:

- Public Transport Operators (PTOs), to better understand the demand potential in certain areas and to adjust their service strategies accordingly.
- Istat, IT providers and players involved in the development and operation of DRT, to collect valuable feedback and engage in a discussion on the methodology, with particular attention to local specificities.
- Users, especially those living in less densely populated or socio-economically fragile areas, who can benefit from enhanced mobility options and improved accessibility to essential services.

The indications provided by the study **"c - Study on DRT costs and the possibility of their inclusion in the Public Transport Contract of Service"** can address a selected group of stakeholders, either directly or indirectly.

The stakeholders directly addressed are:

- Local and Regional public authorities, to rely on cost-related evidence to support the inclusion of DRT services in mobility planning and in defining financial resources.
- PTAs, to assess the financial feasibility and contractual implications of integrating DRT into the Contract of Service.
- PTOs, to better understand the cost framework for DRT and align their operational models with potential contractual opportunities.

The stakeholders indirectly addressed are the users, who can benefit from more cost-effective and accessible DRT services as a result of their efficient integration into the PT system.

The **testing and validation** of the components and activities of the Bologna pilot directly involved the Living Lab (LL) stakeholder group[7]. Specifically, the validation of the results of pilot actions supporting the pilot 1.1 solution component no.3 were carried out during the 4th and 5th Bologna Living Lab meetings, both held on 1 July 2025 in person at the SRM's office in Bologna. The 4th meeting was organized with the purpose of validating and testing the results of pilot action "c", while the 5th meeting focused on validating and discussing the outcomes of pilot action "b".

The composition of the stakeholder group for these meetings was shaped around the technical nature of the activity, with the goal of bringing together different expertise and perspectives.

The stakeholders involved in the 4th LL meeting were:

- Local and Regional public authorities: CMBO, COBO, and RER.
- PTAs (Mobility Agencies) of the Emilia-Romagna Region[8].
- PTOs active in the Bologna area.

The stakeholders involved in the 5th LL meeting were:

- Local public authorities: CMBO, COBO (Mobility Dept. and Statistics Dept.).

[7] The Bologna LL stakeholder group includes a broad and diverse range of stakeholders from multiple sectors and administrative levels, ensuring a comprehensive representation of the mobility ecosystem: Local public authorities, such as the Metropolitan city of Bologna (CMBO) and the Municipality of Bologna (COBO); Regional public authorities, namely Regione Emilia-Romagna (RER); National authorities, such as Istat (Istituto Nazionale di Statistica); PTAs of the Emilia-Romagna Region; PTOs active in the Bologna metropolitan area; Enterprises and SMEs, in particular IT providers and players involved in the development and operation of DRT and MaaS solutions; General public representatives.

[8] Tempi Agenzia Piacenza, S.M.T.P. - Società per la mobilità ed il trasporto pubblico di Parma, AMI - Agenzia Mobilità Impianti Ferrara, Agenzia Mobilità Reggio Emilia, aMo - Agenzia per la mobilità di Modena, and AMR - Agenzia Mobilità Romagnola.

- Regional public authorities: RER and ITL (Istituto sui Trasporti e la Logistica), the latter being a publicly supported Foundation which contribute to the development and promotion of the logistics and transport systems in the Emilia-Romagna region. Its involvement in the LL meeting was important as a provider of good practices and for offering valuable insights based on experiences from other European projects related to DRT and mobility demand.
- PTAs of the Emilia-Romagna Region.
- PTOs active in the Bologna area.
- IT players operating in the DRT and MaaS sectors[9].
- National public authority: Istat (Istituto Nazionale di Statistica), which is the public research institute responsible for producing and disseminating official statistics in Italy. Its involvement was particularly relevant, as Istat data sources were used in the methodology developed in the document "b".
- MaaS Integrator: Lepida, the in-house company of the RER responsible for managing digital infrastructures and services for the public administration. Its role is particularly relevant within the Bologna LL as it represents the Region's Regional Access Point (RAP) in the context of the MaaS4RER[10] initiative, and its involvement was due to their expertise in analyzing data from various sources, providing valuable feedback on the methodology used.

4.3. Description and functionalities

The pilot 1.1 solution component no. 3 "Recommendations on how to develop a PT tendering procedure integrating DRT services" builds particularly on Bologna pilot actions "b - Analysis of potential demand and definition of areas of weak demand at the metropolitan level" and "c - Study on DRT costs and the possibility of their inclusion in the Public Transport Contract of Service".

The purpose of the document resulting from **pilot action "b"** (available as Annex "DREAM_PACE_Bologna pilot_action B_EN") is to define, in a coherent and reasonable manner, the geographical and functional area where to plan and award local public transport services, while identifying the potential mobility demand to be met. In this perspective, the analysis goes beyond a simple description of observed mobility demand and includes latent needs as well as structural and socio-economic characteristics of the Metropolitan city of Bologna - such as morphology, urbanization, demographic profiles, and the local economic system.

The innovative methodology for analysing the potential demand and defining the areas of weak demand at the metropolitan level is built on four key pillars:

- A clear and operational objective, aimed at creating a transparent and replicable methodology.
- The integrated use of heterogeneous data sources, including:
    - A custom survey on residents' mobility patterns (developed for the update of the metropolitan SUMP).
    - Socio-demographic and employment data (from Istat and the metropolitan atlas).

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[9] Padam Mobility, Instant System, My Cicero (Pluservice), SHOTL, Nemi, Ioki, VIA, Open Move, Optibus, and MAIOR

[10] MaaS4RER (Mobility as a Service for Emilia-Romagna Region) project is part of the national MaaS4Italy initiative. It aims to integrate various transportation services into a single digital platform, allowing users to organize, book, and pay for their journeys through a dedicated app.

MaaS4RER: https://mobilita.regione.emilia-romagna.it/piani-programmi-progetti/maas

MaaS4Italy: https://innovazione.gov.it/progetti/mobility-as-a-service-for-italy/

- Mobile phone SIM data.
- Floating Car Data (FCD).

- A data-fusion process that enhances the value of each source and enables the reconstruction of actual and potential mobility patterns in the area.
- A series of structured analytical steps, leading to the definition of appropriate service levels for weak demand areas, through the use of analytical zoning, of a socio-economic territorial model, and of the combined estimation of travel demand based on multiple data sources.

In particular, chapter 4 of the document "b" represents one of the key foundations of pilot solution component no. 3, as it provides a replicable methodology for the calculation of potential demand and for the definition of the service levels in low demand areas. Such a methodological and operational framework is developed for the identification of effective solutions for planning PT services (including DRT) within the Metropolitan city of Bologna, with specific focus on the organization of service areas and their structuring based on demand levels[11]. Indeed, chapter 4 integrates two complementary analyses:

1. The definition of a methodology for identifying 'low-demand' areas in accordance with Italian DM 157/2018, for identifying weak demand areas, i.e. portions of the territory that are less densely served or characterized by structurally fragile demand levels (chapter 4.1). In the specific pilot case, this analysis led to the identification of the municipalities in the Metropolitan city of Bologna that have a weak transport demand, thus enabling the configuration of transport services that are responsive to the specific characteristics of the identified mobility needs.
2. The definition of a methodology for calculating the potential demand and defining the service levels in areas with low demand, with the goal of understanding the spatial and temporal distribution of mobility needs (chapter 4.2). This methodology builds on the information provided in Chapter 3 of the document "b" (which reconstructs, through the data fusion process, the potential mobility demand - i.e. the set of travel needs that can be inferred from multiple data sources). The focus is specifically on weak demand areas. This methodology has been designed to be replicable in future planning, updating, or monitoring phases of DRT services.

The purpose of the document resulting from the **pilot action "c"** (available as Annex "DREAM_PACE_Bologna pilot_action C_EN") is to analyse the costs of DRT services, identifying criteria for a remuneration model consistent with the standard cost system and the operational specificities of this type of service[12]. The study also describes some useful elements to guide the inclusion of DRT services in PT Contracts of Service, analysing in particular economic sustainability and conditions of applicability - within the Italian context.

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[11] It is noted that the activities carried out are aligned with the guidelines set by ART (Autorità di Regolazione dei Trasporti) with the Resolution no. 48/2017. It aims to provide elements consistent with the objectives of Measure 3, which requires the evaluation of the most suitable transport modes and configurations to meet low or weak demand, taking into account economic, environmental, and contextual variables, as well as principles of modal integration and sustainability.

[12] It is noted that the Ministerial Decree (DM) no. 157/2018 is used as a reference for the cost analysis, with the aim of evaluating methodologies applicable to DRT and identifying criteria for its framing within the industry's remuneration models. DM 157/2018 introduced the "standard cost" system for local and regional public transportation services, using specific methodologies for different modes of transportation:

- Linear regression method, applied to bus and railways.
- Analytical method of calculation, used for tramways and subways.

Although Art. 3(3) of DM 157/2018 provides for the use of the analytical method for services for which the regression method cannot be used, Art. 3(6) explicitly excludes on demand services, including DRT services, without defining an alternative economic method for their quantification.

This can be considered a useful starting point for the development of a coherent standard cost system applicable to DRT services, consistent with their operational characteristics and through a system that takes into account the specific processes and industrial activities related to their delivery. This consideration, therefore, introduces the need for an alternative method that is more adherent to the flexible nature of DRT and its operational variability.

The remuneration model proposed in the study aims to comply with the efficiency and cost-effectiveness criteria defined in Ministerial Decree (DM) no. 157/2018. In this framework, the study highlights how the direct application of the traditional per-km remuneration model presents several limitations when applied to DRT services, i.e.:

- The number of kilometres travelled may vary significantly from day to day, without necessarily indicating greater or lesser operational effort.
- The operator must guarantee vehicle availability regardless of actual demand, resulting in fixed costs even when the vehicle is not in use.
- A model based solely on distance travelled fails to incentivize efficient resource use, since an operator who optimizes routes to reduce travel may paradoxically receive lower remuneration.

Chapter 8 of the document "c" represents another key foundation of pilot 1.1 solution component no. 3, as it provides indications on the aspects to be taken into consideration for the smooth integration of DRT services into the PT Contracts of Service. The chapter 8 is structured around three main elements that must be considered for the integration, given their greater operational complexity:

- Priority aspects to ensure effective integration (chapter 8.1), including: coordination between DRT and traditional PT services; financial and fare sustainability; optimization and reduction of fixed costs; service monitoring and use of technological KPIs; compliance with staff contractual regulations; and optimization and reduction of variable costs.
- Possible integration strategies (chapter 8.2), comparing the main approaches and assessing their operational, institutional, and economic implications. The analysis identifies two contractual options: (i) direct inclusion of DRT within the main PT Contract of Service, (ii) separate contractual arrangements through standalone contracts, depending on the network design and the local priorities.
- Performance indicators (KPIs) to be included in the Contract of Service (chapter 8.3), covering: service quality; operational efficiency; economic sustainability; degree of integration with the overall PT system.

Based on the above, the innovative elements can be identified in its data-driven and replicable approach to service planning in weak demand areas, supported by a methodology based on advanced data-fusion techniques, and in the introduction of clear contractual strategies for the integration of DRT in the PT Contracts of Service, which enables the stakeholders to overcome the greater operational complexity typically associated with this type of service.

5. Component 4: Business planning tool for flexible management of DRT-PT

5.1. Objective

The **DREAM_PACE business planning tool for flexible management of DRT-PT** has been designed by Project Partners in order to support the operational and financial planning phase of DRT services, providing comparisons between PT and four different DRT service models, and across three conceptual scenarios ("accessibility", "intermodality", "inclusiveness”). The tool has been tested on different service options by the partners, in order to assess its usability and robustness under different territorial, demand and service hypotheses.

The tool provides an estimation of the main quantitative KPIs of a DRT service (passenger*km, vehicle*km, load factor, costs/km, revenues/costs ratio and public contribution needed to ensure the break even of services.

Results include the ex-ante calculation of public contribution for the services, estimated on the basis of the conversion of the parameters of the service offered into "equivalent vehicle kilometres”, in order to assess the economic adequacy and efficiency of the public compensation.

5.2. Target groups

The business planning tool has been developed as a flexible instrument to support the planning and implementation of DRT services, that can be used ad different levels from the strategic to the tactical, and operational. Target groups addressed by the solution component are the following:

- Regional and local public authorities, interested in assessing the potential of a strategic approach to integrate DRT services in the existing network, can use the tool to better understand the complexity of the strategic choices, and to develop a regulatory and planning framework for planners in which mobility objectives, principles and priorities can be simulated, exemplary cases and a preliminary economic assessment of DRT adoption can be run.
- PTAs will be able to assess and discuss with stakeholders and operators the economic implications of DRT adoption, as well as preliminary assess its costs under different scenarios.
- PTOs can assess the economic implications of developing DRT services, use the re-assess the impact of DRT services once in place and modulate their adoption, e.g. adapting parameters and fine tuning or switching service models if desirable.
- IT players operating in the DRT and MaaS sectors can promote their activities with customers, by developing use cases and simulations highlighting the impact of alternative service models under different context conditions.
- Students and higher education institutions, as the tool can be adopted to design simulations and interactive exercised within sustainable mobility classes, to explain the complexity and dynamics behind the evolution from traditional to flexible mobility options.

5.3. Description and functionalities

The tool has been developed in excel format in its full version to be downloaded, and a light demo version will be implemented on a dedicated platform to explain the main purpose and functionalities by providing basic results to the users.

5.3.1. DRT service models and scenarios

The calculation tool is based on the following **DRT service models:**

- **Public Transit**. Traditional public transit service, with fixed route and stops, and fixed timetables defining the frequency.
- **DRT1 - Fixed route, booked stops.** Demand responsive service designed around a fixed route, where stops (all, or part of them) are activated only upon request of the passengers.
- **DRT2 - Fixed route with deviations**. Demand responsive service designed around a fixed route, where some of the stops representing a deviation on the main route are activated only upon request of the passengers.
- **DRT3 - Free route, predefined stops**. Demand responsive service with no fixed route. The trip is designed according to the booking of origin and destination stops by the passengers, from a predefined list.
- **DRT4 - Free route, free stops**. Demand responsive service with no fixed route nor fixed stops. The trip is designed according to the booking of origin and destination by the passengers, within the service area.

The results of the analysis are also presented taking into account three possible conceptual **scenarios**:

- **Scenario I – Accessibility**. The Scenario I "Accessibility" can be considered as the baseline, and responds to the aim of designing and implementing a DRT service to improve the accessibility of a defined area, in line with the general principles of the project. Under this scenario territorial accessibility is the key, and the service is designed to provide a sustainable mobility option to all citizens, without specific specialisation or dedicated target groups. The assumptions at the basis of the scenario are that different categories of users will benefit from the service, and the DRT service models are able to provide accessibility, with different levels of flexibility.
- **Scenario II – Intermodality**. The Scenario II "Intermodality" responds to the aim of exploiting the different DRT options to integrate the existing network, assuming that the new service will facilitate the access to the traditional lines (and to other networks such as regional railways), and will be used by a relevant share of citizens as "feeder" or first/last mile service. Under this scenario the capacity of being integrated in the existing mobility network is the key, and the service is expected to be accessed by commuters as well as occasional users in combination to others. In this case, the flexibility of DRT services responds to the need of citizens of being included in the network."
- **Scenario III – Inclusiveness**. The Scenario III "Inclusiveness" responds to the aim of including citizens at risk of marginalisation, by providing services especially (but not exclusively around their needs). Under this scenario the capacity of reaching all citizens is the key, and the service is expected to be accessed by citizens that need personalised and accessible options. In this case, the flexibility of DRT services responds to the need of citizens of being able to travel, condition not always guaranteed by traditional services. Although flexibility guarantees a higher satisfaction of citizens' needs, this might not be translated in a higher load factor."

5.3.2. Data input

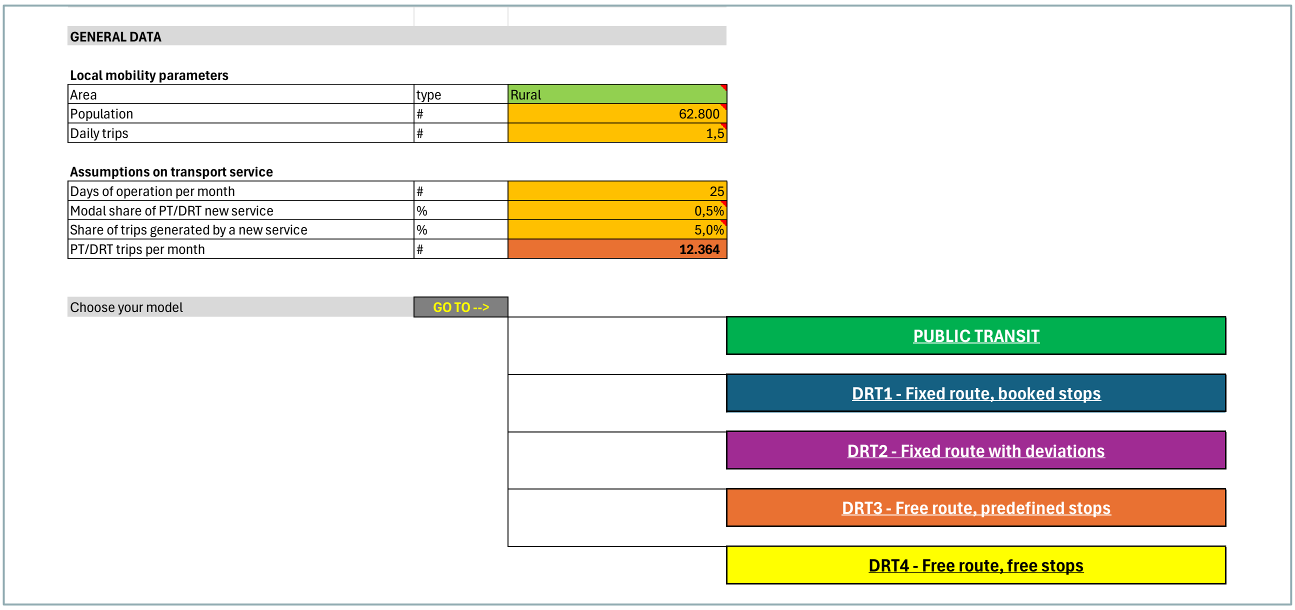
A step-by-step guidance is provided here below for the users .

Step 1 - START

a) Fill in the data about the area where you want to implement a new service.

b) Define main assumptions for the service implementation.

c) Select the **PT-DRT model** you want to design.



GENERAL DATA

Local mobility parameters

Area	type	Rural
Population	#	62.800
Daily trips	#	1,5

Assumptions on transport service

Days of operation per month	#	25
Modal share of PT/DRT new service	%	0,5%
Share of trips generated by a new service	%	5,0%
PT/DRT trips per month	#	12.364

Choose your model — GO TO -->

Figure 2: Example from the "START" page

Step 2 - DRT chosen model (PT, DRT1-2-3-4) input data

In the page corresponding to the chosen model (PT, DRT1-2-3-4) fill in the data on:

a) Passengers (average distance per passenger, average time per trip).

b) Service design (length of the line/network, hrs of operation per day, Length of the line/network, n. of trips per day, n. of vehicles, average commercial speed).

c) Costs (operational costs of running 1 vehicle proportional to time (hourly), operational costs of running 1 vehicle proportional to distance (km), capital cost of 1 dedicated vehicle, monthly cost of DRT software, average trip fare, depreciation period of dedicated vehicle).

d) GO TO the corresponding Results&Scenarios page, through the dedicated link (coloured button) in the page.

DRT3 (Free route, predefined stops)			Notes
Passengers (demand side)			
Average distance per passenger	Km	10	Suggestion for Rural: 10 km
Average time per trip	min	20	Average time needed to perform a trip
P*Km per month	P*Km	123.638	Passenger*Km performed per month
P*hrs per month	P*hrs	4.121	Passenger*hours performed per month
Service design			
Length of the line/network	Km	40	NB: in case of DRT, consider a hipothetical traditional line/network alternative/replaced
Hrs of operation per day	h	6	Daily hours of availability of the service
N. of trips per day	n	20	Number of trips (estimated) performed every day by the service
N of vehicles	n	3	Number of vehicles dedicated to the service
Average commercial speed	Km/h	30	Suggestion for Rural: 30 km/h
V*Km per month	V*km	20.000,00	Vehicle*Km produced per month
V*hrs per month	V*hrs	450	Hours of availability of the vehicles dedicated to the service per month
Load factor	P/V	6,2	Average number of passengers per km of service performed
Costs			
Operational costs of running 1 vehicle proportional to time (hourly)	€/hr	45	The hourly cost of running a single vehicle. Should include insurance, personnel, admin, etc.
Operational costs of running 1 vehicle proportional to distance (km)	€/km	1	The cost per km of running a single vehicle. Should include fuel, maintenance costs, etc.
Capital cost of 1 dedicated vehicle	€	100.000,00 €	Up-front capital investment required to purchase a vehicle
Monthly cost of DRT software	€	1.200,00 €	The monthly cost of running DRT technology
Average trip fare	€	2,60 €	The average fare estimated considering single/daily/weekly tickets, subscriptions and exemptions
Depreciation period of dedicated vehicle	years	15	Depreciation period of the vehicles according to the depreciation plan
	GO TO -->		Results&ScenariosDRT3

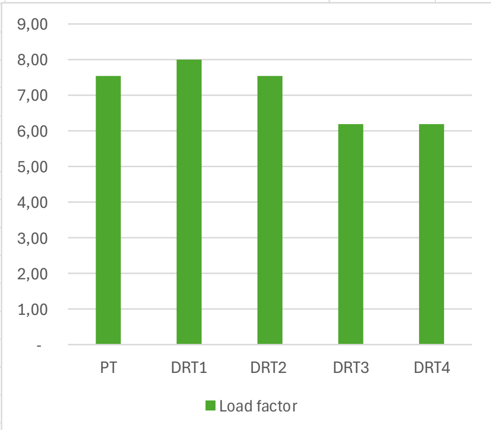
Figure 3: Example from the "DRT3" page

5.3.3. Results

The results page shows the performance of the different DRT service models, expressed through the main operational and economic KPIs. It allows to compare different models and their performance across three different scenarios.

Scenario I - Accessibility						
		PT	DRT1	DRT2	DRT3	DRT4
P*Km per month	P*Km	123.637,5	123.637,5	123.637,5	123.637,5	123.637,5
P*hrs per month	P*hrs	4.121,3	4.121,3	4.121,3	4.121,3	4.121,3
V*Km per month	V*km	16.363,6	15.454,5	16.363,6	20.000,0	20.000,0
V*hrs per month	V*hrs	450,0	450,0	450,0	450,0	450,0
Avg km per hour	km/hr	36,4	34,3	36,4	44,4	44,4
Load factor	**P/V**	**7,56**	**8,00**	**7,56**	**6,18**	**6,18**

		PT	DRT1	DRT2	DRT3	DRT4
Costs of the service	€	38.280,30 €	38.571,21 €	37.455,30 €	41.091,67 €	41.091,67 €
Cost/km	**€/Km**	**2,34 €**	**2,50 €**	**2,29 €**	**2,05 €**	**2,05 €**
Revenues from fares	€	32.145,75 €	32.145,75 €	32.145,75 €	32.145,75 €	32.145,75 €
Break even (public contribution)	€	- 6.134,55 €	- 6.425,46 €	- 5.309,55 €	- 8.945,92 €	- 8.945,92 €
Public contribution per km	**€/Km**	**0,37 €**	**0,42 €**	**0,32 €**	**0,45 €**	**0,45 €**
Revenues/costs ratio	**%**	**84%**	**83%**	**86%**	**78%**	**78%**



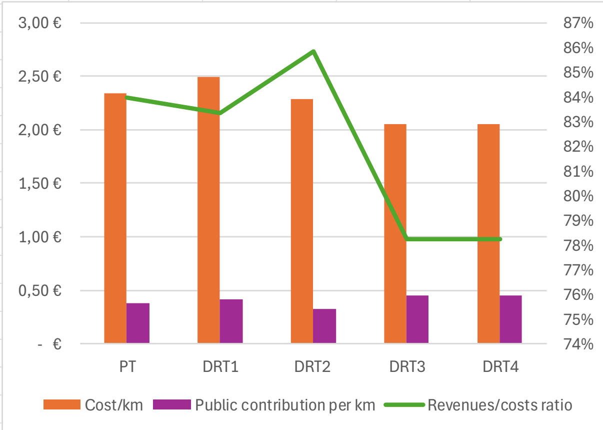


Figure 4: Example from the "Results&ScenariosDRT3" page - Accessibility scenario

Notes on how to read the results:

- The results of the process do not lead to the identification of "preferrable" DRT service model, but rather provide a comparison of the strengths and weaknesses of each alternative, expressed through a set of KPIs (visualised through charts).
- The overview provided by the KPIs is replicated for the three scenarios, depicting the main strategic objective (accessibility, intermodality, inclusiveness) for the design and implementation of a new service; the strategic objective may also be interpreted as the response of the demand to the implementation of a new service, where the most popular use of the flexible service determines its characteristics.
- Based on the data generated by the tool, the choice of a DRT service model might depend on the variables that are considered priority by the policymaker/planner/operator; e.g. maximising the load factor, minimising public contribution, but also taking into account other qualitative KPIs not included in the model.
- The tool can be used to build alternative business plans to be compared, and can be iterated many time in order to optimise the combination of production factors, and balance economic sustainability and increase of effectiveness and demand/responsiveness.

6. Component 5: Data driven approach to DRT service expansion

6.1. Objective

The main objective of the component is to optimize the design, location, and regulation of stops and routes for Demand Responsive Transport (DRT) and flexible DRT services in Budapest, complementing the conventional public transport network with adaptive, passenger-oriented solutions. This includes:

- Transforming traditional low-demand routes into DRT services.
- Introducing new DRT lines in underserved neighbourhoods.
- Upgrading existing DRT services to become more flexible and digitally supported.

In contributes to the project challenges by:

- Enhancing accessibility and mobility in peripheral and low-demand areas.
- Reducing unnecessary vehicle kilometres and environmental impacts.
- Integrating data-driven planning to improve operational efficiency and service sustainability.

6.2. Target groups

The tool, designed on the specific use case of Budapest PTA and mobility planner BKK, has been developed looking at the needs of the following stakeholder categories:

- Transport operators and urban mobility planners.
- Policymakers and municipal authorities responsible for strategic and operational mobility decisions.
- Research institutions and professional organizations analyzing DRT performance.

The application of the data driven approach, as demonstrated through the pilot action run in Budapest, benefits three main user groups:

- Residents in underserved or newly developed areas.
- Elderly or mobility-impaired passengers with limited access to conventional public transport.
- Car-dependent residents who can be encouraged to switch to public transport through DRT services.

6.3. Description and functionalities

The developed component applies to three main areas: transforming existing low-demand lines into DRT services, introducing new lines in underserved neighborhoods, and upgrading existing DRT lines to flexible, digitally supported operations.

Its main features include:

- Data-driven passenger monitoring, enabling precise understanding of ridership patterns.
- Multiple booking channels via mobile applications (BudapestGO), website, phone, or on-site request.
- Digital dispatching and onboard smart devices for real-time route optimization.

- Flexible stop and route structures to respond to demand fluctuations.

Innovative elements part of the solution component consist in the combination of fixed and demand-responsive route sections, the integration of digital tools for operational flexibility, and the implementation in complex urban environments where conventional buses are inefficient.

7. Component 6: A DRT dedicated tendering procedure in new areas and regulatory frameworks, DRT as a Service

7.1. Objective

This solution component has been implemented and tested starting from a specific territorial need within the Split-Dalmatia County, with the objective of creating a replicable and scalable procurement model to bring DRT on the territory withing the newly designed regulatory framework allowing these services to be developed on the territory.

The reference Annex "DREAM_PACE_DRT dedicated tendering procedure (greenfield)" describes the procedure and provides a detailed example of application of the "DRT as a Service" approach, where the tendering procedure fosters the collaboration between PTOs and IT providers in order to deliver flexible mobility options.

Objectives of the process was to develop a comprehensive, structured, and applicable document that will serve as a planning guideline. The document should provide a clear overview with defined instructions, technical requirements, selection criteria, and operational conditions for service providers, tailored to the needs of the area of application and the specific characteristics of the target region and/or area.

The document also addresses the key challenges identified for the design and implementation of such services, including:

- Lack of flexible and efficient transport options in the selected area.
- Geographical features of the area.
- Reference DRT models.
- The need for transparency and measurable criteria to ensure objective evaluation and fair selection of the most suitable bidder.

By developing this tendering document, the project provides a key tool for local and regional authorities, facilitating the procurement and implementation of DRT systems. This will ensure that potential service providers understand the expected operational, technical, and quality standards, thereby increasing the likelihood of successful implementation of a DRT system that is sustainable, user-friendly, and aligned with the mobility and social objectives of the community. Ultimately, the document should aim to contribute to the long-term improvement of public transport accessibility in a way that is cost-effective, scalable, and responsive to the real needs of users.

7.2. Target groups

The tendering procedure targets – directly and indirectly – the main relevant stakeholders engaged in the tactical planning and implementation of a DRT services on a territory. In particular:

- Regional and local public authorities, responsible for planning and funding DRT services.
- PTAs responsible for tendering, awarding and monitoring the implementation.
- PTOs interested in operating DRT.
- IT providers, collaborating with PTOs ion order to enhance the flexibility of the services.

7.3. Description and functionalities

The tendering procedure co-designed and tested primarily on the Split-Dalmatia County territory under the coordination of the DREAM_PACE Project Partners SDC and Dyvolve, and with the support of other experienced and technical partners, covers the main relevant elements to build an official tendering document for the procurement of new services, i.e.:

- **The DRT service.** This section describes the method of providing the DRT service, its duration, funding, the area where the service will be provided, and its organization. It includes specific qualitative parameters for the provision of the service, technical, operational and communication standards and reporting.
- **Software as support to the DRT service.** In this section the main elements of the software solution are displayed including the recommended functionalities for the backup, driver and user applications.
- **Equipment for vehicles.** The tender must specify the characteristics of the hardware to be provided and installed on the vehicles for the management of the services.
- **Selection criteria.** The tendering procedure document provides detailed information on the selection procedure.

8. Expected change

The solution component **Strategic planning approach for DRT in PT** is expected to **contribute to a future, desirable scenario in which DRT services are fully integrated into the PT system since the planning phase starting with the SUMP**. DRT will thus be recognized as both a solution for addressing underserved and low-demand areas, and a strategic instrument to advance broader objectives such as territorial cohesion, social inclusion, and environmental sustainability.

A tangible sign of this expected change is the planned use of the study by SRM. In collaboration with local authorities, the solution component can be considered as a reference for defining future mobility strategies - such as the introduction of new DRT services in the SUMP of the Bologna metropolitan area (the review of the existing SUMP is foreseen in 2026, while the future SUMP is scheduled for 2029) - and for preparing the tender for the next PT Contract of Service (scheduled for the 2028–2029 biennium).

In the long term, the incorporation of DRT into strategic planning tools will mark a significant advancement as it enables the flexibility and adaptability of DRT services to be systematically aligned with the institutional vision, coordination mechanisms, and long-term goals embedded in public mobility planning. This approach will enhance the strategic coherence of service design and also strengthens the capacity of local authorities to deliver user-oriented, efficient, and equitable mobility solutions.

The **Recommendations on the integration of DRT services in MaaS** will support the integration of DRT services into public transport systems and MaaS platforms, by providing technical and operational groundwork by defining integration protocols, service requirements, and responsibilities for both the main transport operator and the DRT operators.

A tangible example of this expected change is the planned use of the study by SRM as a reference document in the preparation of the next Contract of Service, scheduled for the 2028–2029 biennium.

In the long term, the future integration of DRT services into MaaS represents a key step forward, combining the flexibility of DRT with the advantages of an integrated mobility ecosystem. The adoption of standardized technical protocols and requirements can improve the user experience and also strengthen interoperability between operators, optimizes operational management and help to build more efficient, accessible, and inclusive mobility networks.

The **Recommendations on how to develop a PT tendering procedure integrating DRT services** will support the full integration process of DRT into the PT system and the related procurement processes, with clear responsibilities and service requirements for both the main transport operator and the DRT operator.

Local authorities will gain knowledge on how to assess demand levels, design an optimal public transport network for metropolitan-scale connections, and identify areas where DRT can be most effective. This lays the foundation for the targeted and data-driven integration of DRT services into PT networks. At the same time, the recommendations provide a basis for integrating DRT into long-term PT funding and contractual mechanisms, ensuring sustainable operation and financial viability.

A tangible sign of this expected change is the planned use of the studies at the basis of the solution compoent by SRM (in collaboration with Local public authorities) as reference documents in defining future mobility strategies - such as the introduction of new DRT services - and in the preparation of the next Contract of Service, scheduled for the 2028-2029 biennium.

In the long term, the full integration of DRT into the public transport system and its tendering procedures marks a significant step forward, as it combines the flexibility and user-oriented nature of DRT with the stability, coordination, and accountability of structured PT planning. Also crucial is that this helps ensure that these services are provided at a fair and sustainable price for users.

The **Business planning tool for flexible management of DRT-PT** provides support the planning and implementation of DRT services and can be used ad different levels from the strategic to the tactical, and operational.

The adoption of this component as planning tool will change the approach with which the potential adoption of DRT service models is assessed by policymakers, and the way their performance can be monitored, and their implementation can be fine-tuned and continuously improved.

The tool can be used jointly by PTOs and PTAs to create a common ground for co-design of new services as well as transformation of existing ones, in order to identify optimal DRT set-up and funding schemes.

As practical application, Autoguidovie and Redmint will promote the adoption of the tool among PTOs and PTAs through associations, bilateral meetings, workshops and events, and elaborate on the outcomes of the model to develop in dept analysis and plans for further development of DRT services.

The **data driven approach to DRT service expansion** aims at increasing accessibility and mobility in peripheral and underserved areas, through higher public transport usage, and reduced reliance on private cars.

Operational efficiency improves through the reduction of unnecessary vehicle kilometers and optimized service allocation. Passengers benefit from more convenient, reliable, and predictable journeys. Long-term effects include improved network sustainability, and stronger acceptance of public transport among previously car-dependent populations.

The **DRT dedicated tendering procedure in new areas and regulatory frameworks, DRT as a Service**, is expected to have a positive impact especially in those areas where experimental DRT services are designed and implemented, fostering the participation and collaboration of different actors from the transport and IT sectors to the definition of solutions and networks.

Due to the nature of the contexts of application, the participation of certain stakeholders is fundamental, in particular development agencies and sustainability-focused organizations that will enable the introduction of DRT through their engagement and support the acceptance of flexible services.

9. Transferability and replicability

The blueprint and its solution components are designed to be easily transferable to other territorial contexts, offering a robust technical foundation for supporting the integrated planning of PT and DRT services at various levels and in different territorial contexts.

Concerning the **strategic planning**, a coherent and replicable methodological framework has been developed, capable of systematising the key dimensions of DRT service planning: demand, service levels and economic sustainability.

The **recommendations** on integrating DRT in MaaS and on how to develop a PT tendering procedure are highly transferable to other territories, especially those facing similar challenges such as integrating DRT into existing PT networks and MaaS ecosystems, as well as in service contracts.

The **business planning tool** is highly flexible and adaptable to different contexts depending on the DRT models allowed by regulatory frameworks, and to which ones are most desirable according to public objectives, and provides results according to different scenarios reflecting specific socioeconomic conditions and demand response.

The **data driven approach to DRT service expansion** can be transferred to other urban areas, cities, or countries facing similar challenges, and can be adapted to various transport modes and vehicle types.

The **DRT dedicated tendering procedure in new areas and regulatory frameworks, DRT as a Service**, is expected to have a positive impact especially in those areas where experimental DRT services are designed and implemented, fostering the participation and collaboration of different actors from the transport and IT sectors to the definition of solutions and networks.

10. Targeted actions to influence decision makers' attitude towards change

The testing and validation process of the solution components, structured through the involvement of key stakeholders in the LL meetings as well as through direct engagement, constitutes a targeted action aimed at establishing a virtuous exchange for the development of the component, which also influences the decision makers.

In the case of the components jointly developed and primarily tested in the Bologna Metropolitan Area (**strategic planning and recommendations**), given its institutional role as PTA for the Bologna metropolitan area, SRM has the autonomy and capacity to officially adopt and integrate the components in the strategic planning process, in close coordination with the relevant stakeholders and other policymakers.

In the case of the **Business Planning tool**, this not only will be adopted for the future planning and discussions on the development of DRT services in existing and new networks, but targeted actions conducted primarily by Redmint and Autoguidovie will ensure that decisionmakers among PTAs and PTOs understand the added value of considering different DRT models potential on an economic data driven basis as support to the redesign of networks.

With regard to the **data driven approach to DRT service expansion**, to influence decision-makers and promote adoption, BKK has presented the pilot results to municipal authorities, PTA, and PTO management. Stakeholder workshops, awareness campaigns, and conference presentations are organized to communicate the benefits of flexible DRT services. Visualizations, real-time data, and passenger counting results are provided to support informed decision-making, demonstrating operational efficiency, environmental benefits, and rapid public acceptance of the service.

The **DRT dedicated tendering procedure** will be promoted by SDC, Dyvolve and other partners as experimental approach to promote the uptake of specific DRT services, by fostering the collaboration between operators and IT providers. For this purpose, a seminar with IT providers will be organised in order to share the experience and foster their support to contribute to the change of attitude towards DRT and digital technologies by PTOs, PTAs and decision makers.

In the last period of the project, targeted events, dialogues with relevant institutions and communication actions will be organised in order to demonstrate the potential of the solution and of the specific components to public and private decision makers, in order to embark them in the promotion of flexible mobility options as integral part of existing mobility networks and exploit their mobility enhancement, environmental and socioeconomic potential.

The components of the blueprint will also be displayed on an interactive dedicated website developed by the partners, guiding decision makers to select the suitable modules and tools to support their planning process.

11. Conclusions

This deliverable, with its Annexes, summarizes and shows the work done by the DREAM_PACE consortium to co-design and test a modular governance and planning model blueprint, dedicated to the integration of Demand Responsive and Public Transport in a MaaS-logic.

The model – representing one of the outputs (solutions) of the project - is composed by governance and planning, financial and procurement elements, that have been validated and tested with the support of relevant stakeholders and – in some cases – with valuable inputs provided by the DREAM_PACE Business&Tech Community built around the project.

The co-designed and tested solution has been built to foster a substantial change of attitude of decision makers toward the potential of DRT in integrating and enhancing existing public transport networks, accompanying the planning process from the more strategic to the tactical level, across identification of strategic objectives, data processing, digital integration and economic evaluation.

The solution components are characterised by a high level of transferability and replicability thanks to the joint co-design process and to the modular nature of the solution blueprint itself.

On this basis, targeted actions are being put in place in order to influence decision makers' attitude towards change, by showcasing the solution components and their potential applications and promoting their adoption in the planning process.

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13. Annexes

13.1. Annex 1: DREAM_PACE_Bologna pilot_action A_EN

Ref. solution components 1, 2 and 3

- 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

13.2. Annex 2: DREAM_PACE_Bologna pilot_action B_EN

Ref. solution components 1, 2 and 3

- Analysis of potential demand and definition of areas with low demand at metropolitan level (in terms of geographical, socio-eco-nomic, temporal characteristics and relationships between territories), with identification of a methodology and parameters to define the different degrees of de-mand and possible implementation/indication of tools to replicate this analysis at different times and in the future

13.3. Annex 3: DREAM_PACE_Bologna pilot_action C_EN

Ref. solution components 1, 2 and 3

- Study on DRT costs and the possibility of their inclusion in the Service Contract

13.4. Annex 4: DREAM_PACE_Bologna pilot_action D_EN

Ref. solution components 1, 2 and 3

- Study on potential integrations between demand assessment methodologies and parameters, and citizen and metropolitan planning tools

13.5. Annex 5: DREAM_PACE_BPmodel

Ref. solution component 4

- DREAM_PACE Business planning tool

13.6. Annex 6: DREAM_PACE_Data driven approach to DRT service expansion

Ref. solution component 5

- From Traditional Routes to Flexible Networks: A Strategic Approach to Demand Responsive Transport Development

13.7. Annex 7: DREAM_PACE_DRT dedicated tendering procedure (greenfield)

Ref. solution component 6

- DRT dedicated tendering procedure in new areas and regulatory frameworks, DRT as a Service

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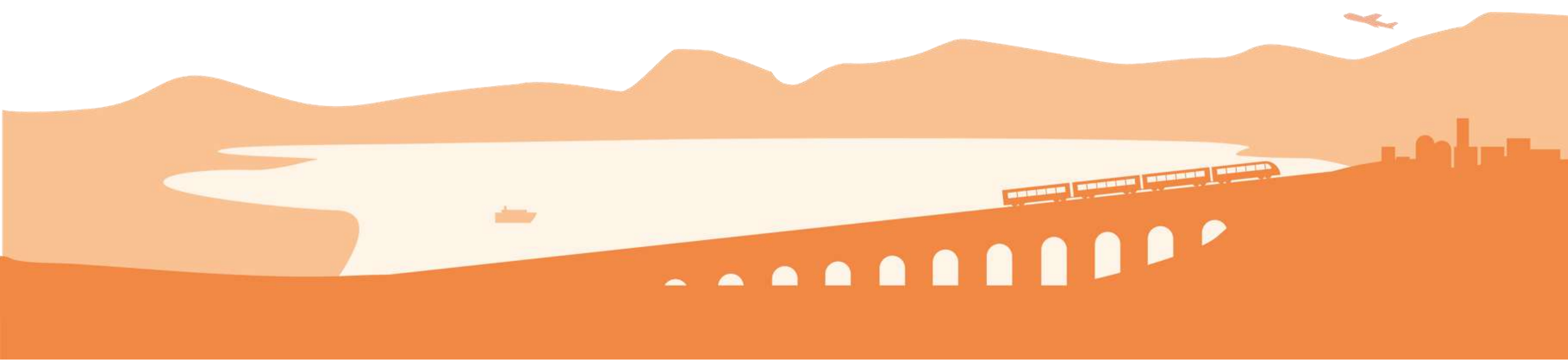
DREAM_PACE

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

02 2025



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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.

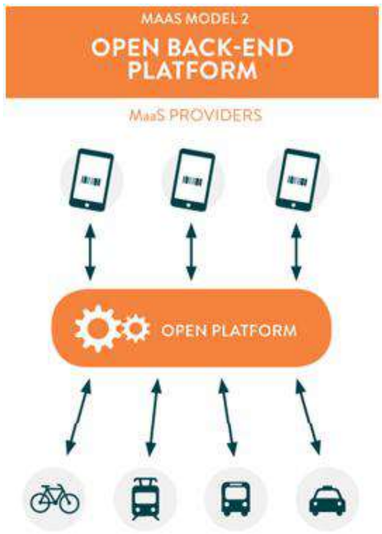

Figure 2-1 MaaS model-2 scheme

"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.

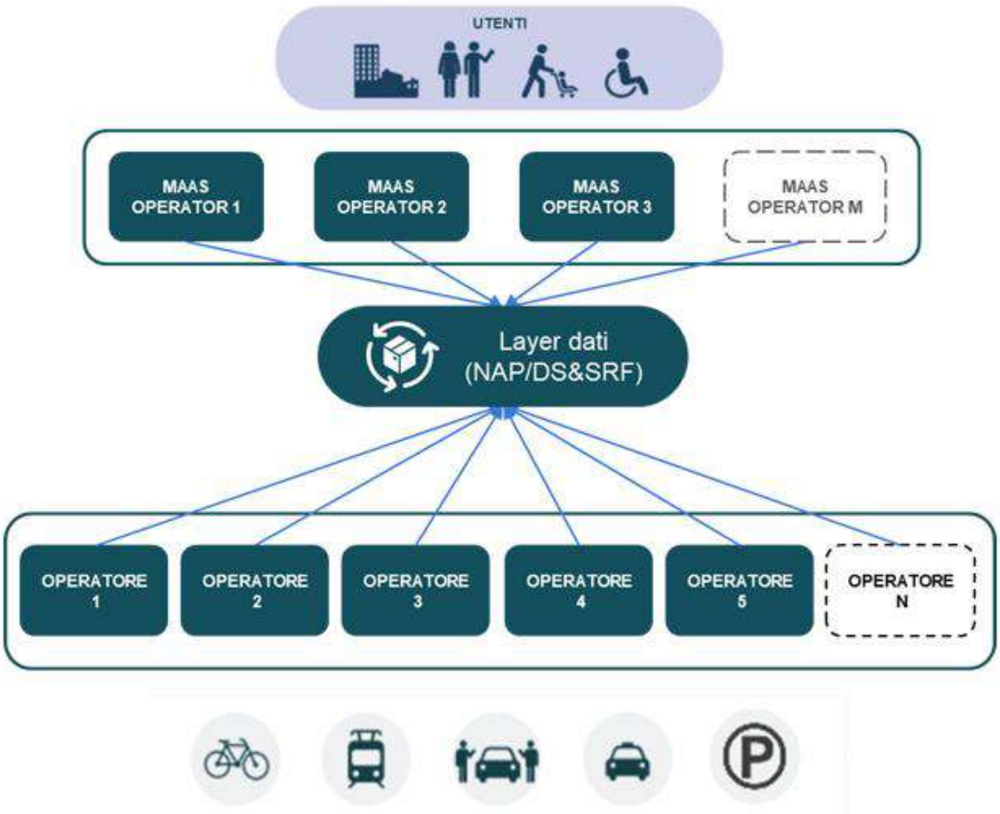

Figure 2-2 NAP/DS&SRF as enabling tools

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.

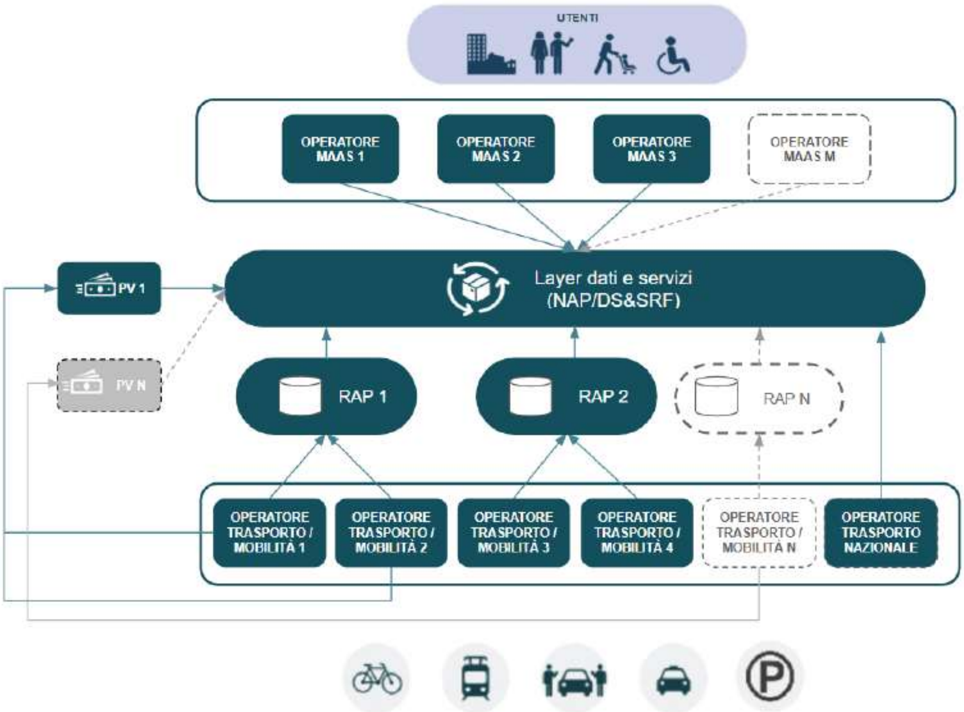

Figure 2-4 MaaS for Italy conceptual architecture

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 pre-defined 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.

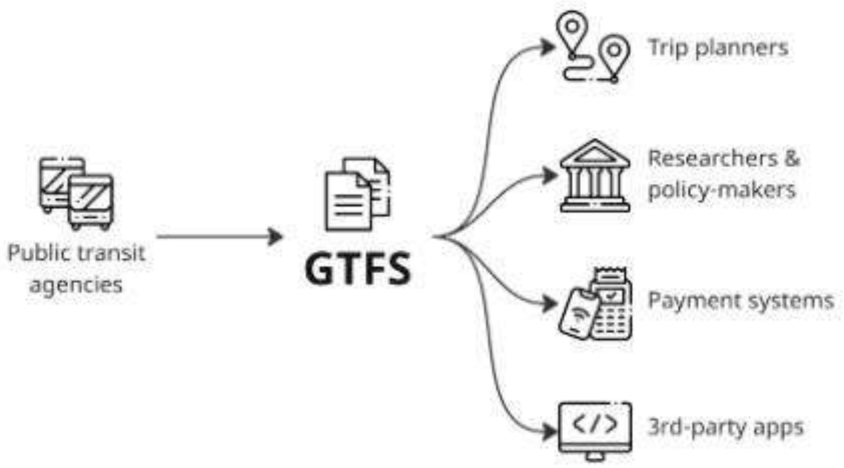

Figure 4-1 Application related to the use of GTFS

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:

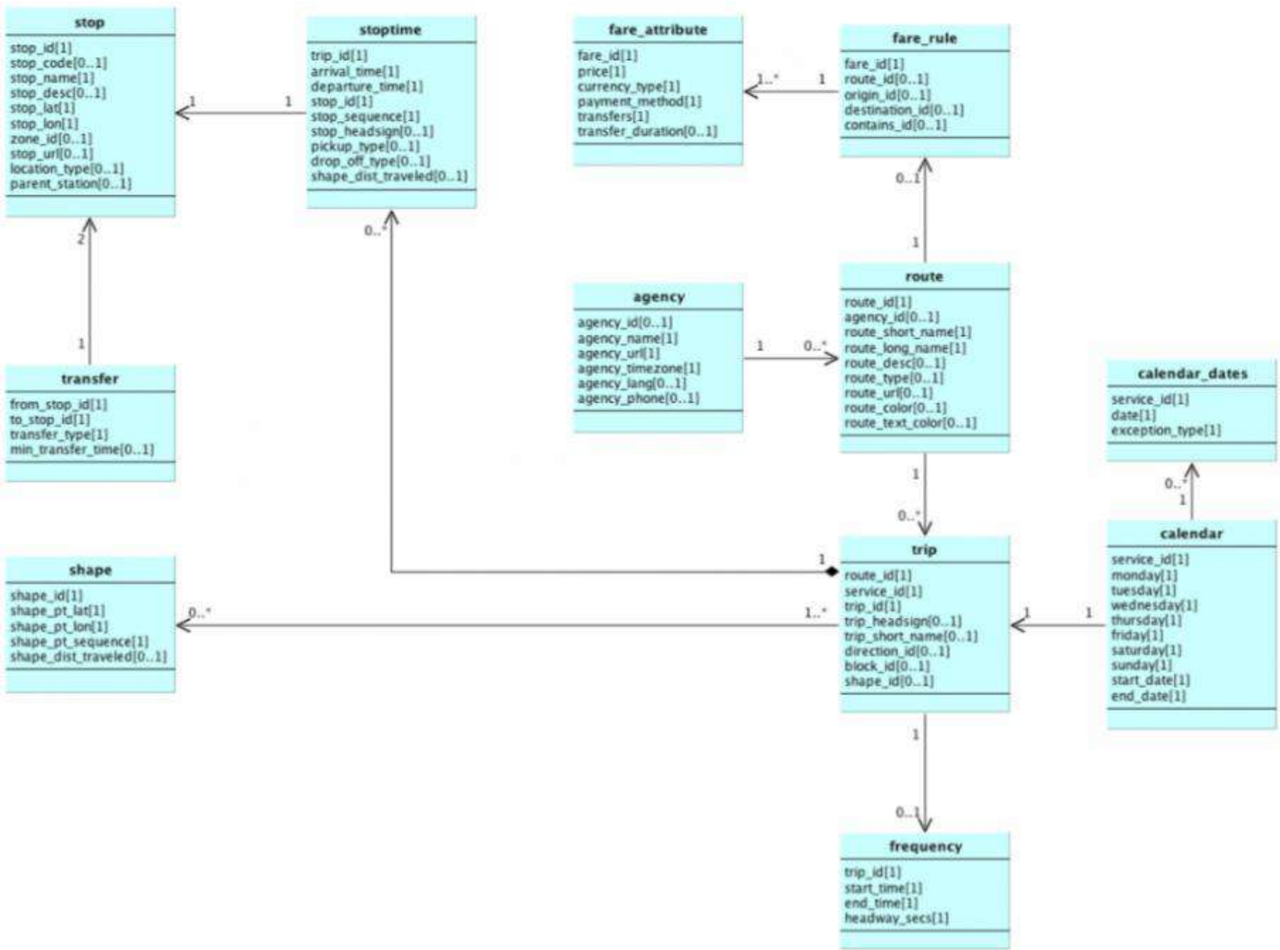

Figure 4-2 GTFS-Static feed interaction

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:

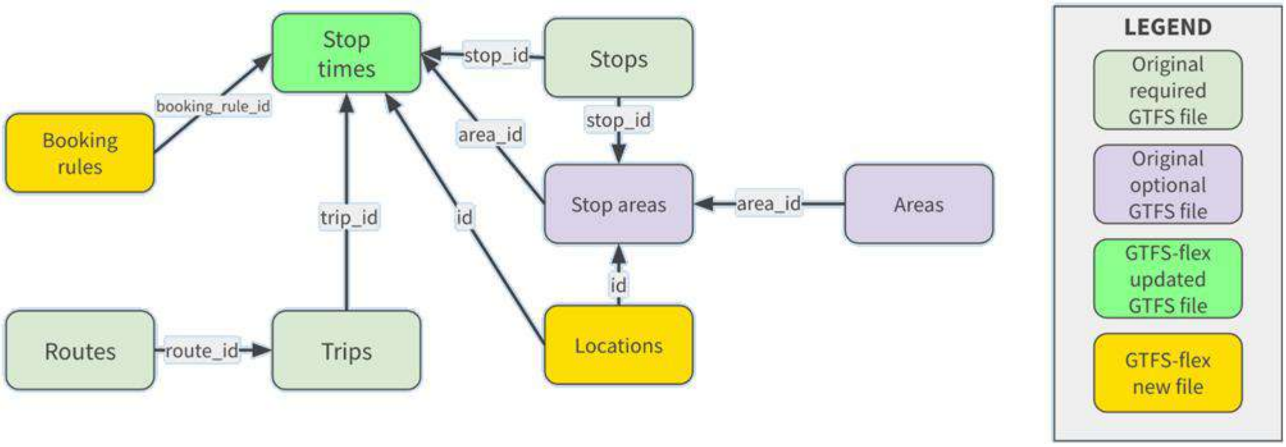

Figure 4-3 GTFS-Flex Feed Interaction

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, interop-erable**, 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

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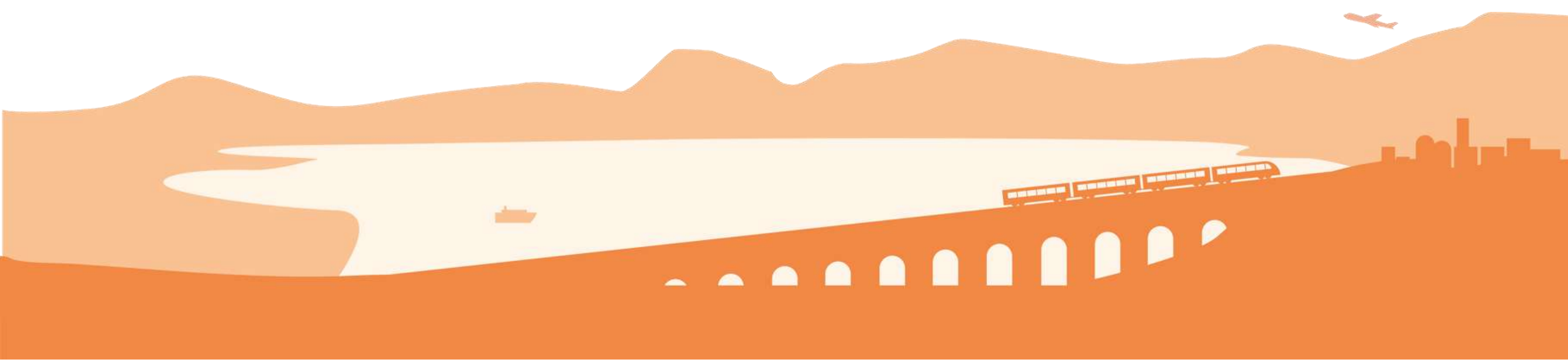
DREAM_PACE

BOLOGNA LIVING LAB - Analysis of potential demand and definition of areas with low demand at metropolitan level (in terms of geographical, socio-economic, temporal characteristics and relationships between territories), with identification of a methodology and parameters to define the different degrees of demand and possible implementation/indication of tools to replicate this analysis at different times and in the future

Final Version

07 2025



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1. Introduction

Measure 1 of Annex 1 to Resolution No. 48/2023 of the Transport Regulation Authority (ART) represents the technical and methodological basis on which all subsequent functional developments for the structuring of service lots (Measure 6) are based, with particular reference to the definition of the public service area and the related mobility catchment area.

The primary objective of this phase is to define, in a coherent and reasonable manner, the geographical and functional area within which to plan and award local public transport services, while identifying the potential mobility demand to be met. In this perspective, the analysis must go beyond a simple description of observed demand, also including latent, unexpressed needs and the structural and socio-economic characteristics of the territory: morphology, urbanization, demographic profiles, and production system. In the case of the Metropolitan City of Bologna, this application is particularly important due to the ***plurality of territories involved***, the coexistence of dense urban areas and mountainous or peripheral areas with less intense demand, and the presence of a widespread production system. Correctly defining the public service area therefore means understanding this territorial complexity and orienting the design of the lots according to criteria of efficiency, equity, and contestability.

To meet these needs, the approach adopted in this document sets out a path consistent with the ART guidelines and based on four methodological pillars:

- ***a clear and operational objective***, aimed at building a robust, transparent, and replicable information base capable of supporting the definition of the mobility catchment area and its subsequent division into coherent lots;
- ***the integrated use of heterogeneous data sources***, including:
  - an ad hoc survey on resident mobility conducted to support the updating of the metropolitan SUMP;
  - socio-demographic and employment data (ISTAT and metropolitan atlas);
  - Big Data from mobile radio networks,
  - Floating Car Data (FCD);
- ***a structured data fusion process***, which enhances the specific potential of each source and allows for the reconstruction of the overall mobility dynamics in the territory in a complementary and consistent manner;
- ***a set of clear operational steps*** that progressively guide the definition of service levels in areas with low demand through the construction of analytical zoning and a territorial socioeconomic model and the subsequent combined estimation of trips from various sources.

In light of the above, the approach proposed in the document fully incorporates the ART guidelines, setting out a process that helps to define the Area and the Basin on the basis of objective information sources, primarily through the reconstruction of the main characteristics of potential demand (Measure 1) in order to provide a complete representation of mobility demand in the Bologna basin.

Secondly, this document also forms the basis for the construction of criteria for identifying service lots (Measure 6) through the proposal of a methodology capable of identifying areas characterized by low demand (Measure 2), starting from the intensity of daily trips measured and the related service levels to be guaranteed (Measure 3) with a view to integrated planning consistent with the objectives of the regulatory intervention.

2. Data sources used

The analysis of mobility demand in the metropolitan area of Bologna presented in this document is based on a ***holistic and integrated approach***, which adopts a *data fusion* logic to combine different information sources in a coherent and complementary manner.

The aim is to provide as accurate, detailed, and representative a picture as possible of mobility behavior at the metropolitan level, leveraging the specific strengths of each source while mitigating the shortcomings that each individual dataset may have when used on its own.

The integration process has made it possible to **accurately map the mobility of residents and city users**, **track journeys that** cannot be detected using traditional methods, and associate each journey chain with **comprehensive information on the reason for travel and mode of transport** for different categories of users, thus providing a detailed and innovative insight into mobility demand in the area.

To this end, the following main information sets were used:

- ***Ad hoc mobility survey*** carried out in 2016 and repeated in 2023, designed to provide useful data for updating the metropolitan SUMP, which made it possible to obtain accurate information on the origin, destination, motivation, and mode of transport of residents' journeys, differentiated by macro-area of residence and type category (combination of gender, age, occupation);
- ***Socio-demographic data (ISTAT and metropolitan atlas)***, essential for characterizing the reference populations in terms of density, territorial distribution, and employment levels, in order to correlate mobility behaviors with settlement contexts;
- ***Big Data derived from the mobile radio network***, used to quantify and spatialize mobility flows on a metropolitan scale, distinguishing between residents and city users and analyzing the exchange and crossing components of trips;
- ***Floating Car Data***, used to integrate analyses of vehicle components and enrich the information derived from telephone big data.

This integration has generated a **multi-level knowledge base** never before achieved on a metropolitan scale, capable of comprehensively and dynamically representing the evolution of mobility and effectively supporting the assessments required by Measure 1 of ART Resolution No. 48/2017.

In the rest of this chapter, each source is described based on its main functional characteristics (such as updating, sample size, time and space detail, modal information, and availability of trip motivation) with a brief specification of its role in the data integration process and in the construction of the information base used for demand analysis.

2.1. Socio-economic data

ISTAT data are the main structured and official source of socio-demographic information for the metropolitan area of Bologna. As is well known, their strength lies in **their almost total coverage of the population and workforce**, with a level of detail that allows for disaggregated analysis by socio-demographic profiles such as gender and age, as well as detailed spatial distribution down to the census cell level. In addition, thanks to the Metropolitan Statistical Atlas, it is possible to obtain updated data **on the employment rate by municipality,** which is crucial for defining the potential demand for systematic mobility.

From a functional point of view, however, ISTAT data have some limitations: first, census-based updates are not annual but decennial; annual updates are only carried out at the municipal level, so it is not possible to take into account short-term developments at the sub-municipal level (new residential/productive settlements). In the data fusion process, ISTAT data played a role as a statistical and territorial, providing references for the residents and employed population to help calculate emission indices and, consequently, travel for each territorial area.

Strengths	Need for integration with other sources
- ISTAT census data on population and employees allow for detailed characterization of territories at the municipal and sub-municipal level (census cells). - The annual ISTAT census on a municipal basis provides a constantly updated demographic reference - The territorial structure based on census cells allows for maximum spatial granularity, which is useful for aggregating and correlating with other data sources. - The data allow expansion to the universe of all sample data sources used in data fusion	- The most detailed territorial subdivisions (census cells) are only available for the 2011 and 2021 censuses - Uneven availability (e.g., 2011–2021 for census cells) may limit analysis at the micro-territorial level - No spatially disaggregated information is available on employment type (e.g., Ateco codes)

Table1Strengths and critical elements of socio-economic data within the data fusion process (Source: GO-Mobility analysis)

2.2. PUMS survey

The survey conducted in 2023 to update the PUMS for the Bologna Metropolitan Area is a valuable source of data for the analytical representation of mobility demand. Aimed exclusively at **the resident population aged between 14 and 85,** the survey made it possible to identify daily travel chains in terms of origin, destination, main means of transport used and reason, with a level of detail broken down into 24 hourly bands.

Strengths	Need for integration with other sources
- Provides a representative estimate of mobility on an average weekday - Includes time details of trips for each time slot - Allows analysis of users' socio-demographic profiles - Collects information on the reason for the trip (work, study, shopping, etc.) - Provides the mode of transport used (car, bus, train, bicycle, etc.) - Allows for a distinction between trips within the municipality and between different municipalities	- Territorial granularity limited to only 16 macro-zones of the metropolitan area - Refers exclusively to residents of the metropolitan city aged over 14 - Sample data declared via questionnaire, not measured directly on actual behavior

Table2Strengths and weaknesses of the PUMS survey within the data fusion process (Source: GO-Mobility analysis)

The reasons for travel were grouped into five categories: ***work***, ***shopping***, ***social activities***, ***study***, ***and other reasons***, thus providing a detailed and qualitative overview of mobility needs.

From a territorial point of view, the segmentation of the survey into **16 aggregate zones** of the Metropolitan City of Bologna allows for refined municipal or supra-municipal analysis. This level of granularity was particularly useful for estimating **self-contained flows at the municipal level**, which are not fully represented in the data from the mobile radio network due to the intrinsic characteristics of the data.

For this reason, the survey played a fundamental role in the **data fusion** process, contributing to **the construction of origin-destination matrices** and **the modal and motivational attribution** of trips, compensating for the typical shortcomings of big data on these qualitative aspects.

2.3. Mobile network data (telephone big data)

Big data from mobile networks is the quantitative core of mobility analysis in metropolitan areas, constituting the most extensive and representative source of observation, thanks to a **sample covering approximately 30% of the population**. This type of data makes it possible to detect not only the movements of residents, but also those of temporary residents (e.g., university students) and city users, i.e., those who gravitate towards the area for work, study, or other services without officially and/or permanently residing there.

Strengths	Need for integration with other sources
- Includes non-residents, domiciled persons, and city users in the mapping, providing a comprehensive representation of mobility - The only source capable of detecting and quantifying movements across the territory - Offers a particularly accurate estimate of inter-municipal and exchange movements - Represents all city users, even outside the main metropolitan centers (airport, stations, trade fair, etc.) - Guarantees extended time coverage over 3 months (May, July, November) and 4 types of days (weekdays, Saturdays, Sundays, events) - It allows specific analyses to be carried out during special events (stadium, concerts) - Territorial subdivision into approximately 200 zones, constructed in line with analytical objectives - Hourly details available - Provides socio-demographic characterization of users (residence, age, citizenship) and travel (type, regularity, cardinality, AV)	- Does not provide information on the reason for and mode of transport - Does not detect movements within the individual zones of the territorial subdivision adopted

Table3Strengths and critical elements of mobile network data within the data fusion process (Source: GO-Mobility analysis)

The added value of mobile radio data lies in its ability to represent all *city users'* movements, not only those observable through access points such as stations, airports, or exhibition centers, but across the entire territory, contributing to a robust and integrated reconstruction of the actual movement chain of this rather significant component of demand in a key area of the country such as the metropolitan city of Bologna.

Another strength of this source is its **high temporal resolution**, which allows **mobility** to **be observed on an hourly and daily basis**, providing a dynamic snapshot of travel behavior and travel patterns. Among other things, this makes it possible to **measure seasonal fluctuations** by continuously monitoring monthly changes in demand and ensuring an up-to-date representation of mobility needs throughout the year (see paragraph §3.3.1).

Compared to other sources, mobile radio data is irreplaceable for observing all extraterritorial exchanges between the metropolitan city and the rest of the country, and for mapping crossings (i.e., flows that affect the metropolitan city without originating or terminating within its territory). Furthermore, thanks to the high degree of representativeness of the sample, it is particularly accurate in providing a detailed view of dynamics at the municipal or sub-municipal level, with a level of spatial aggregation of approximately 200 zones, consistent with the functional logic of mobility. On the other hand, by its very nature, it does not allow for the analysis of mobility within each of the zones defined for data extraction.

In the data fusion process, mobile radio data therefore provided the main basis for quantifying the origin/destination matrices of non-residents, with a degree of granularity and representativeness that is essential for calibrating and integrating other sources with reference to the mobility of residents in the metropolitan city.

2.4. Floating Car Data

Floating Car Data (FCD) is a valuable source for the dynamic analysis of the mobility system, particularly in relation to private car travel, as it consists of anonymized GPS data from connected vehicle fleets (including taxis, commercial vehicles, and shared vehicles), which track the routes actually traveled on the road network and provide granular information on travel times, average speeds, and hourly congestion profiles. shared vehicles), which track the routes actually taken on the road network and provide granular information on travel times, average speeds, and hourly congestion profiles.

Strengths	Need for integration with other sources
- Detects all types of vehicle movements passing through the metropolitan area of Bologna (including interchanges and crossings) - They offer high spatial granularity, down to GPS coordinates, which is useful for road infrastructure analysis - They provide data with minute-by-minute granularity, enabling dynamic analysis in near real time - Enables accurate measurement of average speeds, distances traveled, and travel times, which are key indicators for evaluating network performance - They provide information on the vehicle's area of residence (based on the place of overnight stay), which is useful for statistical expansion to the reference universe	- They cover only car travel, excluding other forms of mobility - They do not provide information about the user, the driver, or any passengers - It is not possible to associate the reasons for the trip with the movements

Table4Strengths and weaknesses of Floating Car Data within the data fusion process (Source: GO-Mobility analysis)

One of the strengths of this source lies in its ability to accurately measure private transport mobility dynamics. This level of detail is otherwise difficult to obtain through surveys based on traditional methods. Thanks to this spatial and temporal granularity, it is possible to calculate key indicators such as average travel times, average speeds along road sections, and hourly, daily, or seasonal variations in network performance. Furthermore, compared to traditional sources, this type of data offers a broader sampling in terms of both quantity and statistical reliability.

In the data fusion process, FCDs were used to enrich and refine the interpretation of data from other sources, especially with regard to metrics of mutual exchange between adjacent areas, which is crucial for maximizing potential and compensating for the inherent shortcomings of telephone data in the case of continuous residential settlements or areas with poor coverage.

2.5. Data fusion process

As mentioned above, in order to ensure that the analysis was as robust, consistent, and representative as possible of mobility demand in the metropolitan city of Bologna, a *data fusion* approach was adopted based on the structured and methodological integration of the aforementioned data sources. This process made it possible to **combine the strengths of the different information bases, while compensating for the inherent limitations of** each and creating a common knowledge base.

The aim was to harmonize the spatial, temporal, and conceptual dimensions of the different sources, ensuring a cross-sectional and layered reading of mobility phenomena, capable of representing the main components of urban and metropolitan mobility: internal, exchange, and crossing trips. This section summarizes the main activities that make up this process.

Phase 1: definition of the territorial basis for analysis

The first phase of the data fusion process involved defining a coherent and sufficiently granular territorial basis to support integration between heterogeneous sources. The construction of an ad hoc zoning system ensured the **spatial standardization necessary to make data from different sources, with different structures and resolutions, comparable**.

1. ***Construction of an ad hoc zoning system with over 1,000 territorial zones within the metropolitan city***

The first step in the integration process was to define a coherent, detailed, and homogeneous territorial zoning, necessary to ensure spatial compatibility between the different data sources. To this end, the territory of the metropolitan city of Bologna was divided into 1,050 zones, constituting the basic unit for subsequent analyses.

2. ***Aggregation and standardization of socioeconomic data on a zonal basis***

The relevant socioeconomic indicators were calculated for each of the identified zones, based on data provided by ISTAT (population census) and the Metropolitan Atlas. This work required the harmonization of sources with different resolutions and structures.

3. ***Recomposition by cross-sociodemographic profiles***

For each area, the resident population was broken down by age group, gender, and employment status, so as to allow for a detailed and multifactorial reading of mobility behaviors. This level of detail proved particularly useful for comparing user characteristics with the data observed on trips and for subsequent sample expansion and user segmentation exercises.

Phase 2: calculation of trips from different data sources

The second phase of the data fusion process is dedicated to reconstructing trips from different sources and is divided into two parallel macro-activities, each focusing on a different subset of the population and a different analytical perspective. On the one hand, trips leaving home and returning home are estimated for residents only, integrating PUMS (sample) survey data with socio-demographic data. On the other hand, the overall movements of all users, residents and non-residents, are calculated from telephone big data, integrated and refined thanks to the contribution of FCD data.

This dual approach allows us to make the most of the wealth of information available, balancing behavioral detail and sample size.

Calculation of trips leaving home and returning home for residents only

1. ***Calculation of movements based on the PUMS survey and socio-demographic data:***

The survey carried out in 2023, targeting residents of the metropolitan city, is used to estimate the average number of inter-municipal and intra-municipal trips made by each user category, broken down by gender, age group, employment status, and origin/destination relationships in the 16 survey areas.

2. ***Normalization with respect to the actual population of each zone:***

The mobility indicators derived from the survey are compared to the resident population at the time of the survey to obtain *'mobility* rates' that can also be used in time projections.

3. ***Disaggregation by mode and reason for travel:***

Once the total volume of trips for each 'key' user profile combination has been defined, the trips are further broken down by reason (work, study, shopping, etc.) and main mode of transport, based on the distributions observed in the survey.

4. ***Estimation of trips with detailed zoning:***

The mobility rates are finally applied to the updated resident population, reconstructed for each of the 1,050 analysis zones. The result is a travel matrix that combines high spatial granularity and socio-demographic detail.

It is important to note that the matrix obtained has asymmetrical zoning, with greater spatial detail on the origin (1,050 zones) for departures from home and on the destination for returns.

Calculation of total movements from telephone big data and FCD

1. ***Extraction of movements measured by the mobile network for all user profiles:***

Telephone data is used to quantify the total number of daily movements across the entire metropolitan area, distinguishing between residents, city users, and non-residents, and classifying users according to age, origin, and mobility components (internal, exchange, crossing).

2. ***Verification and enrichment of data using Floating Car Data:***

FCD data is used to correct any distortions, such as "bounces" due to accuracy and coverage limitations of data from the mobile network. This eliminates false trips that do not correspond to actual routes, improving the quality and consistency of the information flow, particularly on short inter-municipal routes and in high-density urban areas.

Phase 3: production of two integrated outputs for different analysis purposes

The third phase involved the construction of the outputs resulting from the integration process between the sources, obtained for different analytical purposes, differentiating the level of territorial and informational detail and thus allowing a two-pronged approach: one broader and more systemic, the other focused on areas with less intense demand.

Creation of a database for comprehensive mobility analysis

This first output aims to provide an overview of mobility behaviors affecting the metropolitan city of Bologna and is designed to support general assessments of the structure and intensity of mobility demand, regardless of user residence:

- ***Broad spectrum of population covered***: the database includes trips made by all types of users, residents and non-residents, including city users and through traffic, as detected by the mobile radio network;

- ***Zoning consistent with telephone data***: the information is aggregated into approximately 200 areas, consistent with the zoning used for extracting data from the mobile network;
- ***Focus on volumes***: the dataset does not contain details on the reason for or mode of transport, but focuses on quantities, distribution, and the socio-demographic profiles of users.

Creation of a database for specific analyses of areas with low demand

The second output was designed to enable targeted analysis of areas characterized by more discontinuous or dispersed mobility demand, such as peripheral areas, and was created to support the definition of the level of public transport service in these areas, providing a more granular reading of residents' mobility behavior:

- ***Disaggregated information on origin and return***: the database focuses on the home-based movements of residents only, with the possibility of clearly distinguishing between departures and returns for each socio-demographic profile;
- ***Highly detailed zoning for a detailed understanding of the territory***: the territorial basis consists of the 1,050 socioeconomic zones defined in the first phase, making it possible to achieve a high level of spatial granularity;
- ***Details on modes of transport and reasons for*** travel: the dataset includes information on the reason for travel (work, study, shopping, etc.) and the mode used (car, public transport, bicycle, etc.), which is essential for assessing service needs and the effectiveness of the existing offer.

The overall result is an integrated knowledge system that, in a way that is unprecedented on a metropolitan scale, allows for a coherent and flexible reading of the different components of mobility demand: from the most systematic to the occasional, from local to cross-city trips, from the dynamics of residents to those of city users.

2.5.1. Estimation of the intra-zone travel component

A crucial step that cut across the entire methodological process was the ***estimation of the intra-zone component of mobility***, i.e., the part of travel that takes place within the same zone. As these are internal movements that cannot be directly detected from telephone data, this component would risk remaining "invisible" if not adequately estimated, compromising the robustness and representativeness of the final analyses. To fill this gap and ensure a complete and reliable picture of mobility, a specific methodological process was developed, structured in several stages:

- firstly, a transcoding matrix was constructed between the two main zoning systems adopted: telephone zoning (approximately 200 zones), used to extract data from the mobile network, and more granular zoning (1,050 zones), used for socio-economic analyses related to the territory and potential demand. This operation made information from different sources compatible with each other.
- subsequently, based on PUMS mobility survey data, a gravitational model was calibrated to estimate the share of *self-contained* trips for each municipality, distinguishing appropriately between trips within Bologna and those within other municipalities in the metropolitan area, to take into account the different dynamics;
- the model was then applied to the zoning of 1,050 zones to reconstruct internal origin/destination relationships with the highest possible level of detail;
- Finally, the percentage share of intra-zone trips for each zone of the telephone zoning was estimated, maintaining the average proportion of trips starting and ending in the same area relative to the total generated and attracted by each zone.

3. Analysis of actual, potential, and low demand

The analysis of mobility demand is a key step in defining the public service area and the mobility catchment area, in accordance with Measure 1 of Resolution No. 48/2023 of the Transport Regulation Authority (ART). This analysis provides the technical and methodological basis for the subsequent identification of the services to be included in the service contract, the identification of areas with low demand (Measure 2) and, finally, the structuring of the lots to be awarded on an exclusive basis (Measure 6).

This chapter aims to reconstruct, in an integrated and coherent manner, the potential demand for mobility, i.e., the set of citizens' travel needs that can be identified through a process of data fusion between statistical sources, mobility surveys, mobile network data, and socio-demographic indicators (see chapter §2). Through an integrated reading of these, the chapter aims to provide a complete and up-to-date picture of mobility demand in the metropolitan area of Bologna, which is useful for planning an efficient, accessible, and sustainable public transport system.

3.1. Territorial framework and reference zoning system

The metropolitan city of Bologna covers an area of approximately 3,700 km² and has an extremely diverse territorial morphology, which **significantly influences population distribution, settlement dynamics, and mobility needs**.

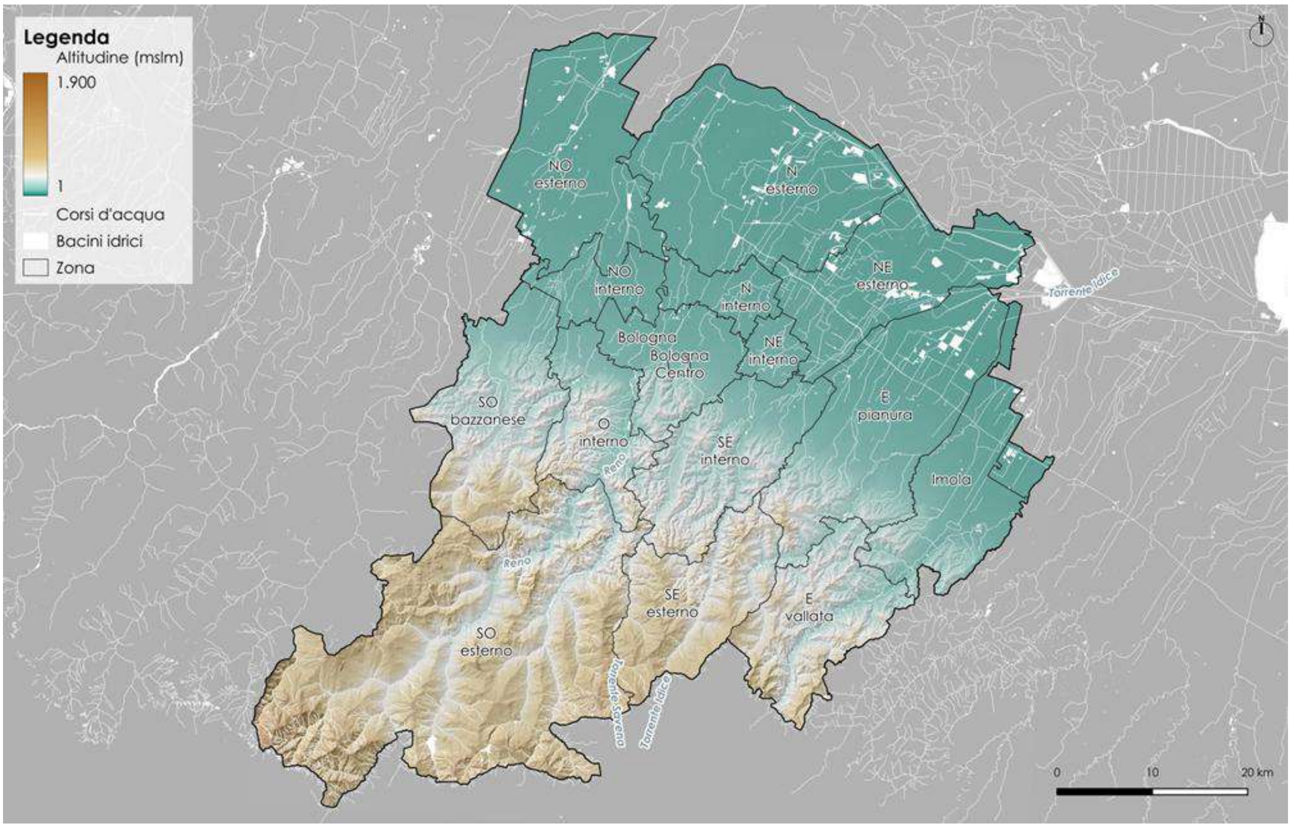

Figure 1 Location of the main urban centers at the provincial level (Source: GO-Mobility analysis based on TINITALY 1.1 data)

The territory is divided along an altitudinal and functional gradient that stretches from the Po Valley in the north to the Tuscan-Emilian Apennines in the south, passing through a central hilly belt that forms an environmental and settlement hinge (Figure 1). From an orographic point of view, three large areas can be distinguished:

- ***the plain***, which occupies about 40% of the territory, historically linked to agriculture and now also home to important production centers. The main towns include Imola, San Lazzaro di Savena, Castel San Pietro Terme, and San Giovanni in Persiceto;
- ***the hilly area***, located south of the Via Emilia, includes municipalities such as Casalecchio di Reno, Sasso Marconi, and Valsamoggia, which are examples of mixed territories with widespread residential areas and strong ties to the provincial capital;
- ***The Bolognese Apennines***, covering about 35% of the area, are characterized by peaks over 1,000 meters and low population density; the main municipalities, such as Porretta Terme, Vergato, and Loiano, are distributed along the main valleys (Reno, Setta, Santerno).

The settlement system reflects this territorial structure and can be divided into several main categories:

- the metropolitan urban center of Bologna, the economic, demographic, and infrastructural hub;
- the centers along the Via Emilia, with linear development and continuous settlement;
- the small hill towns, distributed along ridges and mountain ranges;
- the mountain settlements in the valley bottoms, which are more isolated and less densely populated.

Bologna, with its approximately 400,000 inhabitants, is therefore the hub of the basin's socio-economic relations and generates an urban polarization effect along the east-west axis of the Via Emilia. This urban and territorial structure defines **a complex polycentric system, with strong functional interdependencies and different mobility needs between the various areas,** thus constituting a complex operational context for the planning and regulation of local public services.

3.2. Socio-economic characterization

The socio-economic characterization of the metropolitan area of Bologna is a **key factor in understanding the potential demand for mobility**, in line with the provisions of Measure 1 of Resolution 48/2023 ART, since the demographic and productive structure of the territory influences both the expected volumes of travel and the related modes and reasons for travel.

This section analyzes two fundamental components: the resident population and the economic structure, with the aim of providing a concise but robust overview of the socio-economic conditions that influence daily and systematic mobility needs in the territory, to support planning decisions and the identification of areas with low demand.

3.2.1. Population and demographic structure

Over the last thirty years, the resident population in the metropolitan city of Bologna has seen **steady growth** (+11.5%), in line with the regional trend in Emilia-Romagna. This growth has been largely fueled by positive net migration—both internal and international—which, at least until 2011, offset the gradual decline in the natural population balance. However, this demographic development has taken on different characteristics across the territory, profoundly influencing the distribution of the population and, consequently, the demand for mobility.

In particular, the **municipality of Bologna** experienced a significant decline in population in the 1990s, attributable to **suburbanization phenomena** that encouraged people to move to neighboring municipalities. In the following years, there was a gradual recovery, although without reaching previous levels. The areas of **the inner metropolitan belt,** on the other hand, benefited most **from demographic expansion,** thanks to greater accessibility, more affordable housing, and infrastructure development. In contrast, the **hilly and mountainous areas** have maintained a **more sparse and dispersed settlement structure,** with an often-elderly population distributed in villages in the valley bottoms or on poorly urbanized ridges.

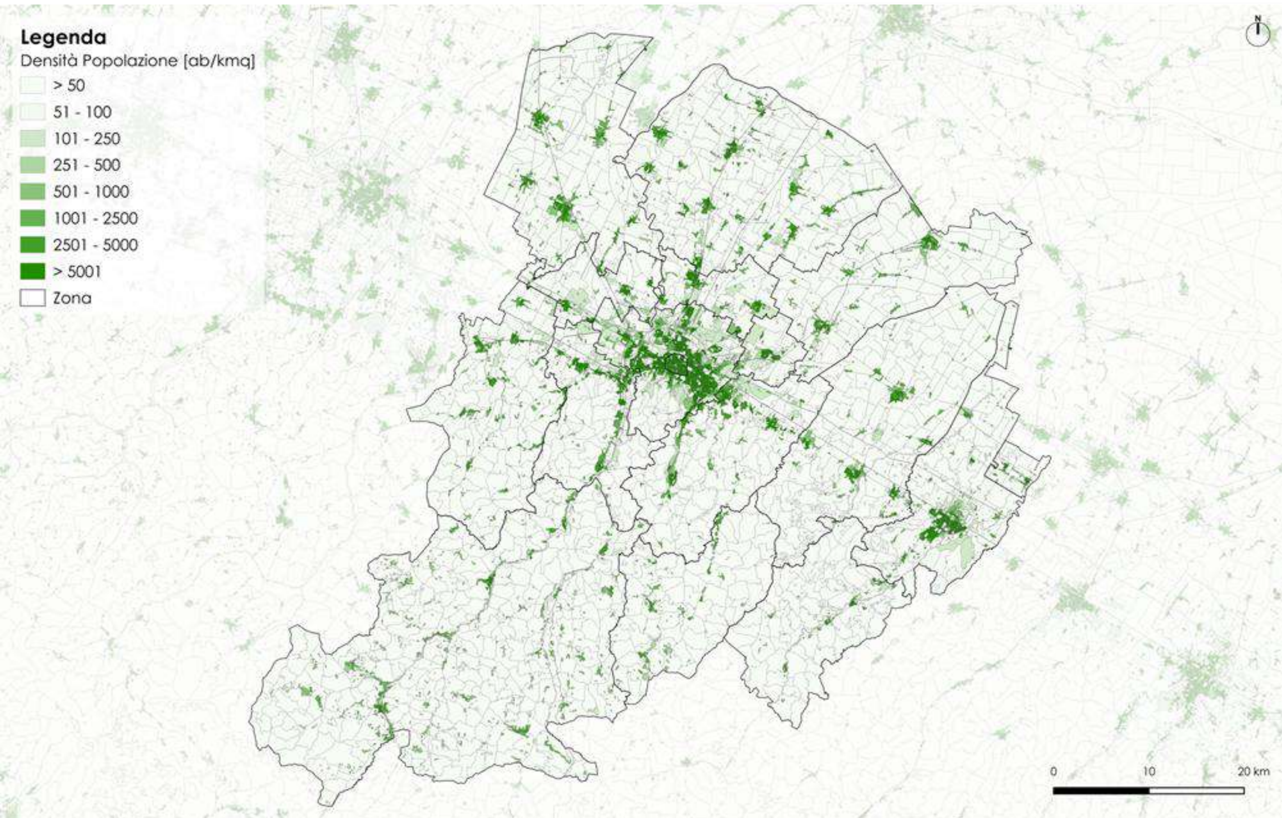

Figure 2 Population density per census cell in the study area in 2021 (Source: GO-Mobility analysis of ISTAT data)

These dynamics are clearly reflected in the population density (Figure 2): while Bologna exceeds 2,750 inhabitants per km^2 and Imola stands at around 340 inhabitants per km^2, the Apennine areas show much lower values, often below 300 inhabitants per km^2. These thresholds identify the so-called "rural *areas*" according to the Eurostat definition, which in the province affect a significant proportion of the population; this **scattered settlement pattern leads to a less concentrated demand for mobility,** with a need for more flexible, accessible, and widespread services, often incompatible with the traditional public transport offer.

It is important to note, however, **that these density values are calculated on a municipal basis** and reflect the entire administrative area, not just urbanized areas. For example, the low average density of Imola is influenced by its large territorial extension and the presence of rural hamlets and does not fully represent the density of the compact urban area, which is significantly higher. The difference between Bologna and Imola, therefore, although real, is accentuated by the calculation method and should be interpreted taking into account these morphological and administrative specificities.

Demographic trends in the decade 2011–2021 confirm the vitality of intermediate areas (+10 on average), while the Apennine areas have experienced a further slight contraction. The rest of the territory shows more modest but still positive growth rates, contributing to overall relative stability. Specifically, expanding areas require a strengthening of systematic transport services, while areas in decline pose challenges in terms of service sustainability and universal accessibility.

Another important factor is the **transformation of family structure**: throughout the province, there has been an increase in the number of families, even where the population is stable or slightly declining. This phenomenon is linked to the reduction in average family size, with smaller households and a growing number of people living alone, particularly in central areas such as the historic center of Bologna. Finally, in terms **of age structure,** there is a general aging of the population, with a higher average age in hilly and mountainous areas (over 47 years). In these areas, old-age and dependency ratios are high, indicating a reduction in independent mobility and a growing demand for accessible, often non-systematic, transport by users with reduced mobility. At the same time, the capital is experiencing slighter rejuvenation and a reduction in dependency indices, which is reflected in more structured and regular mobility patterns at the urban level.

3.2.2. Employees and economic structure

The evolution of the economic structure of the metropolitan city of Bologna is also reflected in the sectoral composition of the workforce, which over the last two decades has shown different dynamics between **the capital**, **the metropolitan belt**, and **the peripheral areas**. The total number of employees in the region grew steadily between 1991 and 2011, with a more marked expansion in the first decade (+6.3% at the provincial level between 1991 and 2001); however, in the subsequent period 2001–2011, **growth stabilized,** with a slight decline in the number of employees in the province (-0.4%) and a more significant decline in the municipality of Bologna (-6%).

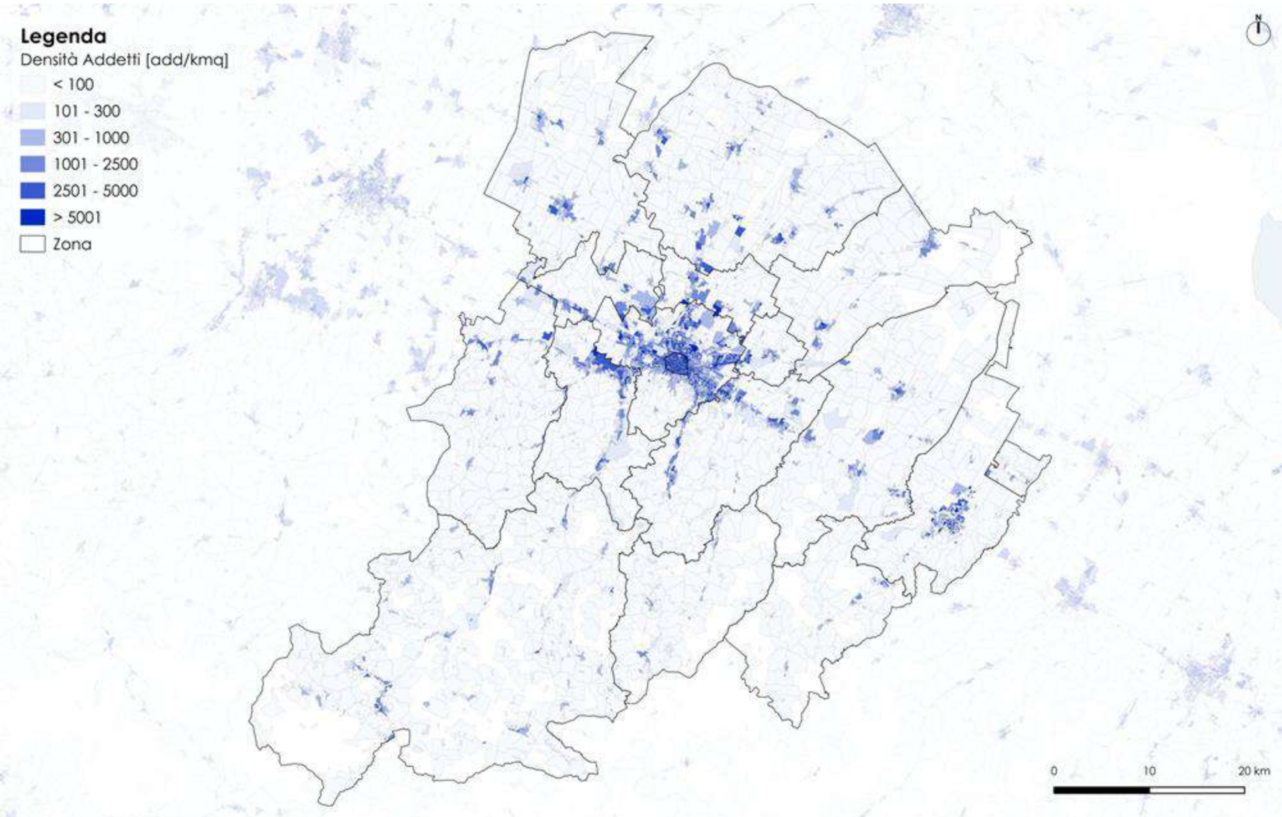

Figure1Density of employees per census cell in the study area in 2011 (Source: GO-Mobility analysis of ISTAT data)

The agricultural sector has suffered the most marked and widespread decline, in line with the structural downsizing that has affected the entire sector at national level. As for the industrial sector, although it has shown a slight decline over time, it still has a significant weight in the flat and suburban areas of the province, especially north of Via Emilia. In these areas—including Calderara di Reno, Anzola dell'Emilia, San Lazzaro di Savena, and Castenaso—industry is developed along the main infrastructure axes (road and rail), benefiting from good accessibility and adequate production space. The **Bologna Interport hub and the industrial area of Zola Predosa** are also important production hubs: the concentration of employees in these areas generates significant demand for systematic and commuter mobility, both for the resident workforce and for flows from neighboring areas.

At the same time, in the capital and particularly in the Bologna city center, there is a **gradual expansion of the tertiary sector**: the commerce, transport, and services sectors are showing significant growth, driven by digitalization, logistical developments, and growing demand for urban services related to mobility, culture, education, and healthcare. This transition has direct and us impacts on the configuration of urban mobility: there is an increasing need for accessible, frequent, and widely distributed public transport to serve both service workers and users generated by these activities.

Finally, intermediate areas have experienced the most dynamic changes, with significant growth in the commerce and services sectors at the expense of agriculture and, to some extent, industry. This heterogeneity requires ***demand-driven*** planning of mobility services capable of responding to evolving economic contexts and the increasing dispersion of workplaces.

Commercial areas (Figure 4) are much more concentrated than industrial areas, located mainly in the urban center of Bologna and in the main neighboring municipalities, often **close to strategic interchange nodes or high-traffic axes**. Although more compact, this distribution generates complex mobility demand, consisting of short but intense journeys spread over a long period of time, typical of mobility linked to services, commerce, and urban use.

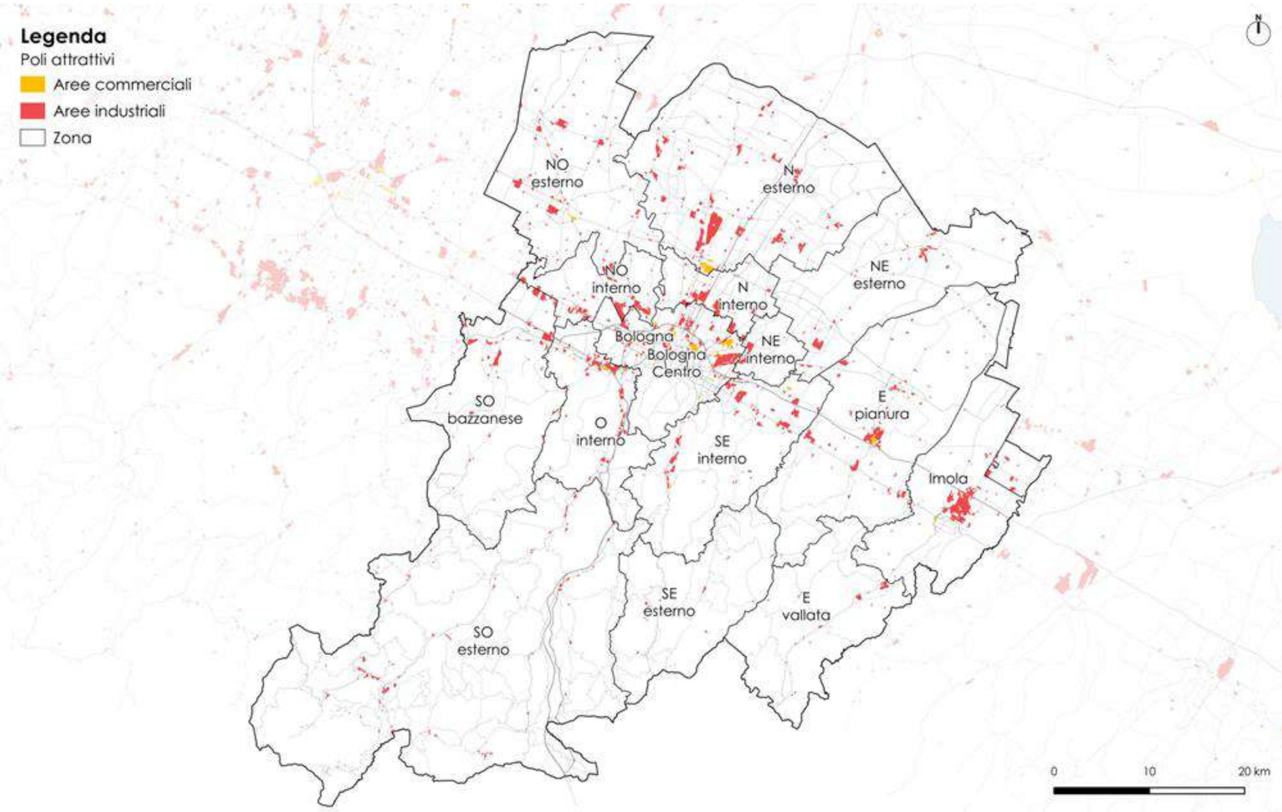

Figure 4 Distribution of commercial and industrial areas at the provincial level (Source: GO-Mobility analysis based on OpenStreetMap data)

Overall, the sectoral distribution of employees confirms a hybrid and functionally differentiated territorial model, in which production hubs, tertiary centers, and rural areas coexist. To respond to this complexity, it is crucial that public transport planning balances the need for efficiency in high-demand corridors with flexible and targeted mobility solutions for peripheral and less well-served areas, thus ensuring accessibility, competitiveness, and social inclusion on a metropolitan scale.

3.2.3. General considerations

The analysis conducted on the population, economic structure, and territorial distribution of the metropolitan city of Bologna highlights ***a highly heterogeneous context, marked by growing polarization between dense and dynamic central areas and peripheral or mountainous areas with less intense demand***.

In urban and suburban areas, particularly along the Via Emilia axis and in the inner suburbs, the combination of high population density, an active workforce, and a tertiary-based economy generates **systematic demand for mobility**, which must be met by high-frequency, widespread services throughout the day. In contrast, hilly and Apennine areas are characterized by low density, high aging indices, and poor infrastructure accessibility, resulting **in low demand in quantitative terms but with a high social impact.** In these areas, the adoption of flexible solutions such as DRT can be essential to ensure equitable access to mobility and territorial inclusion.

The distribution of employees by economic sector also reinforces this interpretation: **the urban center and the most densely-populated areas are characterized by a high concentration in** the **advanced tertiary**, commerce, and services sectors, while the outlying areas maintain a greater presence of industrial or agricultural activities, often associated with **less regular and more fragmented travel needs**. In this context, potential demand cannot be understood solely in terms of absolute volumes, but must be interpreted in relation to spatial distribution, the socio-demographic characteristics of users, and the nature of travel.

The integration of these elements with a *data-driven* approach consistent with the guidelines of the metropolitan PUMS is key to structuring a public service that is both **efficient and accessible**. This approach makes it possible to design a mobility system that is more in line with the specific characteristics of the territories, capable of adapting to actual and potential demand and of recognizing and protecting situations of low demand in a targeted manner, as required by the ART regulatory framework. The analyses carried out are therefore a fundamental building block for the construction of a service based on territorial evidence and on principles of equity and effectiveness.

3.3. Transport demand analysis

As mentioned above, the analysis of mobility demand in the metropolitan area of Bologna is a fundamental step in understanding **actual and potential travel needs** and allows the territorial and socio-demographic dimensions previously analyzed to be integrated with direct observation of travel behavior, in order to provide a dynamic and temporally articulated picture of actual mobility.

The survey was structured by examining three months of the year—May, July, and November—chosen to **represent different seasons** and conditions of use of the transport system. For each month, demand was analyzed in two distinct time contexts: average weekday and public holiday, in order to capture both the regularity of systematic mobility and variations related to leisure, tourism, and other non-recurring behaviors.

The observation focused on a set of functional macro-components of demand, reflecting the main types of spatial relationships in the catchment area:

- ***Movements within Bologna***, indicative of intra-municipal urban mobility in the capital;
- ***Movements within other municipalities***, indicative of intra-municipal urban mobility in the rest of the metropolitan area;
- ***Exchanges between Bologna and other municipalities***, i.e., metropolitan flows to and from the capital;
- ***Inter-municipal movements***, between municipalities in the metropolitan area excluding the capital;
- ***Exchanges with the outside***, i.e., flows to and from the metropolitan city of Bologna;
- ***Crossing movements***, with no origin or destination in the basin but which affect it in transit.

For each of these components, the analysis is divided into various levels, including:

- *Reason for travel*, which breaks down the relative weight of the reasons for travel (work, study, other, etc.);
- *Modal split*, which shows the relative weight of the different modes of transport (public transport, private cars, active mobility, other systems);
- *User profiling*, distinguishing between residents, city users (non-residents who gravitate towards the area) and regular users, with recurring behavior for work or study reasons.

The objective of the analysis is twofold: on the one hand, to reconstruct the geography of travel and usage profiles in the metropolitan area; on the other hand, to identify temporal variations and functional differences useful for defining service levels, calibrating timetables, and assessing weak and/or potentially unserved demand.

3.3.1. Seasonality

Firstly, a comparison between the months of May, July, and November highlights the effects of seasonality on transport demand, highlighting variations in travel volumes, modal split, and user profiles.

November

An analysis of the distribution of **journeys by macro-component** over three typical days (weekday, Saturday, and Sunday) reveals a complex but generally stable demand pattern, with absolute values remaining high even at the weekend (Table 5). The highest volume is recorded on weekdays, with over 3.6 million trips, but Saturdays (3.39 million) and Sundays (2.93 million) also show significant levels, confirming that holiday mobility is a structural component of the system.

Component	Weekdays	Saturday	Sunday
Within Bologna	1,043,711	940,141	749,551
Other municipalities	954,130	854,186	684,572
Rest of CM from/to Bologna	461,499	422,683	327,304
Exchange between other municipalities	478,288	443,860	356,257
Exchange with external parties	486,641	495,188	495,448
Crossing	254,821	234,715	320,847
Total	**3,679,090**	**3,390,773**	**2,933,979**

Table 5 Absolute value of journeys within the metropolitan city of Bologna by macro-component and typical day - November 2024 (Source: GO-Mobility analysis)

Among the individual components (Figure 5), journeys within Bologna are predominant on all typical days, with a peak of over 1 million journeys on weekdays, gradually decreasing over the weekend. travel within other municipalities follows a similar pattern, while travel between the rest of the metropolitan area and Bologna is particularly intense on weekdays (around 461,000), falling by around 30% on Sundays. Travel between other municipalities remains stable but decreases at the weekend, while travel to and from outside the metropolitan area is remarkably consistent across the three days, with almost identical values, suggesting a more structural component of mobility or one linked to interprovincial networks.

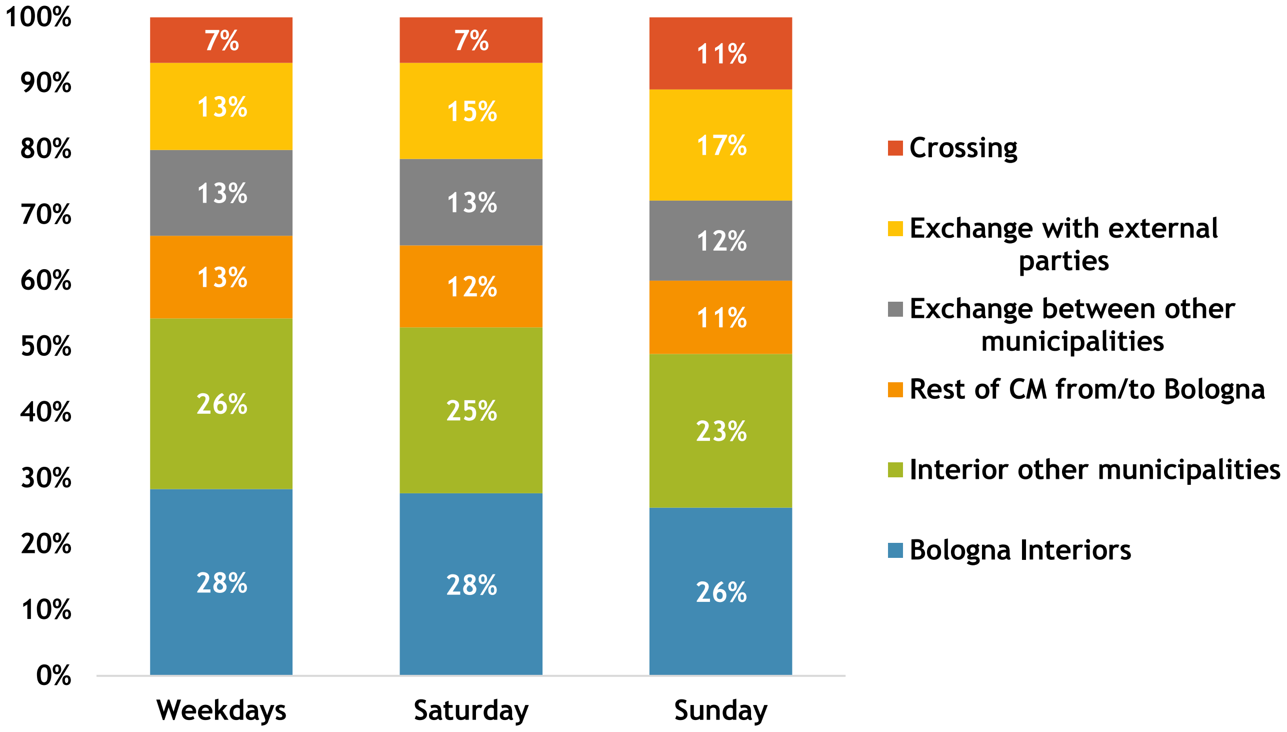

Figure 5 Percentage weight of the various macro-components of travel in the metropolitan city of Bologna per typical day - November 2024 (Source: GO-Mobility analysis)

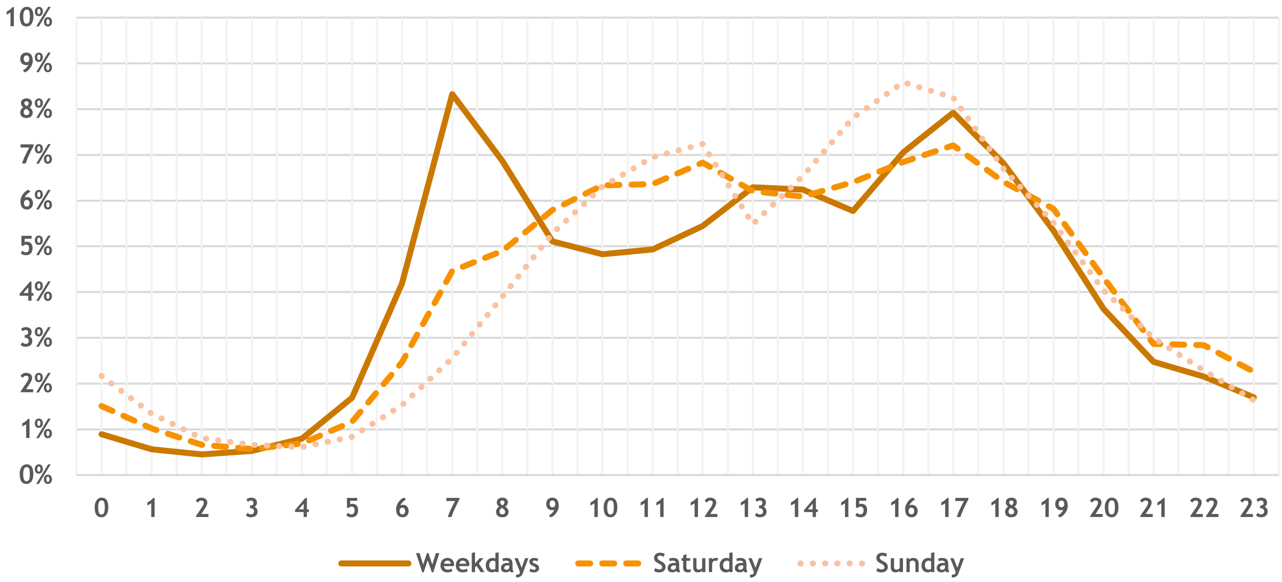

Figure 6 Hourly distribution of trips in the metropolitan city of Bologna on a typical day - November 2024 (Source: GO-Mobility analysis)

An interesting fact concerns the cross-town flow, which peaks on Sundays (over 320,000 trips), exceeding both Saturdays and weekdays. This behavior seems to reflect mobility linked to long-distance flows, tourism, or non-systematic trips that cross the metropolitan area without an internal origin or destination. Overall, **the picture shows broad demand spread throughout the week, with a functional reshaping of the components rather than a net contraction in mobility.**

The analysis of the hourly distribution of trips carried out for the month of November (Figure 6) highlights, however, distinct patterns between weekdays and holidays, with direct implications for the temporal organization of transport services and the calibration of supply.

On weekdays, there are two main peaks: one in the morning between 7:00 and 8:00, typical of systematic mobility linked to work and school, and one in the afternoon between 5:00 and 6:00, which has a peak value slightly lower than in the morning in terms of percentage weight but spread over a wider time slot. This latter aspect suggests diluted pressure on the metropolitan transport system in the second half of the day, consistent with greater heterogeneity in the reasons for and times of return. There is also a small midday peak around 1:00 p.m., mainly attributable to students leaving school and a share of light midday mobility.

At **the weekend**, behavior changes significantly. Saturday and Sunday show a morning peak delayed to around 12:00 and an afternoon peak brought forward to around 16:00 and 17:00. Saturdays are characterized by a more uniform distribution of movements between 9:00 a.m. and 7:00 p.m., with substantial continuity in activities, while Sundays show a marked reduction in mobility around lunchtime, with a sharp drop around 1:00 p.m., indicating a day characterized by more concentrated movements in specific time slots.

May

In May, mobility demand in the metropolitan city of Bologna remained **high and stable throughout the week**. Unlike other seasons, the volume of travel peaked on Saturdays (over 3.6 million) but remained at comparable levels, albeit lower, on weekdays and Sundays, indicating active and distributed mobility, even at weekends. (Table 6 andFigure2). The most significant figure is represented by the *Bologna Internal* component, which records substantially constant volumes between weekdays and Saturdays (over 950,000 trips), with a physiological decline on Sundays, confirming the central role of the capital city in non-work and leisure mobility. A similar pattern can be observed in *the other municipalities* component, with a slight increase on Saturdays and overall stability even on public holidays, reflecting widespread local vitality throughout the area.

Component	Weekdays	Saturday	Sunday
Internal Bologna	952,539	957,686	799,550
Other municipalities	929,559	968,800	827,133
Rest of CM from/to Bologna	428,006	433,545	364,787
Exchange between other municipalities	447,759	464,962	397,292
Exchange with external parties	457,648	527,585	579,865
Crossing	262,077	303,475	385,480
Total	**3,477,588**	**3,656,053**	**3,354,106**

Table 6 Absolute value of journeys within the Metropolitan City of Bologna by macro-component and typical day - May 2024 (Source: GO-Mobility analysis)

The *exchange* components *between municipalities* in the metropolitan area and *between the rest of the metropolitan city and Bologna* show a stable trend, with limited variations between days, but a slight decline on Sundays. More significant is the trend in the *'Exchange with outside'* component, which grows progressively from weekdays to reaching almost 580,000 trips: a clear sign of the metropolitan area's openness to the outside world, especially for non-systematic activities and opportunities to enjoy the area at the weekend.

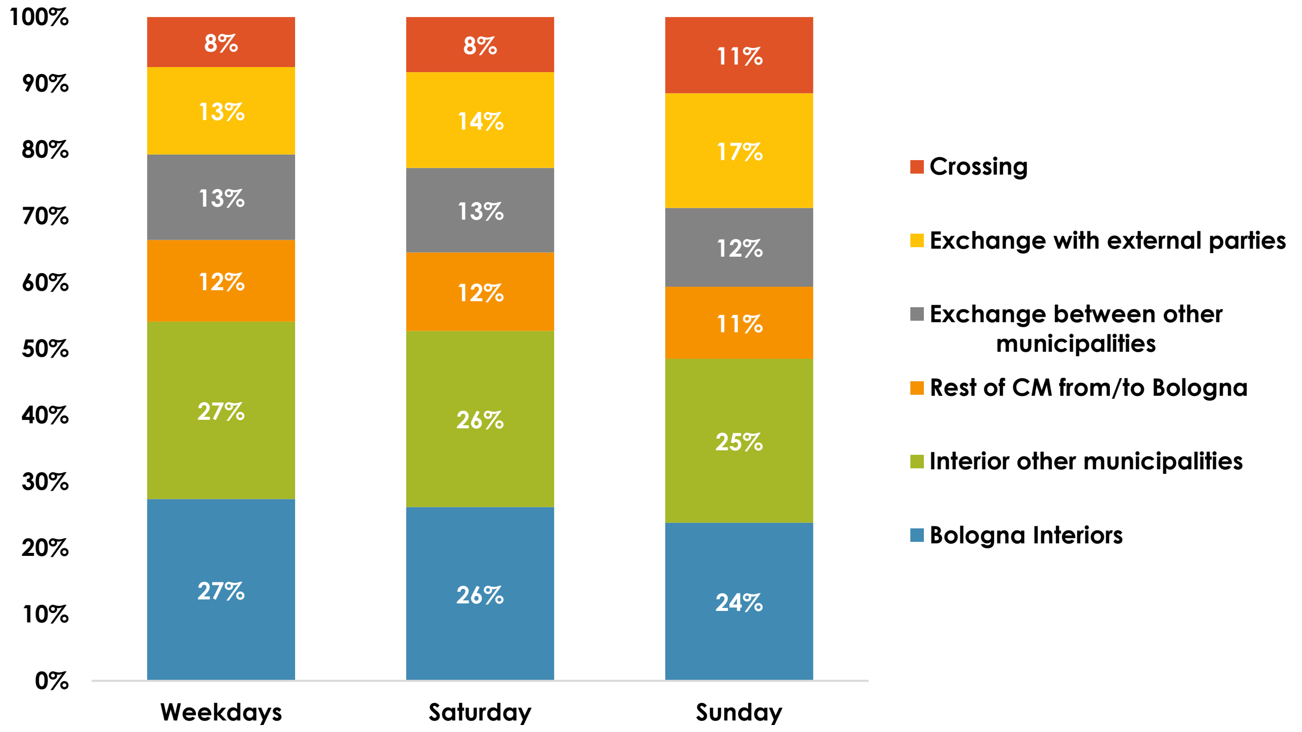

Figure2 Percentage weight of the various macro-components of trips in the metropolitan city of Bologna per typical day - May 2024 (Source: GO-Mobility analysis)

Finally, the crossing component shows a steady increase at the weekend, rising from 262,000 trips on weekdays to over 385,000 on Sundays, indicating heavier transit traffic, probably linked to tourism, leisure, or interregional travel. Overall, therefore, the May data paints a picture of **extensive, continuous, and multifunctional mobility that extends well beyond the traditional boundaries of systematic mobility**.

Furthermore, in May, the hourly distribution of trips (Figure 8) largely confirmed the behavior observed in the autumn period, while highlighting some seasonal differences that reflect the adaptation of mobility patterns to the greater social and climatic liveliness of the spring period.

During **weekdays**, there are two established peaks in systematic mobility: one in the morning between 7:00 and 8:00 a.m. and one in the afternoon between 5:00 and 6:00 p.m., which are entirely comparable to those observed in November. However, there is a more pronounced and longer lunch peak, extending from 1:00 p.m. to 3:00 p.m., indicating greater use of transportation in the middle of the day. This trend can be interpreted as an effect of the greater outdoor and social activity typical of the spring season, which broadens the range of reasons for travel (e.g., extended school trips, recreational activities).

On **Saturdays and Sundays**, the general behavior remains consistent with that observed in November, with a fairly constant distribution of trips on Saturdays and peaks concentrated in the midday and afternoon hours. In particular, there is an increase in the intensity of the Sunday afternoon peak, which is more pronounced than in the fall, consistent with greater mobility for leisure, family activities, or events.

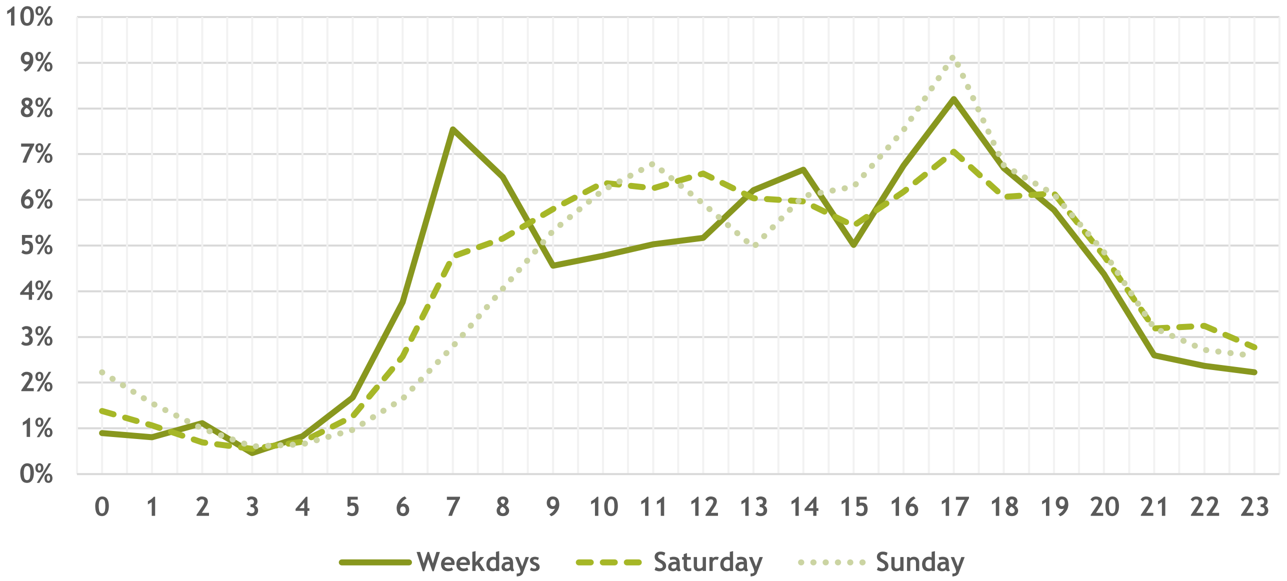

Figure 8 Hourly distribution of trips in the metropolitan city of Bologna by typical day – May 2024 (Source: GO-Mobility analysis)

July

In July, mobility demand in the metropolitan city of Bologna showed a **trend consistent with the summer season, marked by a slight progressive decline from weekdays to weekends**, but with travel levels remaining high: over 3.5 million on weekdays, almost 3.2 million on Saturdays, and 2.8 million on Sundays (Table 7). This confirms that, even in summer, mobility in the metropolitan area remains extensive and varied, albeit with different functions compared to the months when schools and work are in full swing.

Component	Weekdays	Saturday	Sunday
Bologna	1,061,351	851,699	674,837
Other municipalities	671,172	540,649	464,472
Rest of CM from/to Bologna	424,034	328,667	271,534
Exchange between other municipalities	486,412	418,361	357,600
Exchange with external parties	536,960	568,583	549,235
Crossing	352,810	478,110	491,954
Total	**3,532,738**	**3,186,069**	**2,809,632**

Table 7 Absolute value of trips within the Metropolitan City of Bologna by macro-component and typical day - July 2024 (Source: GO-Mobility analysis)

Travel *within the municipality of Bologna* remains in first place in terms of volume on all typical days, but with a marked decrease at weekends, indicating a reduction in systematic mobility and a partial emptying of the capital on public holidays. A similar pattern can be observed for *travel within other municipalities*, which falls significantly at weekends, particularly on Sundays.

The decline is more marked in *the component connecting the rest of the metropolitan city to Bologna*, confirming the predominant role of the city-suburb relationship on working days and its attenuation during the summer weekend. *Travel between municipalities within the metropolitan area* also decreases at week-ends, but to a lesser extent, suggesting a widespread and local share of mobility that remains active even outside the systematic circuits.

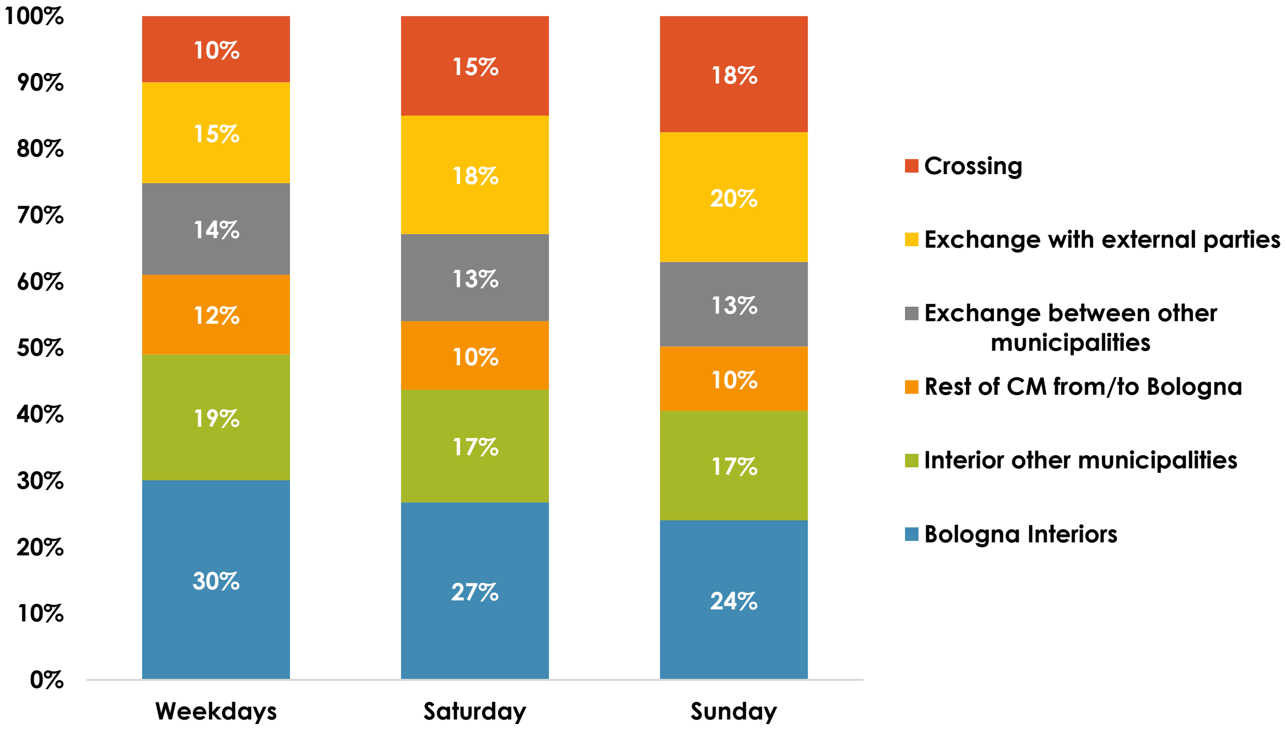

Figure3Percentage weight of the various macro-components of travel in the metropolitan city of Bologna per typical day - July 2024 (Source: GO-Mobility analysis)

The opposite behavior is observed for *exchanges with the outside*, which increase on holidays, reaching their peak on Saturdays. This indicates a mixed component of systematic and non-systematic travel, strongly influenced by extra-metropolitan movements, tourism, or recreational flows affecting the metropolitan area from outside.

Finally, the *transit* component shows a clear reversal of the trend compared to other months: on public holidays, especially Sundays, transit movements through the territory far exceed those on weekdays. These are most likely supra-local or regional flows, linked to holiday mobility or long-distance routes crossing the basin without an internal origin or destination.

Overall, **the macro-components in July show that mobility was less focused on work/school dynamics and more oriented towards non-systematic uses, leisure, and interregional travel**.

From the point of view of hourly trends (Figure4), July shows a significantly different hourly mobility profile compared to the spring and autumn months, reflecting the typical characteristics of the summer season: a reduction in systematic mobility, greater flexibility in schedules, and an increase in travel for recreational or personal reasons. **Weekdays** show a much more spread-out distribution of trips, with less pronounced peaks and a smoother pattern throughout the day. The morning peak is between 7:00 a.m. and 9:00 a.m., but with less pronounced values than in May and November. Between 9:00 a.m. and 3:00 p.m., there is a constant flow with no obvious peaks, partly due to the absence of school travel, which in other months contributes to a lunchtime peak.

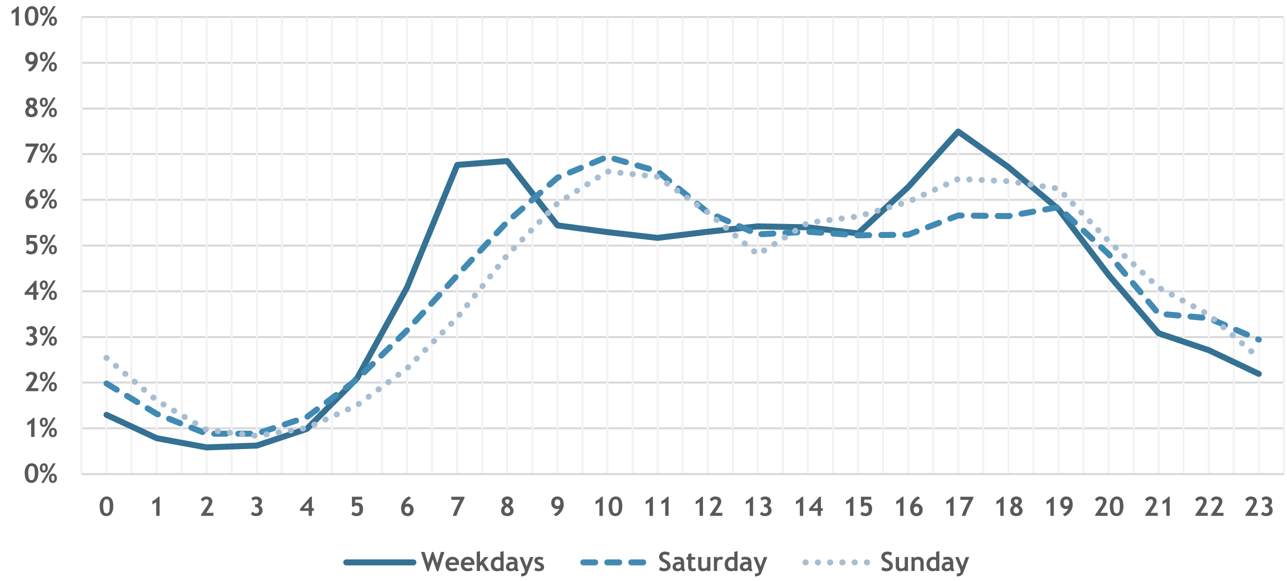

Figure4 Hourly distribution of trips in the metropolitan city of Bologna on a typical day - July 2024 (Source: GO-Mobility analysis)

Overall, the weekday pattern in July is more similar to that of public holidays, suggesting greater coexistence between systematic and occasional mobility. This results in more continuous and widespread pressure on the public transport system, but with demand less concentrated in specific time slots.

Saturdays and Sundays follow the patterns observed in previous months, but with some seasonal differences. The morning peak is brought forward to around 10:00 a.m., while the afternoon peak is more spread out, extending between 5:00 p.m. and 7:00 p.m. There is also a significant amount of evening travel, more pronounced than in May and November, reflecting greater activity in the late afternoon and evening, typical of the summer period.

General considerations

A comparison of the three months analyzed—November, May, and July—shows a **fair degree of consistency in overall levels of mobility demand**, with differences that are more evident in **the functional and temporal structure of demand than in absolute volumes**. Weekdays are the days with the highest number of trips in all months, but Saturdays and Sundays also show consistent values, confirming the structural centrality of holiday mobility in the metropolitan area (seeTable 8).

Seasonality	Weekdays	Saturday	Sunday
November	3,679,090	3,390,773	2,933,979
May	3,477,588	3,656,053	3,354,106
July	3,532,738	3,186,069	2,809,632

Table 8 Comparison between estimated average daily travel figures and seasonality (Source: GO-Mobility analysis)

On a weekday basis, November remains the month with the highest overall volume, exceeding 3.6 million trips, and representing a useful reference point for analyzing systematic trends. May and July are very close to each other, but with different patterns: July shows a higher value in *the Bologna interior* and in *exchanges with the outside*, probably due to greater tourism or transit mobility, while May stands out for a more balanced distribution across all components.

Saturday in May is the day with the highest number of trips among all Saturdays observed, even exceeding the weekday of the same month, a sign of highly active spring mobility, including for recreational and non-systematic reasons. In contrast, July shows lower values on Saturdays, but a clear increase in the components of crossing and exchange with the outside, confirming the importance of interregional mobility or summer transit.

Sunday in May represents the highest value among the three Sundays, with over 3 million trips, distributed across all components, but with a marked increase in trips within municipalities and between municipalities. July, on the other hand, saw a decline in local components and a sharp increase in crossings, which became the second largest component in terms of volume, signaling a change in the function of the catchment area from a local mobility service area to a transit hub for external flows.

From the point of view ***of the analysis of hourly trends for a typical day***, *weekdays* in the three months considered (May, July, November) show a demand structure which, while maintaining some constants linked to systematic mobility, adapts significantly to seasonal conditions:

- ***November***: demand is highly structured and concentrated, with a clear prevalence of work- and study-related travel;
- ***May***: the pattern is similar but with a more pronounced and extended lunchtime peak (1:00–3:00 p.m.), reflecting greater mobility in the middle of the day. This indicates a more diversified demand, which integrates the systematic component with trips related to leisure or social activities;
- ***July***: stands out for its much more diluted and uniform profile. The morning and afternoon peaks are less pronounced and the period between 9:00 a.m. and 3:00 p.m. shows stable but poorly segmented demand, in the absence of school travel. The hourly pattern on weekdays in July is similar to that on public holidays, indicating that seasonality is less tied to standard schedules and more influenced by personal reasons and leisure time.

Behavior on *Saturdays and Sundays* remains fairly consistent across the three months, but with variations in the timing and intensity of peak periods.

- ***November and May***: Saturdays show a regular distribution of movements between 9:00 a.m. and 7:00 p.m., while Sundays show a sharp drop around lunchtime and an afternoon peak between 4:00 p.m. and 5:00 p.m.;
- ***July***: the pattern is similar but with some time shifts: the morning peak is brought forward to around 10:00 a.m., the afternoon peak is more extended between 5:00 p.m. and 7:00 p.m., and there is a significant increase in evening travel, linked to summer leisure activities.

The seasonal comparison therefore suggests that **mobility demand may be homogeneous in absolute terms throughout the year but with varying spatial and temporal characteristics**. Consequently, the public transport system must modulate its service according to the time structure, intensity, and reasons for travel.

An effective service model can benefit from the adoption of a **seasonal and flexible approach**, capable of adapting to different demand patterns. In particular, it may be useful to provide additional services during peak hours on weekdays during the school and work year, greater coverage during the middle and evening hours in the spring and summer, and a reorganization of services on public holidays and during the summer months, taking into account the needs of non- r systematic mobility and the characteristics of areas with low or scattered demand, especially in less urbanized areas.

3.3.2. Average weekday

Analysis of weekdays in the three months observed—May, July, and November—shows an overall **stable** picture **in terms of travel volumes**, with demand remaining at similar levels between seasons. The differences observed in the hourly distribution reflect physiological adjustments in mobility with respect to the seasonal context (e.g., school calendar, weather conditions, recreational activities), but do not substantially alter the overall structure of demand.

In this context, **November** is a **balanced and representative** period, falling outside the seasonal peaks of tourist and school travel. Its position in the middle of the working and school year allows for stable, ordinary, and fully active demand to be observed, with a clear and easily readable hourly structure. This makes it particularly suitable for analyzing dynamics such as *modal split* and the *composition* of travel *users*.

As a month without marked seasonal anomalies, **November is therefore a good operational reference point for analyzing transport demand in the metropolitan area**, useful for comparative assessments to support planning. Overall, on a typical weekday in November, **mobility in the metropolitan city of Bologna is full, regular, and systematic,** offering a representative picture of the ordinary dynamics that animate the area during periods of full school and work activity. The total volume of trips exceeds 3.6 million, the maximum value compared to Saturdays and Sundays, confirming the centrality of weekdays in metropolitan mobility planning.

The main travel routes are attributable to mobility within the territory, both in the municipality of Bologna and in other metropolitan municipalities, with **a distribution that reflects the centripetal force of the capital, but also the liveliness of local centers (Imola in particular)**. Flows between municipalities in the metropolitan area, as well as those to and from Bologna, contribute to shaping **a polycentric network of daily exchanges,** supported by well-established systematic mobility. The external exchange component is also significant, demonstrating that the metropolitan city is strongly integrated into regional flows. The flow of external traffic through the area is more limited on weekdays, but still present, confirming the infrastructural function of the basin as a transit hub.

The **hourly distribution of demand reinforces the image of structured mobility**: the day is marked by two peaks, one in the morning, between 7:00 and 8:00 a.m., triggered by the convergence of school and work, and one in the afternoon, between 5:00 and 6:00 p.m., which is the symmetrical counterpart, where occasional or leisure trips also converge. In addition, the afternoon peak is slightly more diluted, indicating a more fragmented and differentiated return journey.

The middle part of the day maintains a constant and sustained flow with a peak around 1:00 p.m., indicating systematic and significant demand (returns from school). Finally, although the evening hours show a gradual decline, they remain active until 8:00 p.m., suggesting the opportunity to maintain service in the mid-evening hours as well.

This overall profile paints a picture of consistent, predictable, and dense mobility, ideal for conducting in-depth analyses of modal split and profiling. In fact, in the absence of distorting factors related to summer seasonality or holiday periods, November provides a robust basis for evaluating adjustment options and realistically calibrating service levels.

Reason for travel

The **distribution of trips generated from home by reason highlights a functional structure of the metropolitan area that is strongly oriented towards commuting**, especially in inter-municipal and radial flows. Work is the main reason for overall travel (around 30%), but its incidence increases significantly in movements connecting Bologna to the rest of the territory: over 45% of trips to/from the capital are for work purposes, with a maximum value in the flow out of Bologna (54%), indicative of **the presence of production centers and company headquarters in neighboring municipalities.**

On the contrary, for *travel within individual municipalities*, both in Bologna and elsewhere, the reasons are mainly related to daily life and proximity: shopping is the second most common reason for travel (over 28%), with a particularly high proportion in municipalities other than Bologna (over 34%) and also within the capital (30%), indicating widespread and frequent mobility based on short distances and accessible destinations.

Social activities (around 25%), which include visits, leisure, and recreation, also show a homogeneous distribution but are more localized, with a higher incidence of trips within municipalities and less significant inter-municipal flows. These are less structured trips, but they contribute substantially to non-systematic demand, which must be managed with more flexible service models.

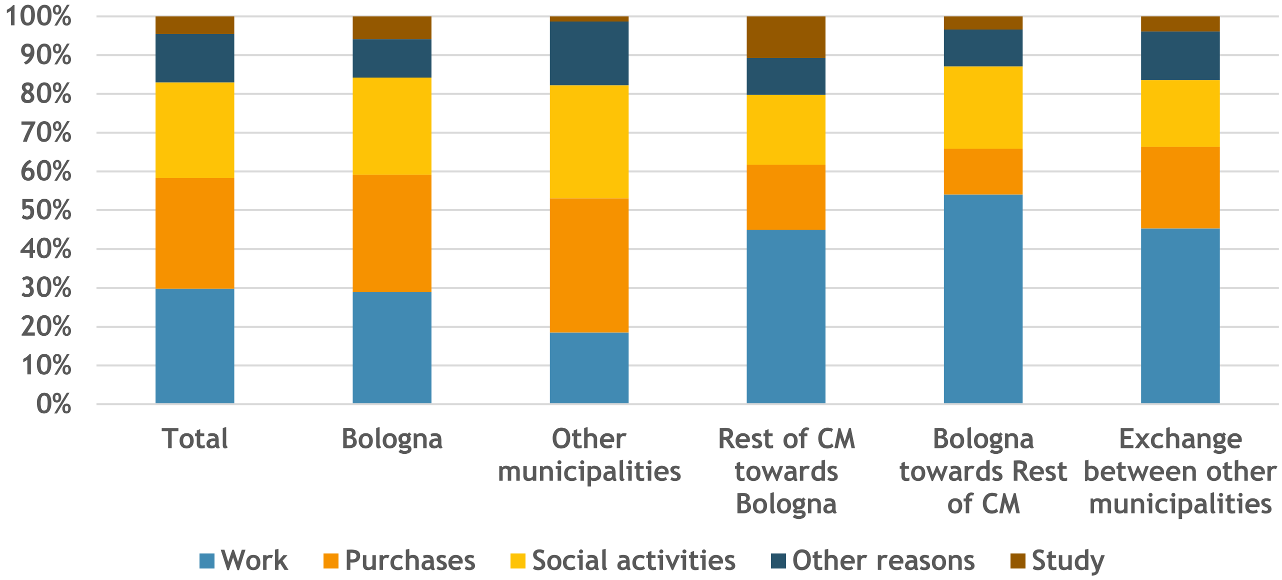

Figure5Percentage weight of reasons for travel in the metropolitan city of Bologna by macro-component on a typical weekday (Source: GO-Mobility analysis of PUMS survey)

The *'other reasons'* category, which includes secondary or occasional reasons, remains around 10–15% in the various components, with a slight increase in journeys within municipalities other than the provincial capital, probably associated with personal or health-related reasons or accompanying others.

Finally, although it accounts for only 4.5% of total trips, the study plays an important role in flows into Bologna (around 11%), consistent with the presence of attractive schools and universities in the metropolitan area.

In summary, the functional picture that emerges highlights a **fairly marked distinction between systematic commuting and local mobility**: in general, inter-municipal and radial flows are driven purely by work and school needs, while journeys within municipalities reflect, to a greater extent, daily, social, and shopping activities.

Modal split

An analysis of ***the modal split of total average weekday travel within the metropolitan city of Bologna*** reveals a highly differentiated picture, reflecting both the urban structure and the availability and accessibility of different modes of transport (Figure 12).

Private vehicles are the most common mode of transport in the metropolitan area, accounting for over 59% of the total, but with significant variations depending on the geographical area. While its use is reduced to 42% for journeys within the municipality of Bologna, in favor of soft mobility and urban public transport, in exchanges between Bologna and the rest of the metropolitan area, the share exceeds 90%, reflecting a strong structural dependence on cars for radial and inter-municipal journeys.

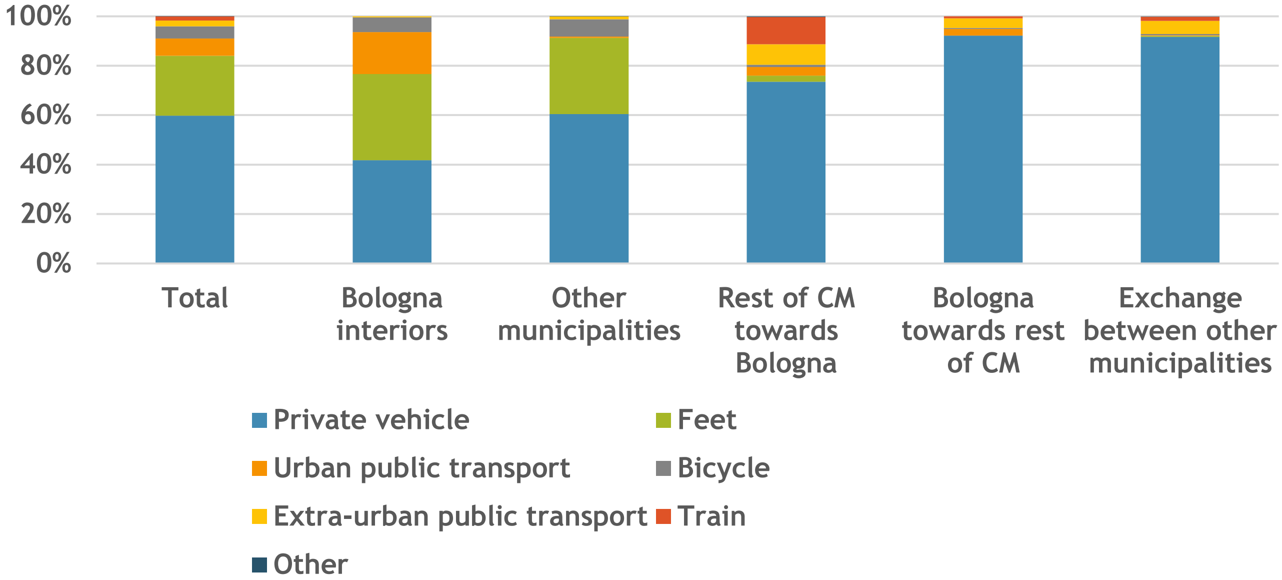

Figure 12 Modal split of trips originating from home by macro-component on an average weekday (Source: GO-Mobility analysis of PUMS survey data)

Local urban public transport is significant only within the municipality of Bologna (17%), with virtually no use in other areas of the territory. This highlights the strong concentration of urban public transport services and their effectiveness in the capital, while suggesting the need for strategies to enhance and integrate services on a metropolitan scale.

Extra-urban public transport is most prevalent on routes into Bologna (just over 8%), where it plays an important role alongside trains, which account for 11% of journeys on the same route. In other contexts, however, its share is significantly lower, highlighting the need to strengthen modal integration in areas outside the capital.

Pedestrian mobility emerges as the second most important mode in terms of incidence (just over 24%), with particularly high values for journeys within urban centers (35% in Bologna and 31% in other municipalities), where short distances and the density of services make walking competitive. However, this mode disappears almost entirely in larger-scale exchanges, where it is impractical.

Cycling, with an average of 5%, achieves interesting shares in journeys within municipalities other than Bologna (7%), indicating room for growth in small and medium-sized contexts, but remains marginal in larger-scale journeys, probably penalized by distances and less favorable infrastructure conditions.

Overall, the picture that emerges is therefore one of a **system with strong modal and geographical polarization, where the capital stands out for its greater balance between modes, while in the rest of the territory, private vehicles remain dominant**.

Furthermore, a clear picture emerges from the ***modal breakdown of trips originating from home*** on an average weekday, showing systematic morning mobility oriented towards public transport, especially in the early hours of the day (Figure 13), with a balance gradually shifting towards car use and active mobility during the rest of the day (Figure 14). **Between 7:00 and 9:00 a.m., public transport (in all its forms) reaches particularly high levels of use:** urban public transport peaks at 8:00 a.m., accounting for 27% of journeys; a similar figure is observed for extra-urban public transport, which meets the demand of commuters from more peripheral municipalities. During this same time slot, trains play a decisive role in medium- and long-distance connections, covering over a third of trips at 8:00 a.m.

This intense concentration of demand makes the early morning hours the peak time for public transport, driven by the need to get to work, school, or university. After 9:00 a.m., the use of public transport gradually decreases, although it remains significant until late morning. In the afternoon and evening, public transport becomes marginal, with low shares and a visible decline in systematic mobility.

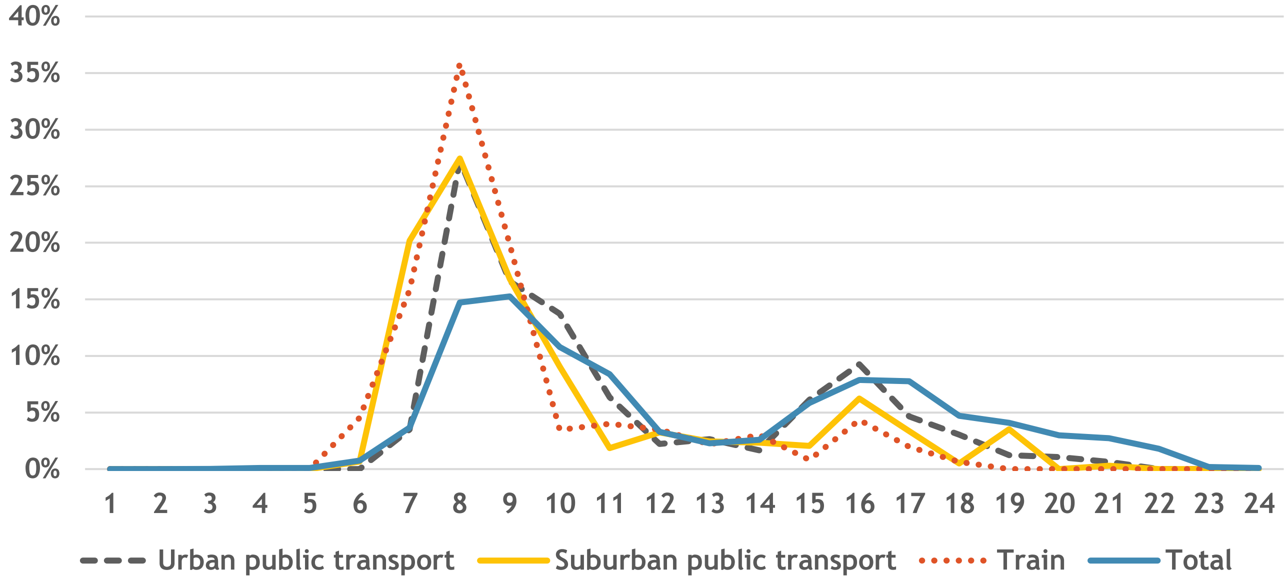

Figure 13 Modal split of public transport journeys originating from home in the metropolitan city of Bologna on an average weekday (Source: GO-Mobility analysis of PUMS survey data)

Private vehicles, on the other hand, maintain a constant presence throughout the day, but are also concentrated between 7:00 a.m. and 9:00 a.m., with peaks of 16% in the same time slots when public transport is most used. This suggests competitive use of cars for commuting, particularly where accessibility conditions or a lack of alternatives make public transport less effective.

Active mobility—represented by walking and cycling—is particularly significant between 8:00 a.m. and 11:00 a.m., especially in urban contexts and over short distances. Pedestrians account for up to 14% of trips at 10:00, while bicycle use is stable between 10% and 16% in the same time slot. This is a time slot when shorter distances and more flexible schedules (such as errands, accompanying others, or working different hours) make light individual vehicles competitive.

Overall, therefore, weekday trips originating from home show a more marked dependence on public transport in the middle of the morning, compared to the return trips observed in the evening, when private vehicle use regains a dominant role.

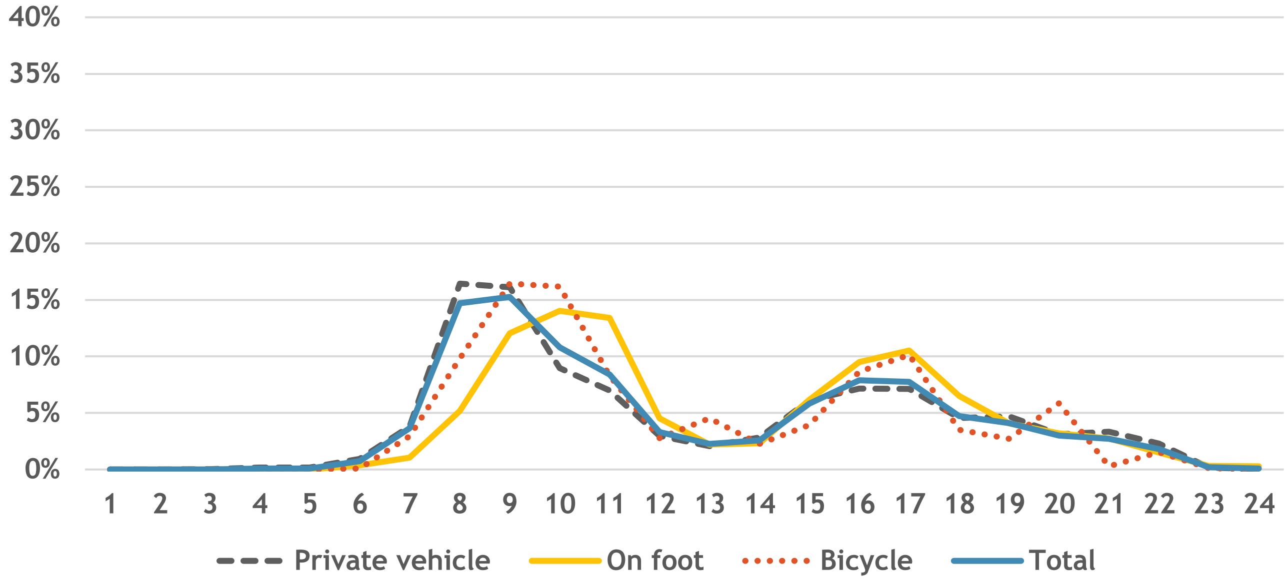

Figure 14 Modal split between private transport and soft mobility for journeys within the metropolitan city of Bologna with destination home on an average weekday (Source: GO-Mobility analysis of PUMS survey data)

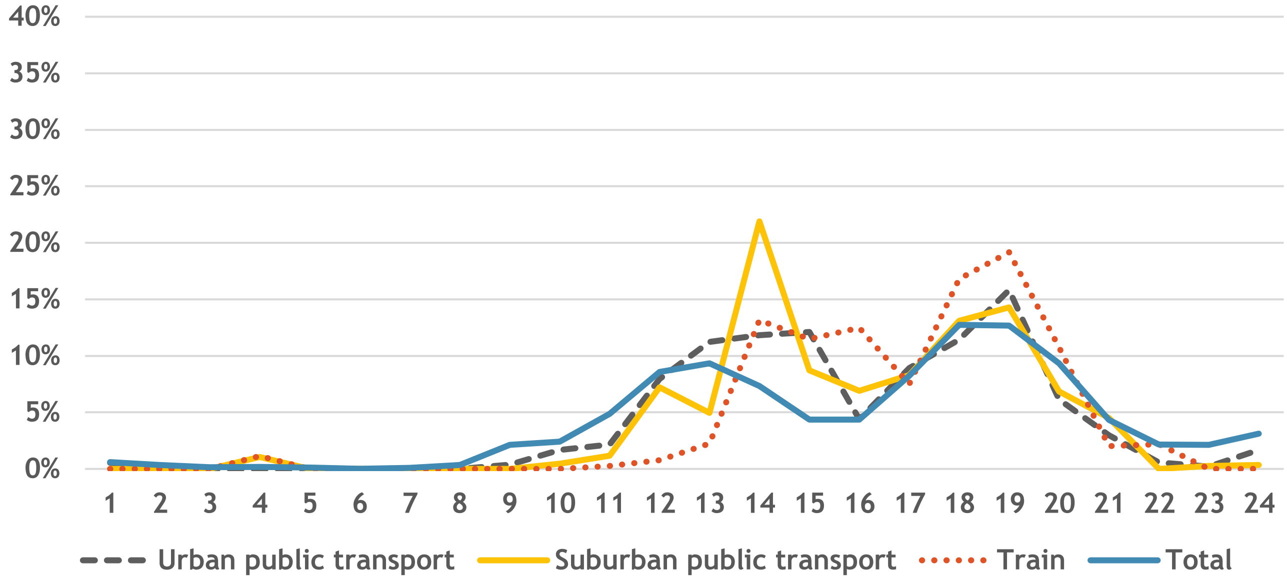

Figure6 Modal split of public transport for journeys in the metropolitan city of Bologna with destination home on an average weekday (Source: GO-Mobility analysis of PUMS survey data)

At the same time, analysis of ***the modal split by time of*** day ***for journeys to home*** on an average weekday reveals a complex pattern that changes significantly throughout the day, both in terms of the most common modes of transport and the territorial function of the journeys. Public transport is busiest in the afternoon between 1:00 p.m. and 4:00 p.m., when urban and suburban public transport and trains record some of the highest percentages of the entire day (Figure6). In particular, **suburban public transport** reaches a peak of 22% around 2:00 p.m., probably linked to school and work returns from medium-long journeys; at the same time, urban public transport shows a significant incidence, especially in the middle of the day, while trains, although less used overall, perform well between 1:00 p.m. and 4:00 p.m., confirming their strategic role in inter-municipal mobility . Outside these times, public transport use for returning home drops significantly, becoming almost non-existent in the evening and morning hours.

In contrast, **private vehicles are distributed more evenly throughout the day**, with evening peaks between 5:00 p.m. and 7:00 p.m., coinciding with the general return from work (Figure 16).

It is also present in the early morning hours, reflecting a proportion of early returns, while **active mobility**, represented by walking and cycling, emerges more clearly in the middle of the day and in the early afternoon, with peaks between 11:00 a.m. and 2:00 p.m. Walking, in particular, reaches 13% in the afternoon, suggesting short journeys in urban or semi-urban areas. Cycling also shows a significant presence in afternoon returns, with percentages close to 15% between 5:00 p.m. and 6:00 p.m.

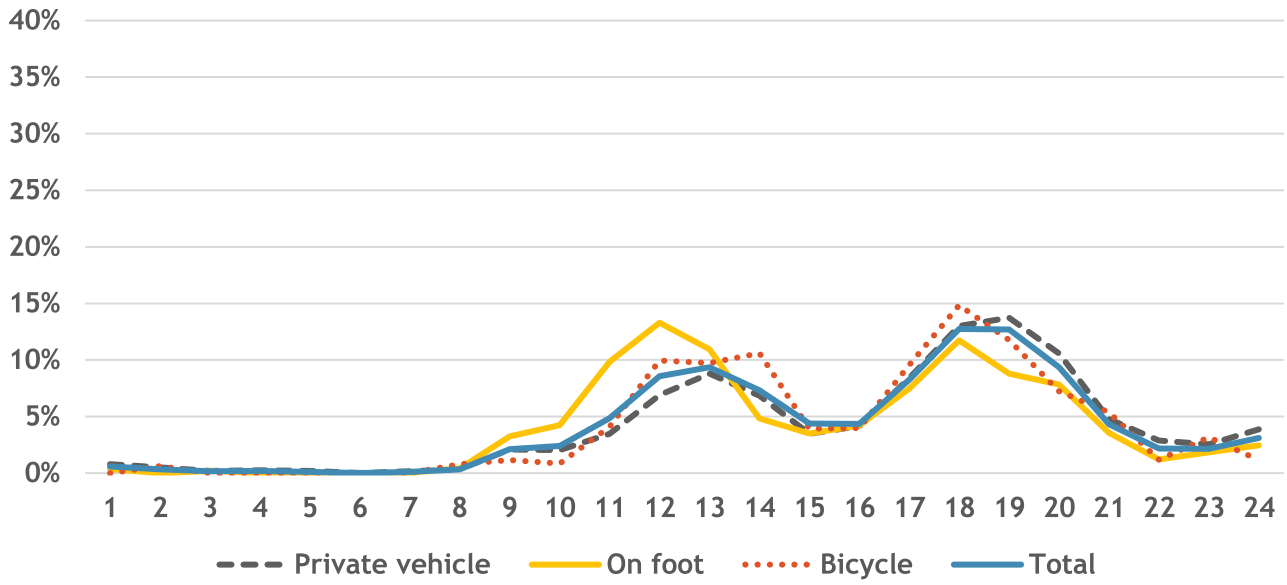

Figure 16 Modal split between private transport and soft mobility for journeys originating from home in the metropolitan city of Bologna on an average weekday (Source: GO-Mobility analysis of PUMS survey data)

Overall, therefore, these data confirm a mobility system that is still heavily reliant on car use for evening returns, with signs of consolidation of public transport and active mobility during peak hours, especially where territorial and infrastructural conditions allow.

User profiling

To better understand the dynamics of mobility demand in the metropolitan city of Bologna, this section analyzes the hourly distribution of trips, distinguishing between ***residents*** and ***city users***. This analysis allows us to identify differences in temporal behavior between those who live permanently in the area and those who access it daily for work, study, or other services. Furthermore, user profiling allows us to further refine the interpretation of actual demand and to tailor public transport solutions more closely to different mobility needs.

Residents (Figure 17) account for about three-quarters of total trips recorded in the metropolitan city of Bologna, confirming their position as the dominant component of mobility demand. Analyzing their **hourly distribution for a typical weekday in November**, we observe behavior that is entirely consistent with the overall trend in demand (as illustrated inFigure 6).

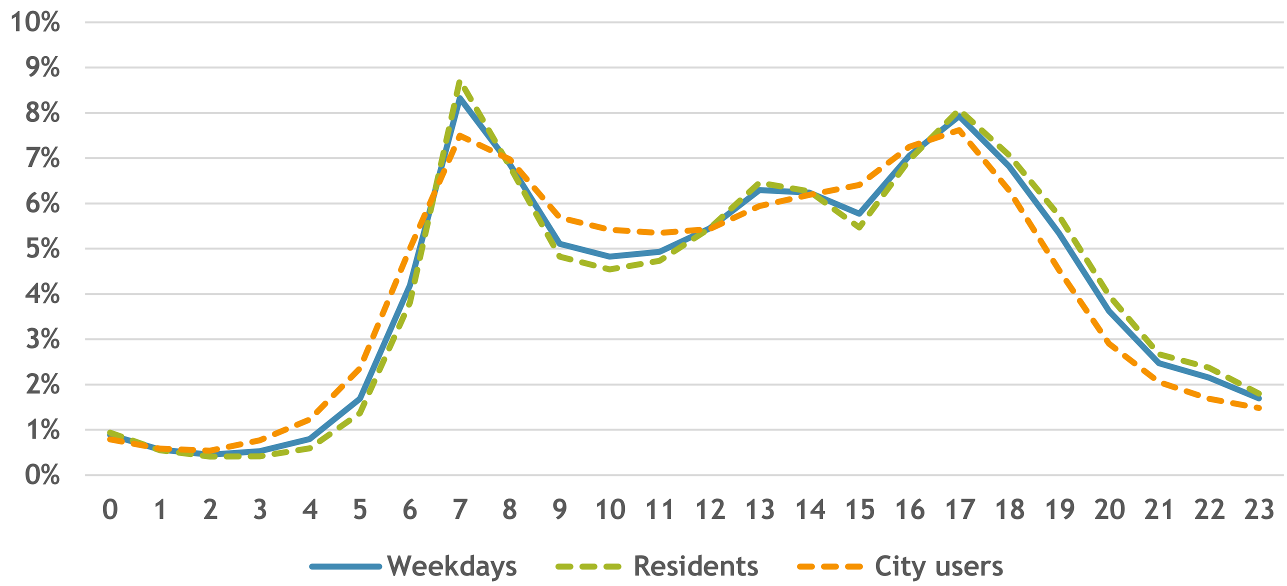

Figure 17 Hourly distribution of trips by residents and city users in the metropolitan city of Bologna by typical day – November 2024 (Source: GO-Mobility analysis)

The morning and afternoon peak times, as well as the stability of travel during the central hours, are almost identical, reflecting the fact that the time choices of the resident population largely shape the hourly structure of the weekday mobility system.

On the other hand, ***city users***, i.e., those who do not reside in the area but travel there for functional reasons, show a slightly different time profile compared to residents, while maintaining a consistent structure in terms of volume. On weekdays, in fact, **behavior is similar to that observed in July,** with a double peak (morning and afternoon) that is symmetrical in terms of both percentage weight and duration, both distributed over several hours, reflecting greater flexibility in arrival and departure times. The middle of the day, between 9:00 a.m. and 3:00 p.m., also shows a steady trend, with sustained levels but no marked peaks, confirming the presence of not only systematic trips but also those related to services, appointments, and personal activities. Overall, therefore, the mobility of city users is more fragmented and less bound to standard schedules than that of residents, but still significant in all time slots.

Systematicity

The analysis of ***systematic trips***, defined as those that **are repeated at least 13 times in November 2024**, allows for a more targeted understanding of the recurring and predictable component of mobility demand, distinguishing it from the more occasional or flexible component. On an average weekday, this systematic component represents a minority of total trips, but with values that vary significantly depending on the macro-territorial component considered (Figure7). Journeys *within the municipality of Bologna* have the highest proportion of systematic journeys (31%), reflecting the presence of structured daily demand linked purely to homework or home-school journeys in urban areas. This figure reflects the density of services and the concentration of central functions in the capital, which attract recurring and regular mobility even over short distances.

Moving down the territorial scale, the share of systematic trips decreases in exchange flows: both *towards the interior* of the metropolitan area (around 20%) and *towards the exterior* (around 19%), the systematic component remains less than one-fifth of the total, leaving room for more irregular mobility, consisting of occasional, flexible, or infrequent trips. This suggests that inter-municipal and inter-regional mobility, although intense in absolute terms, is less anchored to daily routines and more sensitive to non-systematic motivations such as services, errands, events, or non-recurring personal needs.

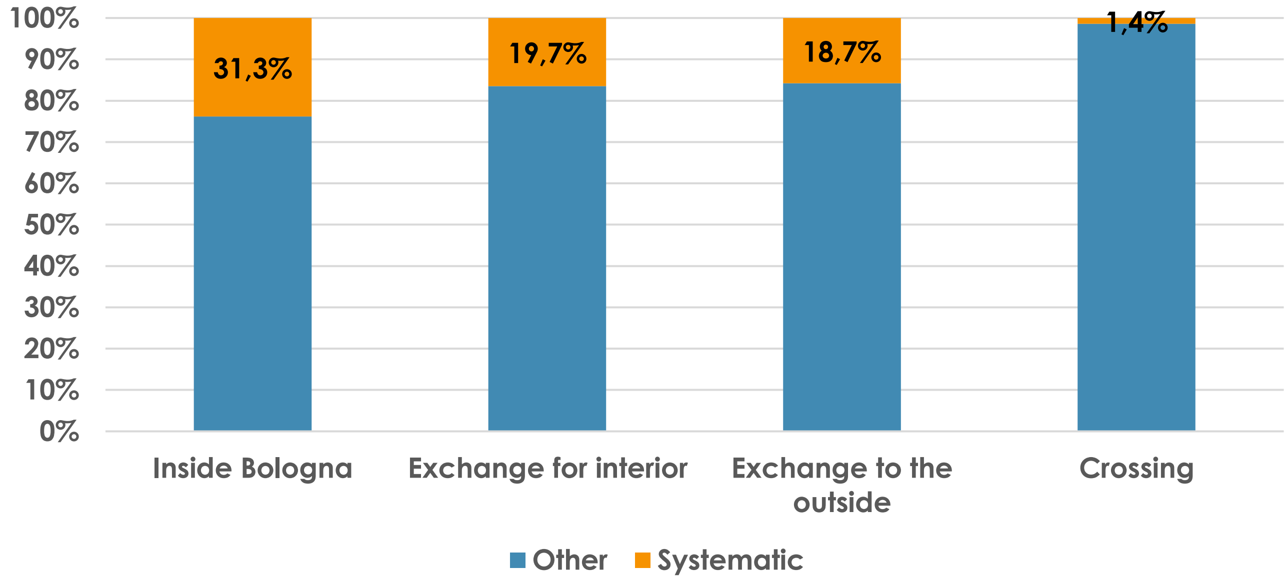

Figure7 Percentage weight of systematic trips in the metropolitan city of Bologna by macro-component on a typical weekday - November 2024 (Source: GO-Mobility analysis)

Finally, the component of *travel* across the metropolitan area remains almost entirely non-systematic, accounting for just 1.4%, indicating that transit traffic is likely to be highly episodic or occasional, linked to long-distance flows, tourism, or passing traffic that does not directly involve the area as its origin or destination.

Overall, therefore, the data confirms that **systematic demand is concentrated mainly within the capital**, while irregular mobility patterns prevail in other areas, requiring more flexible and adaptable planning approaches over time.

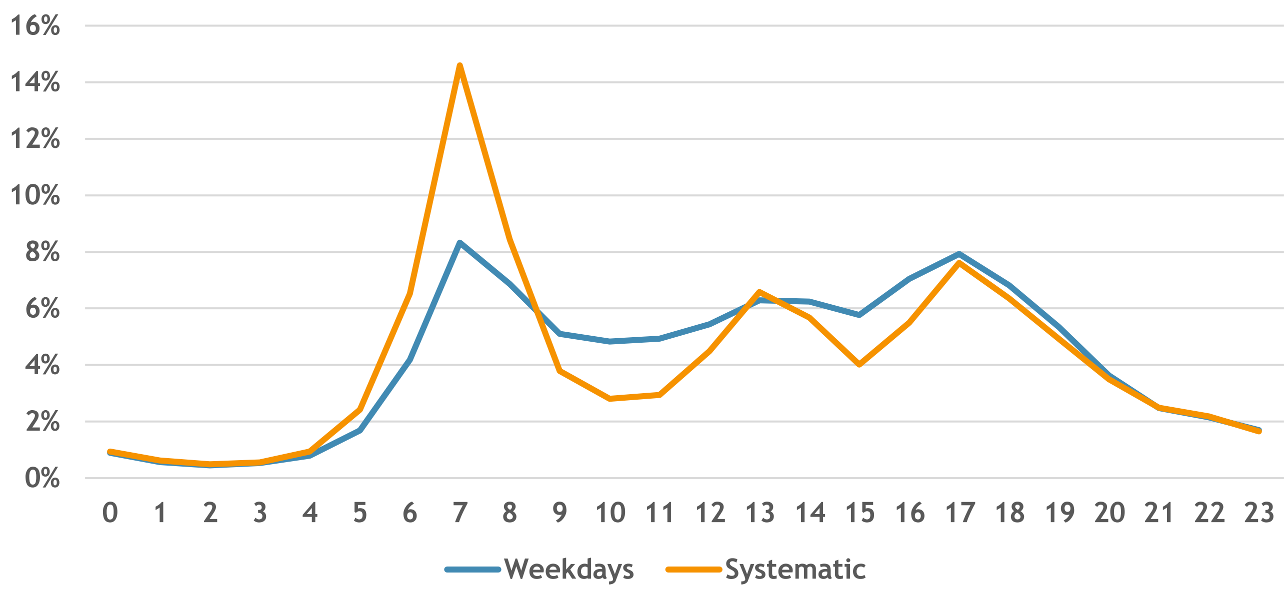

Figure 19 Hourly distribution of systematic trips in the metropolitan city of Bologna on a typical weekday - November 2024 (Source: GO-Mobility analysis)

As regards the comparison between the ***hourly distribution of systematic trips and that of total weekday trips***, there are some structural differences that help to distinguish more precisely the behavior of the different components of demand (Figure 19). Although following a similar general pattern, **systematic** trips **show a more concentrated profile in the standard time slots, consistent with working and school hours**.

The most pronounced peak is in fact recorded at 7:00 a.m., when systematic trips account for 15% of the systematic total, compared to 8% of the total on weekdays. The 6:00–8:00 a.m. slot is also busier overall, with higher-than-average percentages, indicating greater punctuality and regularity in the behavior of this specific user group. Immediately afterwards, between 8:00 and 9:00, the two curves tend to overlap, indicating that the bulk of systematic demand has already been activated, while the rest of the population moves in a more distributed manner.

Starting at 10:00 a.m., systematic trips drop more sharply than the total, indicating that mobility linked to occasional or flexible reasons becomes predominant in the middle of the day. The same phenomenon can also be observed in the early afternoon, where the systematic curve is flatter, with values between 3% and 5%, while the total curve remains higher and more stable until 5:00 p.m.

The afternoon and evening hours (5:00 p.m.–8:00 p.m.) see an alignment between the two profiles, with identical values at the afternoon peak (5:00 p.m., 8%) and a gradual evening decline common to both curves. This indicates that even among regular trips, there is a second wave of returns, although less concentrated than in the morning. Overall, therefore, **systematic trips are characterized by greater intensity in the early hours of the day,** reduced presence in the middle of the day, and significant but more diluted participation in the late afternoon.

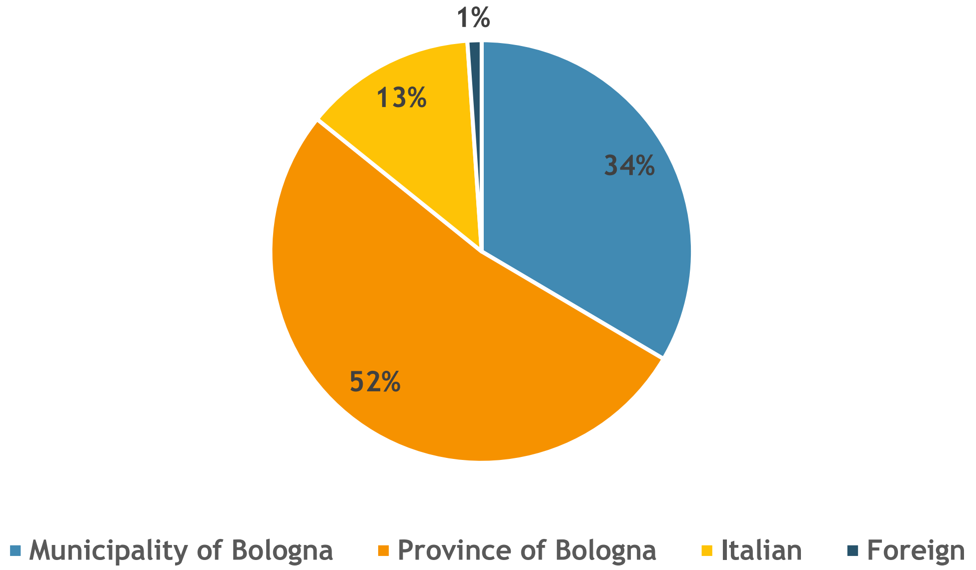

Figure 20 Percentage weight of the user profile of systematic trips in the metropolitan city of Bologna on a typical weekday – November 2024 (Source: GO-Mobility analysis)

Finally, analysis of ***the composition of systematic trips by user type*** (Figure 20) highlights **the central role of metropolitan residents**, who together generate 85% of this type of mobility. In particular, more than half of systematic trips (52%) are generated by residents in the municipalities of the Province of Bologna, a sign of strong inter-municipal and radial commuting that crosses the metropolitan area on a daily basis. The municipality of Bologna also contributes significantly, with 33% of the total, confirming its importance as a point of origin (and not only of attraction) for recurring flows related to work, study, and services.

The contribution of city users, i.e., those who do not reside in the metropolitan city but access it systematically, **is** significantly **lower**: only 13% of systematic trips are attributable to non-resident Italian users, while foreigners account for just 1%. These figures confirm that systematic demand for mobility is mainly internal to the metropolitan area and that service planning strategies, particularly on weekdays and at peak times, must take into account the central role of the resident population in shaping daily mobility. At the same time, the small proportion of regular users among external users suggests that mobility from outside the area is less regular and more oriented towards occasional use, which requires flexible tools that are less constrained by high-frequency logic.

Mobility to/from Bologna

Mobility to and from the municipality of Bologna **highlights a functional centrality consistent with the demographic weight of the capital**: journeys within Bologna account for just over a quarter of the metropolitan total (28%), a figure slightly lower than the percentage weight of the resident population, confirming that the capital accounts for a significant part of the demand for mobility.

Traffic between the capital and the rest of the country amounts to approximately 95,000 trips per day in each direction, covering a total of approximately 40% of total traffic between the entire metropolitan area and the outside (i.e., trips into and out of the metropolitan city). This is a significant share, confirming the intense, two-way relationship between the city and the rest of the country, which is distributed evenly throughout the average working day.

Looking at the overall weight of exchanges, a particularly significant figure emerges: exchanges between Bologna and the rest of the metropolitan city (approximately 470,000 trips) are equivalent in magnitude to all other exchanges between municipalities in the metropolitan area, demonstrating the central role of the capital in the territorial system. In this sense, Bologna is at the center of a network of strong relationships that extend outward and balance its attractive and distributive roles. It is also interesting to note that 320,000 of these exchanges take place with municipalities in the first belt, confirming the role of urban proximity of these territories and their daily integration with the city.

Finally, it is worth noting that internal movements within Bologna are more than double those with the rest of the metropolitan area, confirming that the city generates and absorbs very dense and autonomous internal mobility, as well as interacting steadily with the hinterland. This balance between internal and relational mobility reinforces the idea of Bologna as a compact but connected urban center, capable of supporting a dual function: serving its resident population and structuring metropolitan-scale relationships.

After analyzing the structure of exchanges between Bologna and the rest of the metropolitan city, it is useful to focus on an equally significant component, namely the **overall "through" demand for Bologna**. These are journeys that, although they do not originate or terminate in the capital, pass through it to connect areas and municipalities in the inner belt located on opposite sides of the urban center.

This component was estimated by considering the journeys involving the five PUMS survey areas adjacent to Bologna (*N internal, NE internal, NW internal, W internal, SE internal*), which include 11 municipalities in the first belt, including **Casalecchio di Reno, Castenaso, Zola Predosa, San Lazzaro di Savena, Anzola dell'Emilia**, and others. The connections considered are not tangential but involve crossing the municipal territory of Bologna, often in the absence of alternative routes.

On an average weekday, this type of mobility can be quantified at approximately 9,000 trips, out of a total of 320,000 exchanges involving Bologna, which is a numerically limited figure (less than 3%) but should not be underestimated in terms of infrastructure pressure, as it generates through traffic that is not destined for the capital, which can have an impact on congestion and vehicle load, especially during peak hours.

In particular, the highest intensity of these movements is concentrated along the axis between the inner north (municipalities of Castel Maggiore and Granarolo dell'Emilia) and the inner southeast/inner west (municipalities of Casalecchio di Reno, San Lazzaro di Savena, Sasso Marconi, Pianoro, and others), confirming the presence of radial routes crossing the provincial capital.

This 'transit' mobility represents a form of potential demand that is often poorly served by public transport and difficult to capture by traditional policies. Its relatively marginal weight in the total does not reduce its interest but, on the contrary, offers a useful starting point for reflecting on the central role of Bologna in metropolitan flows and on possible strategies for improving connectivity between municipalities in the belt. A more in-depth analysis of these movements could help to evaluate infrastructure or service solutions that can better support inter-municipal demand, reducing the indirect burden on the city and promoting a more balanced distribution of flows across the metropolitan area.

Mobility to/from neighboring provinces

Mobility exchanges between the metropolitan city of Bologna and the province of Ferrara amount to approximately 80,000 trips on an average weekday, a figure which, although significant in absolute terms, represents **only about one-sixth of the total number of trips to and from outside the Bologna basin**. This figure places Ferrara among the neighboring territories least involved in structured mobility with Bologna, especially when compared with flows generated towards other regional or interprovincial centers (especially the Province of Modena).

A second factor reinforces this interpretation: about half of the trips are limited to nearby destinations, mainly between municipalities located along the border, such as Pieve di Cento and Molinella. These are therefore largely short-range trips, likely linked to local and daily reasons, which do not indicate a systemic relationship between the two territories as a whole.

Overall, these elements suggest that the relationship between Bologna and Ferrara is more one of administrative contiguity than of an integrated functional area: the low volumes, the local nature of trade, and the absence of significant flows towards the major centers of Ferrara confirm a weak structural interconnection between the two basins, limited to territorial margins and not to extensive commuting or economic complementarity.

At the same time, trade with the province of Ravenna amounts to around 70,000 movements on an average weekday, a figure similar to that of Ferrara (around one sixth of total trade to/from outside the area), but which is distinguished by greater intensity along the administrative border and the centrality of local centers. In particular, the strongest links involve the municipalities of Conselice, Lugo, Massa Lombarda, and Castel Bolognese on the Ravenna side, connected to Imola and Castel San Pietro on the Bologna side.

Even more significant is the situation in the province of Modena, with approximately 120,000 trips per day, equivalent to a quarter of total external trade. In this case, there is strong urban and functional continuity along the western border of the metropolitan city. The most intense relations are concentrated in the area between Castelfranco Emilia and Crevalcore, San Giovanni in Persiceto, and Valsamoggia. These are areas with strong infrastructural and productive integration, reflecting structured economic and residential links, in some ways comparable to those within the Bologna basin.

3.3.3. Event days

In order to assess the impact of mobility induced by exceptional events on the metropolitan area, a comparison was made between the hourly distribution of journeys on average days and that observed during two types of event: a concert at the Unipol Arena in Casalecchio di Reno and a football match at the Renato Dall'Ara stadium. This analysis **makes it possible to understand whether and to what extent such events affect the daily dynamics of mobility demand,** altering their temporal structure or introducing peaks and abnormal concentrations in flows.

Concert

This section compares ***the trips generated and attracted*** on an average weekday in May with those on weekdays when a concert was held at the Unipol Arena (Wednesday 15, Thursday 16, and Friday 24 May) to assess the impact of this type of event. As can be seen fromTable 9 , with reference only to the area affected by the event, there was an increase in attracted demand.

	Weekday May	Concert	Δ	Δ
Generated to-wards Bologna	1	21,510	+5,649	+35
Generated to all	45,763	66,252	+20,489	+44.8
Attracted by Bologna	16,310	23,105	+6,795	+41.7
Attracted by all	45,473	69,395	+23,922	+52.6

Table 9 Comparison of travel in the concert area, Unipol Arena (Source: GO-Mobility analysis)

The analysis of ***the hourly distribution of journeys between Bologna and Casalecchio di Reno*** is shown below. The differences are more evident **in the early evening and evening**, but with distinct dynamics.

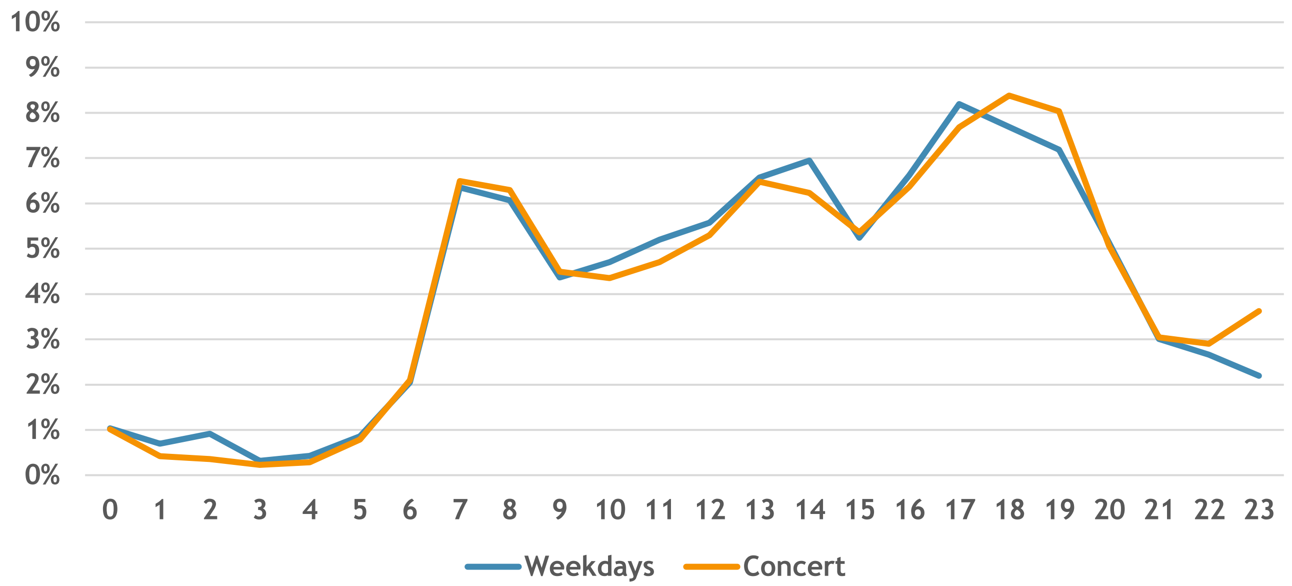

Figure 21 Hourly distribution of journeys between Bologna and Casalecchio di Reno on a typical weekday and on a weekday when there is a concert at the Unipol Arena - May 2024 (Source: GO-Mobility analysis)

In the hours leading up to the event, between **5:00** p.m**. and 8:00 p.m.**, travel volumes remain **in line with those of an average weekday, albeit slightly delayed**: this suggests that **the influx to the concert is distributed smoothly**, probably diluted and partially absorbed by the flows already present linked to commuters returning home. The fact that no abnormal peaks are detected at this stage indicates **that the regular transport system is able to absorb the audience well,** with no noticeable effects on overall pressure.

However, the main difference is observed in **the evening after the event**: at **11:00 p.m.**, travel increases from **2% of the average weekday to 4% on concert days**, marking an **increase in outbound traffic** between the two municipalities. This effect can be attributed to **the departure of concert attendees**, which is concentrated at the end of the event. Although numerically limited, this difference represents a **localized**

and recognizable pressure, which **only** manifests itself **after the event has ended,** without altering the overall demand profile.

Overall, the analysis shows that events such as concerts at the Unipol Arena **do not interfere with pre-existing mobility in the two-way flows between Bologna and Casalecchio** but introduce **a well-defined additional evening share** (from 60,000 to 80,000, equal to a 30% increase), which can be managed with targeted interventions focused on the outflow phases.

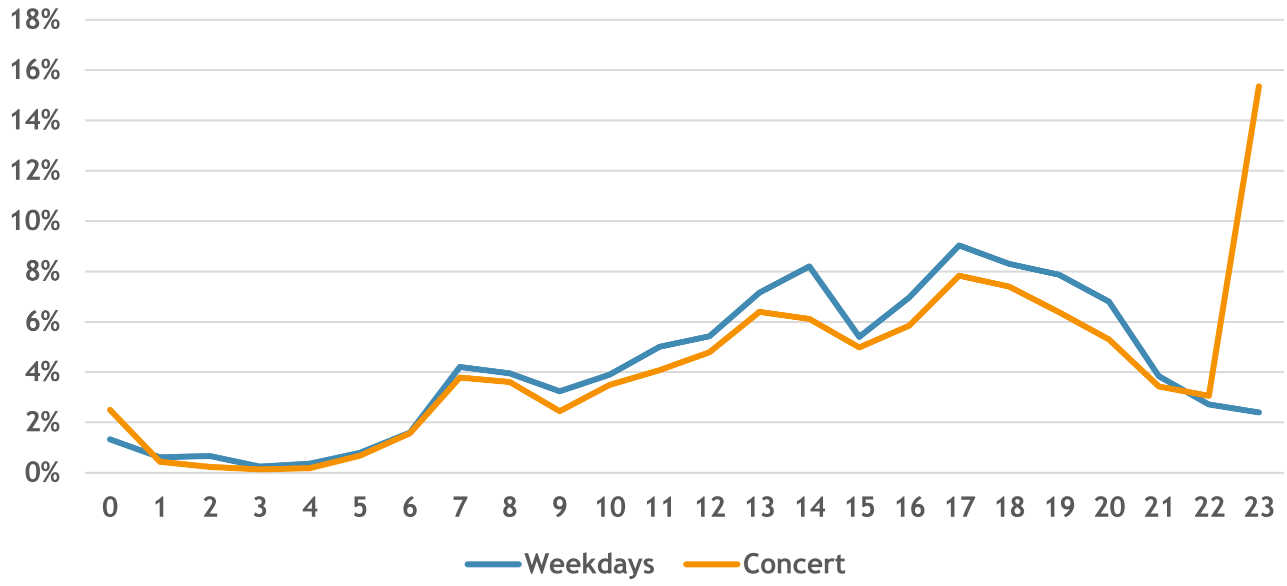

Figure 22 Hourly distribution of total trips originating from the Unipol Arena area on a typical weekday and on a weekday when there is an event at the stadium - November 2024 (Source: GO-Mobility analysis)

In this regard, analysis of ***total movements originating from the Unipol Arena area alone*** clearly highlights the localized impact generated by evening events, such as the concerts on May 15, 16, and 24. A comparison between concert days and an average weekday shows a net increase in mobility volumes, with an estimated increase over the course of the day equal to 60% of journeys to and from the entire country. This data confirms that the event not only attracts an additional audience but also generates a marked change in the hourly distribution of journeys.

Until 8:00 p.m., the travel curve remains almost superimposed on that of a weekday, with minimal differences, indicating that the neighborhood's ordinary mobility is not particularly altered during the day. However, starting at 9:00 p.m., the distribution begins to diverge, and at 11:00 p.m., the most evident data is recorded: trips rise from 2% to 15% of the daily total. This evening peak clearly represents the post-concert outflow, which is much more concentrated than that observed in the stadium area for sporting events.

This localized and highly time-dependent pressure demonstrates the polarizing effect of the event, as the return journey is concentrated, placing particular strain on road infrastructure and exit points in the late evening.

At the same time, the hourly profile of ***total inbound travel to the Unipol Arena area*** on concert days shows a significantly different pattern compared to the average weekday from late afternoon onwards (Figure 22), with a **concentrated but progressive influx effect**, clearly distinct from ordinary mobility. During the day, until 4:00 p.m., the distribution of arrivals remains largely in line with that typical of a weekday, with a slight decline in the middle of the day, suggesting a lower percentage of routine activities (work, school) on event days.

However, starting at 5:00 p.m., there was a clear and progressive increase in movement toward the concert area: the percentage of arrivals rose to 10% between 5:00 p.m. and 7:00 p.m., reaching a peak of 12% at 6:00 p.m., compared to 7% at the same time on an average weekday. This trend indicates a continuous and distributed influx that intensifies progressively in the hours immediately preceding the start of the event, without generating sudden peaks. After 8:00 p.m., the curve returns to standard levels, indicating that the audience has now entered the venue and that pressure on the access network has already peaked.

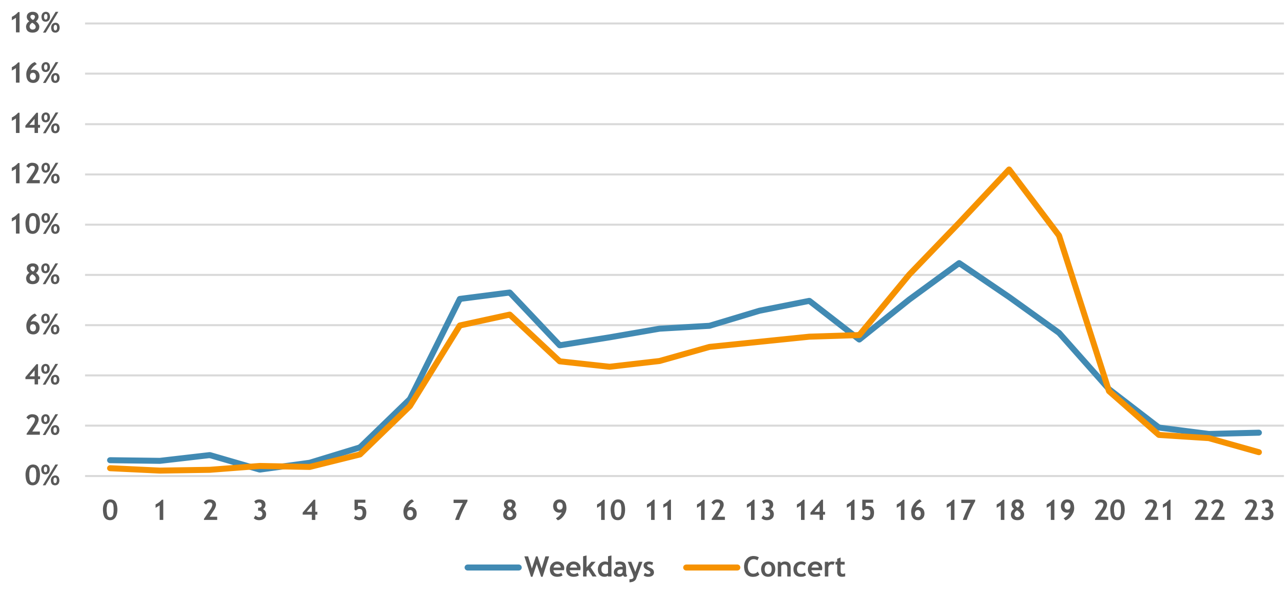

Figure8Hourly distribution of total movements to the Unipol Arena area on a typical weekday and on a weekday when an event is taking place at the stadium - November 2024 (Source: GO-Mobility analysis)

Overall, therefore, the Unipol Arena area shows a good capacity to absorb the mobility induced by concerts, with an orderly but concentrated influx between 5:00 p.m. and 7:00 p.m. and more pronounced pressure during the evening outflow, when flows significantly exceed the norm. The estimated increase in travel **confirms the significance of the impact on the area, without compromising its resilience.** These factors suggest that operational planning should be strengthened, particularly in the pre- and post-event periods, through the introduction of targeted measures on traffic and public transport to ensure efficient absorption of temporary peaks.

Stadium

This section compares a standard weekday in November with a match day to assess the impact of the latter on ***the overall travel generated and attracted*** to the area where the Renato Dall'Ara stadium is located.

	Weekday in November	Match	Δ	Δ
Generated towards Bologna	81,247	88,458	+7,211	+8
Generated to all destinations	132,955	146,674	+13,719	+10.3
Attracted from Bologna	80,687	91,409	+10,722	+13.3
Attracted by all	132,789	153,195	+20,406	+15.4

Table5Comparison of travel in the stadium area, Renato Dall'Ara (Source: GO-Mobility analysis)

A comparison between travel within the municipality of Bologna on an average weekday and on the day of the match (Tuesday, November 5, at 9:00 p.m.) confirms an **almost total overlap in the hourly profile**, with variations that do not alter the general structure of demand. The two curves develop regularly, reflecting the daily urban mobility patterns dictated by work and school schedules.

The main peaks – in the morning between 8:00 a.m. and 9:00 a.m. and in the afternoon between 5:00 p.m. and 7:00 p.m. – occur on both days, with very similar values. The only significant deviation is recorded at 5:00 p.m. and 7:00 p.m., when a slight increase in travel (up to 8%) is observed on match days, likely linked to the approaching sporting event and local travel by those going to the stadium or benefiting from it (e.g., traffic, services, commercial activities).

Even in the evening (from 8:00 p.m. onwards), the 'stadium' curve remains substantially in line with the weekday curve, with a slight increase at 8:00 p.m. and 11:00 p.m., probably due to the post-match exodus. However, there are no off-scale peaks or concentrations that alter the ordinary curve: the urban system absorbs the event flows without any particular discontinuity.

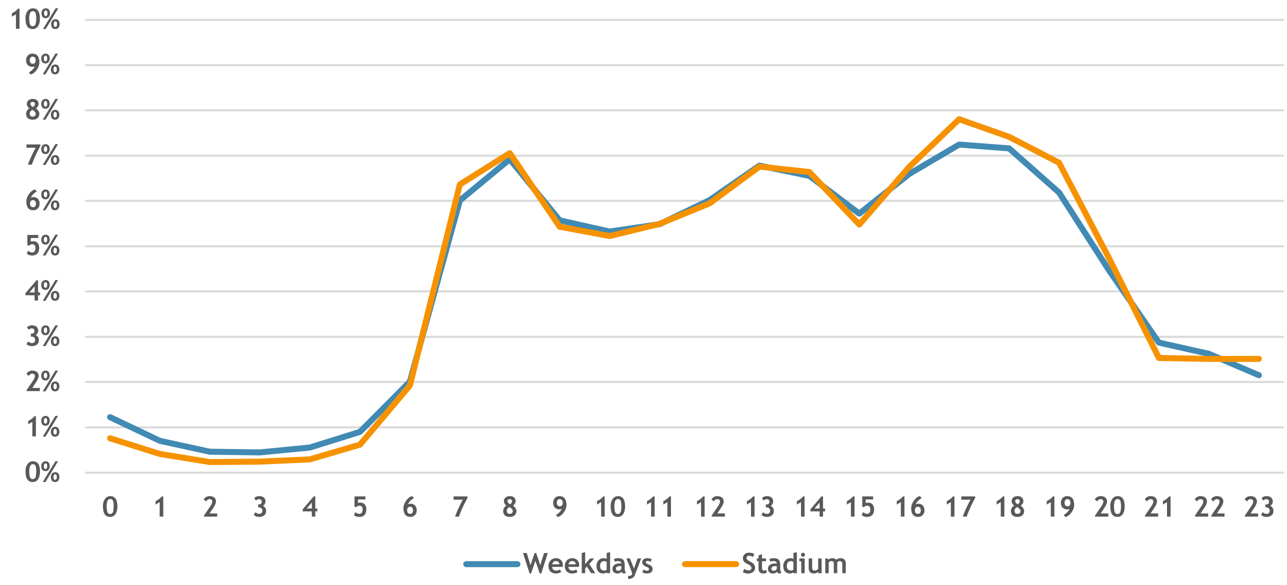

Figure9Hourly distribution of internal movements in Bologna on a typical weekday and on a weekday with an event at the stadium - November 2024 (Source: GO-Mobility analysis)

Focusing **solely on total outbound movements from the Renato Dall'Ara stadium area**, a clear and localized effect linked to the sporting event emerges, especially in the evening (Figure 25). Until 9:00 p.m., the travel curve on match days follows a pattern very similar to that of an average weekday, with minimal deviations reflecting normal neighborhood, school, and work mobility. However, starting at 10:00 p.m., the first signs of a discrepancy appear: the share of outbound travel rises from 2% on weekdays to 4% on match days.

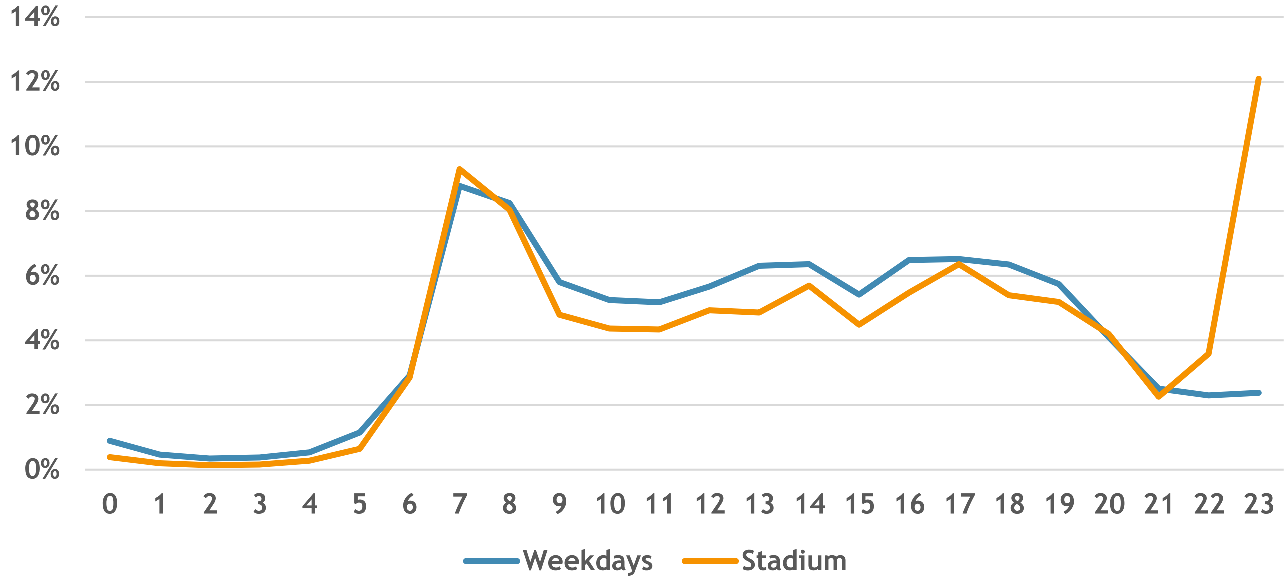

Figure 25 Hourly distribution of total trips originating from the Renato Dall'Ara stadium area on a typical weekday and on a weekday when there is an event at the stadium - November 2024 (Source: GO-Mobility analysis)

However, the most significant data emerges in the 11:00 p.m.-midnight time slot, where the curve for the day of the match reaches a peak of 12%, compared to 2% on an average weekday. This increase is unequivocally attributable to post-match traffic, which concentrates a significant portion of mobility demand in a limited time frame, when the neighborhood normally experiences low traffic intensity.

This is clear evidence of the pressure exerted by the event on the local system, which requires attention not only during the influx phases but also (and above all) in the management of the evening outflow, when the effect on accessibility, the road network, and any public transport services can be more critical for coexistence with ordinary mobility.

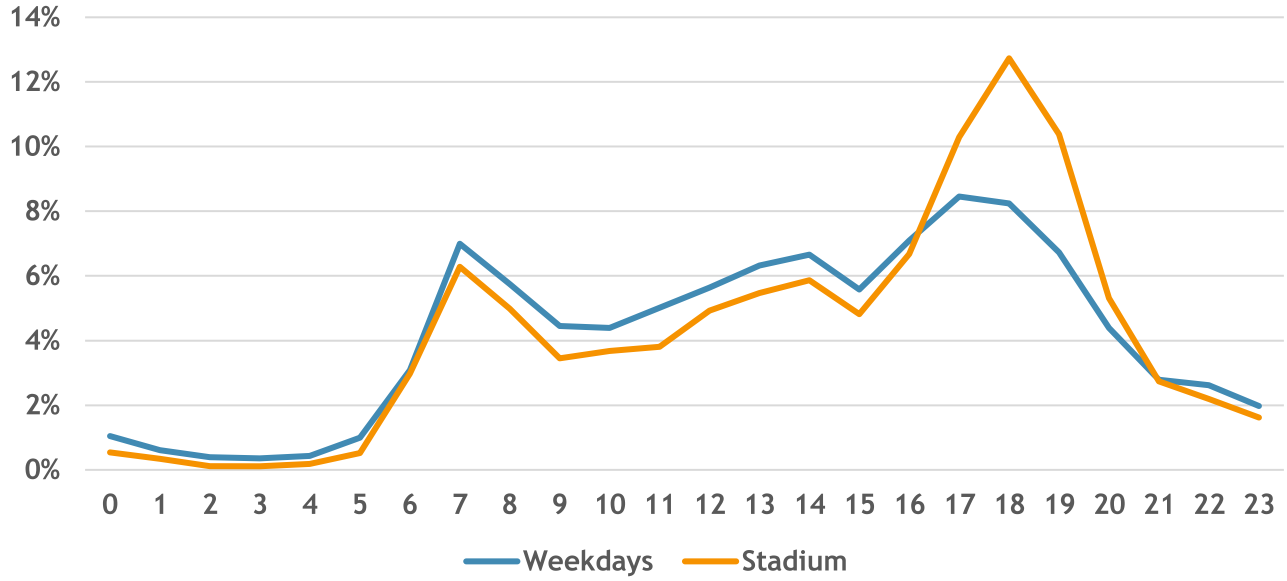

Figure 26 Hourly distribution of total trips to the Renato Dall'Ara stadium area on a typical weekday and on a weekday when an event is taking place at the stadium - November 2024 (Source: GO-Mobility analysis)

At the same time, focusing the analysis on **total journeys into the Renato Dall'Ara stadium area on match days**, these show an hourly profile that is broadly similar to the average weekday ( ) until late afternoon, but with clear differences in the early evening slots, which clearly highlight the pressure exerted by the event on the local system (Figure 26). Until 4:00 p.m., the percentages of arrivals on the day of the match are almost identical to those of the average weekday, suggesting that ordinary systematic mobility (work, school, services) maintains its usual pattern.

However, starting at 5:00 p.m., the picture changes significantly: there is a gradual increase in arrivals, peaking at 6:00 p.m. (13%), well above the average weekday value (8%). This time slot marks the start of the influx of fans and staff heading to the stadium, but even at 7:00 p.m., the percentage remains high (10%), with higher values than on a typical day. The distribution of arrivals on match days therefore shows a concentration between 5 p.m. and 7 p.m., which adds to normal traffic and increases pressure on the road network and public transport.

In contrast, in the following hours, the curve returns to the weekday profile: between 8:00 p.m. and 11:00 p.m., arrivals are stable or slightly decreasing, consistent with the closure of access once the event has started. This suggests that the impact of the influx is concentrated over a period of two to three hours and requires dedicated management in terms of security, traffic management, and support services to ensure accessibility and safety without compromising regular urban mobility.

Overall, therefore, the evidence provided by the analysis of the stadium area suggests that, **although generating localized and concentrated pressure in the hours immediately before and after the event**, a midweek soccer match **does not structurally alter established urban mobility patterns**. The influx and outflow associated with the event are superimposed on internal urban demand in Bologna, which remains **stable and resilient** and appears capable of **absorbing temporary peaks** without any noticeable disruption to the overall travel pattern.

The local impact, although limited, is nevertheless significant, with an **estimated pressure of around 10% more than the ordinary mobility in the area**, i.e., around **30,000 additional trips on a basis of 260,000 exchanges with the rest of the metropolitan area**. Even in the presence of symbolically significant and potentially attractive events, therefore, the city **maintains a functional capacity to adapt,** integrating such phenomena into the usual flows.

4. Repeatable methodology for the calculation of potential demand and defining service levels in low demand areas

This chapter aims to provide a **methodological and operational framework to support the identification of effective solutions for the planning of public transport services** (including DRT services) in the metropolitan area of Bologna, with particular reference to the organization of service areas and their articulation according to demand.

The work falls within the guidelines established by Resolution No. 48/2017 of the ART and aims to provide elements consistent with the objectives of Measure 3, which requires an assessment **of the most suitable modes and types of transport to meet low demand**, taking into account economic, environmental, and contextual variables, as well as the principles of modal integration and sustainability.

In order to outline a coherent and objective picture, the chapter integrates two complementary analyses:

- the ***definition of areas with low demand***, in implementation of Measure 2 and in accordance with the criteria set out in Article 4, paragraph 4, of Ministerial Decree 157 of March 28, 2018, which guides the identification of the least densely served areas or those with the most fragile demand levels;
- ***the definition of a methodology for calculating potential demand and service levels***, in line with the provisions of Measure 3, in order to understand the geographical and temporal distribution of mobility needs, drawing on the detailed information provided in the previous chapter §2.5.1 and with a specific focus on areas with low demand.

With regard to the first point, the information sources used (including territorial, socio-demographic, and local public transport supply and demand databases) are illustrated, as well as the indicators to be calculated in accordance with MIT Ministerial Decree No. 157. In addition, the results of the identification of municipalities with low demand in the metropolitan area of Bologna are presented, with the aim of providing technical support for the definition of a service configuration capable of responding in a targeted manner to the different characteristics of demand, both in urban and less densely populated areas.

The methodology proposed for calculating potential demand and service levels in areas with low demand is designed to be clear and replicable, so that it can be reused in subsequent phases of planning, updating, or verification of DRT services.

4.1. Methodology for identifying 'low-demand' areas in accordance with DM 157/2018

Based on the above, the identification of areas with low demand is a key step in the local public transport service planning process, especially in relation to the need to ensure a minimum level of accessibility even in less dense or more fragile areas from a socio-demographic and economic point of view. Accordingly with Article 4, paragraph 4, of the Decree of the Ministry of Infrastructure and Transport No. 157 of March 28, 2018, the analysis of these areas must be conducted on the basis of ***objective indicators*** capable of providing a coherent representation of the territorial characteristics and potential mobility.

The orographic, temporal, subjective, or socio-economic characteristics of a territorial area determine the presence of areas in which potential mobility is modest, spatially dispersed, or rare over time, and can therefore be defined as "low demand." Specifically, this phenomenon is closely related to factors such as:

- the ***physical conformation of the territories***, such as orography, population distribution and density, degree of urbanization, and accessibility;
- the ***social and demographic structure of the population***, with particular reference to 'vulnerable' groups such as minors, the elderly and the disabled;
- ***economic conditions***, which influence the degree of inclusion and autonomy in travel.

When these factors reach critical levels, the generative potential of mobility is low, resulting in limited transport demand that is unevenly distributed in space and/or time. In such contexts, even in the presence of low demand, there is still a need to ensure adequate, integrated, and sustainable mobility solutions, in line with the principles of equity and territorial cohesion.

Therefore, in accordance with Resolution No. 48/2017, the identification of areas with low demand in the metropolitan area of Bologna was carried out by examining the five territorial and socio-economic indicators provided for in Ministerial Decree 157/2018. The following paragraphs detail the indicators established by the ministerial decree, accompanied by the relevant thresholds, information sources, and calculation methods.

4.1.1. Indicators for the assessment of areas with low demand

The indicators provided for in Ministerial Decree No. 157 for calculating areas with low demand were created with the aim of providing parameters capable of **objectively and comparably describing the territorial, socio-demographic, and economic characteristics of the various areas of the basin**. These indicators make it possible to assess the presence of structural conditions that hinder or limit the potential demand for collective mobility, providing a useful information base for defining priorities for action, designing coherent services, and planning service areas.

This section lists the indicators used for the analysis, divided into the two categories provided for by Ministerial Decree No. 157:

- ***primary indicators***, which represent the structural factors most directly linked to the generation and concentration of public transport demand;
- ***secondary indicators***, which supplement the analysis by providing additional contextual elements useful for territorial interpretation and calibration of the assessment.

'Primary' indicators

Primary indicators represent the fundamental structural factors for identifying areas with low demand, as they directly describe the generative capacity of mobility, the demographic composition of the population, and the degree of remoteness of the territories:

- ***Generative potential:*** a municipality is considered to have low demand if it generates a total number of daily trips of less than 3,000 according to data provided by ISTAT. This value represents an indicative threshold for identifying areas with low mobility density and therefore limited demand for public transport services;
- ***Demographic composition of the population:*** a municipality is considered to have fragile demand characteristics if more than 10% of the population belongs to the school age group (5-24 years) or if more than 10% consists of residents over the age of 70[1] . These groups are typically associated with greater dependence on public transport or specific forms of mobility;
- ***Degree of peripherality***: municipalities with a degree of peripherality of 'D' (*intermediate*), 'E' (*peripheral*) or 'F' (*ultra-peripheral*) are considered to be indicators of low demand. This classification[2] is based on the functional distance from the main centers and the availability of essential services, indirectly reflecting the difficulty of access to mobility opportunities.

[1] Source: Resident population as of December 31, 2023, according to ISTAT

[2] Source: Metropolitan Statistical Atlas based on ISTAT data "Map of Internal Areas" (https://www.cittametropolitana.bo.it/atlantemetropolitano/territorio/Mappe_Abitazioni/mappe_aree_interne/tabelle_aree_interne/mappe_aree_interne)

Secondary indicators

Alongside the primary indicators, which represent the main structural reference factors for identifying areas with low demand, the methodology provides for the integration of ***secondary indicators*** capable of capturing additional elements of territorial complexity. Although these indicators alone are not sufficient to define an area as weak, they help to refine the knowledge base and better interpret the local dynamics that influence potential mobility and access to services. In particular, two relevant aspects are considered:

- ***Altitude range***: the difference between the maximum and minimum altitude above sea level in the municipal area is a useful indicator of the degree of orographic complexity of the territory. Values above 600 meters suggest a rugged morphology, which can constitute a natural obstacle to mobility, continuity of access, and rationalization of public transport services.
- ***Territorial dispersion***: this indicator measures the fragmentation of the settlement fabric within the municipality, through the average distance between the municipal center and its hamlets or districts, weighed up by the population residing in the hamlets themselves. Situations where the average distance exceeds 1.5 km are considered critical, as this leads to greater difficulty in providing service coverage and a potential increase in operating costs to ensure widespread accessibility.

To address the limited availability of data on the precise location of settlements, the indicator relating to territorial dispersion was calculated using the ***degree of urbanization*** provided by ISTAT and Eurostat for each municipality[3] . In particular, municipalities classified in ***class 3***, corresponding to so-called **'rural or sparsely populated** areas', were identified as critical, as they are more exposed to conditions of settlement isolation and difficulties in providing services.

4.1.2. Data sources used

This section briefly describes the information sources and territorial data used, with particular reference to their use in constructing the indicators and supporting the classification analysis.

Commuting Matrix - ISTAT (2019)

To construct the indicator relating to the generative potential of travel, ISTAT data on commuting for study and work purposes, updated to 2019, was used[4] . This choice was made because this information is fully consistent with the logic of Article 4, paragraph 4, of Ministerial Decree 157/2018, which identified systematic travel as a key factor in assessing the weakness of public transport demand.

The indicator takes into account the total number of daily trips generated by the municipality (i.e., outgoing) for study or work purposes, assuming a reference threshold of 3,000 trips/day. Municipalities that generate less than this threshold are classified as having low generative potential and therefore potentially falling within low demand areas.

The use of ISTAT data on commuting ensures territorial comparability, updating, and regulatory consistency, representing a solid and recognized indicator for assessing structural mobility demand.

Territorial and socio-demographic data - ISTAT

Among the main sources used to construct the indicators required by Ministerial Decree 157/2018, the data provided by ISTAT are an essential reference point due to their territorial coverage, temporal continuity,

[3] Source: ISTAT (https://www.istat.it/classificazione/principali-statistiche-geografiche-sui-comuni/)

[4] Source: Territorial mobility: changes of residence and daily commutes - ISTAT (https://istat.maps.arcgis.com/apps/dashboards/8ec70613105d4846849ca4cb49d416fb)

and methodological consistency. The combined use of these data makes it possible to calculate robust, territorially comparable, and up-to-date indicators that meet the requirements of transparency and replicability for identifying low demand areas.

Specifically, the following datasets were used: resident population by age group, municipal altitude variation, and degree of urbanization.

Map of Internal Areas - ISTAT (2022)

The ***Map of Internal Areas*** is a tool developed as part of the National Strategy for Internal Areas (SNAI) with the aim of identifying, on a municipal basis, Italian territories characterized by structural disadvantages in terms of access to essential services (education, health, mobility), depopulation, and socio-economic fragility. The classification is based on a functional and dynamic approach, which considers distance from hubs (i.e., centers capable of offering an adequate level of essential services) as the guiding criterion for defining internal territories. The basic territorial unit is the municipality, which is classified into one of the following five categories:

- ***Pole***: municipality or group of municipalities with a significant provision of basic services and high attractiveness (*class A*);
- ***Belt***: municipalities directly connected to the poles, which gravitate functionally towards them (*class C*);
- ***Intermediate***: municipalities with increasing functional distance from the poles, but still not completely isolated (*class D*);
- ***Peripheral***: municipalities distant from the poles, with reduced access to services (*class E*);
- ***Ultra-peripheral***: municipalities very distant from the poles, with serious connection problems and accentuated structural fragility (*class F*).

This classification is updated periodically (most recently in 2020) based on data relating to road travel times from municipalities to hubs and the presence of essential services. It is an important source for analyzing areas with low demand, as it captures the components of isolation, low density, and social fragility that often coincide with low demand for public transport and limited territorial accessibility.

4.1.3. Identification of areas with low demand

The analysis of the primary and secondary indicators provided for in Ministerial Decree No. 157 and described in the previous paragraph §4.1 therefore leads to the identification of two levels of areas with 'low demand':

- Areas ***with 'potentially low*** demand', where demographic and territorial characteristics determine an intrinsic weakness in transport demand. This category includes territories that **exceed all the thresholds of the primary indicators**;
- Areas ***with*** "***priority low demand***," where "intrinsic weakness" is compounded by additional urban/territorial factors. These are identified among territories where, **in addition to exceeding the threshold for primary indicators, at least one secondary indicator is also exceeded**.

Areas with "potentially" low demand

The municipalities that constitute 'potentially low demand' areas, i.e. those that 'activate' all three primary indicators (respectively shown inFigure10 ,Figure11 andFigure12) are the 11 shown in orange in the followingFigure13 .

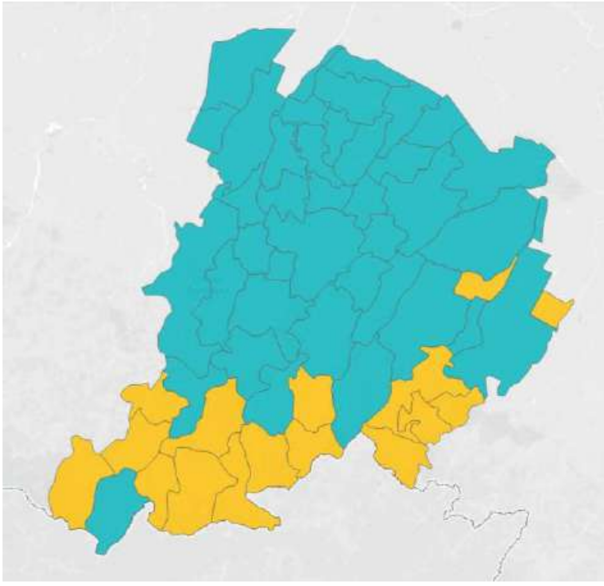

Figure10 Municipalities identified by the 'Generative potential' indicator (Source: GO-Mobility calculations)

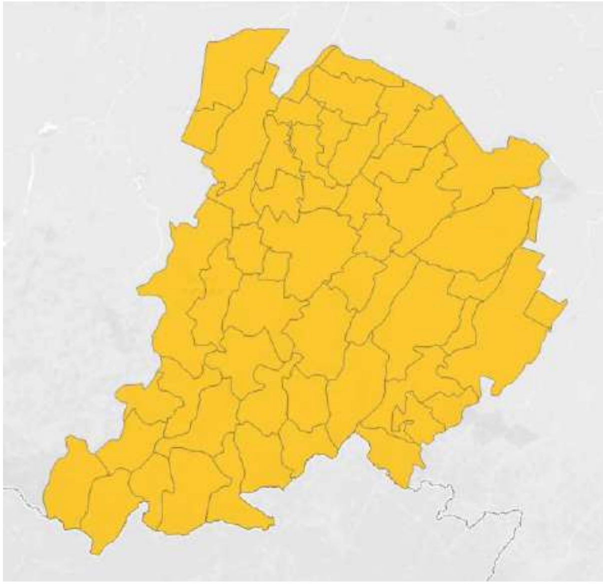

Figure11 Municipalities identified by the "Population composition" indicator (Source: GO-Mobility calculations)

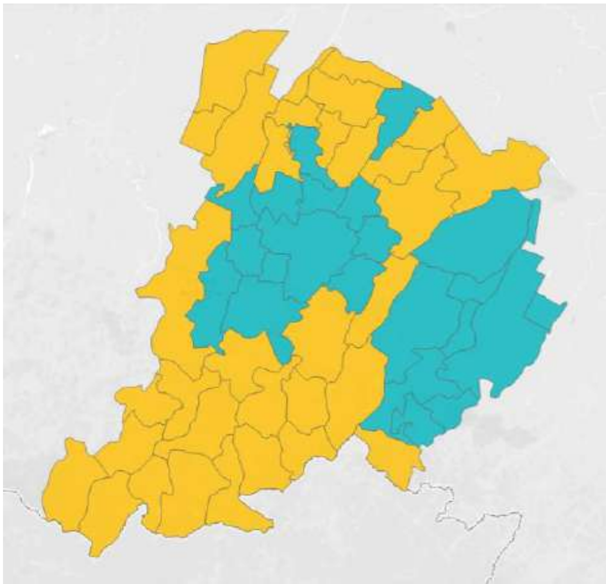

Figure12 Municipalities identified by the "Degree of peripherality" indicator (Source: GO-Mobility calculations)

Figure13 Municipalities identified as "potentially low demand" (Source: GO-Mobility calculations)

Areas with "priority" low demand

The municipalities where the "secondary" indicators are activated are listed below (Figure14 andFigure15), while the map atFigure16 shows all 11 municipalities to be considered **"priority areas with low demand.**"

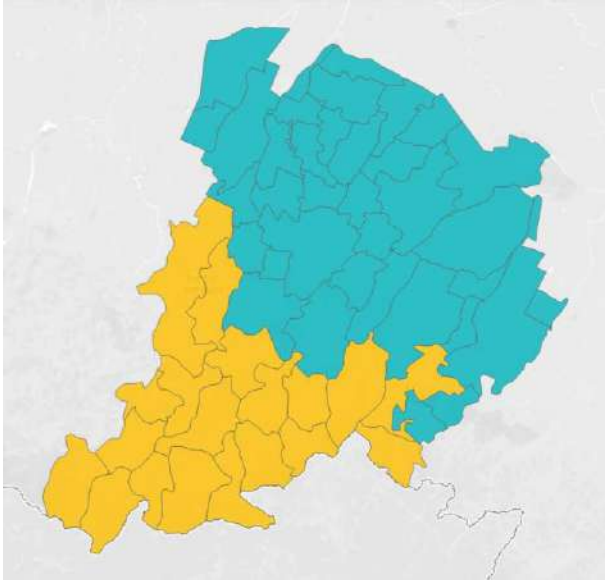

Figure14 Municipalities identified by the "Altitude range" indicator (Source: GO-Mobility calculations)

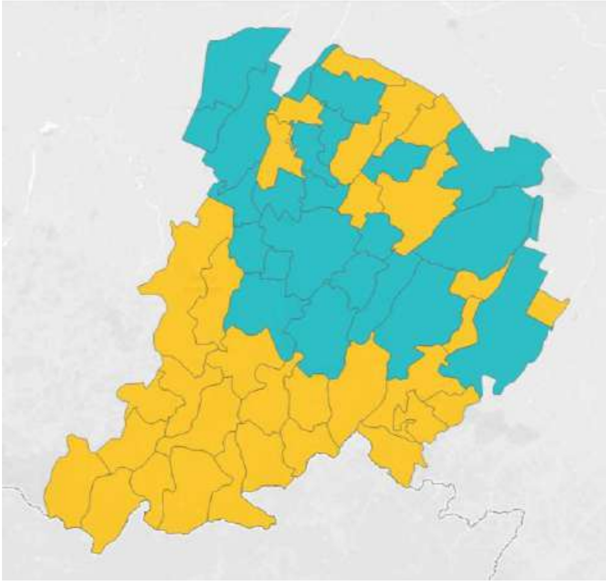

Figure15 Municipalities identified by the "Territorial dispersion" indicator (Source: GO-Mobility calculations)

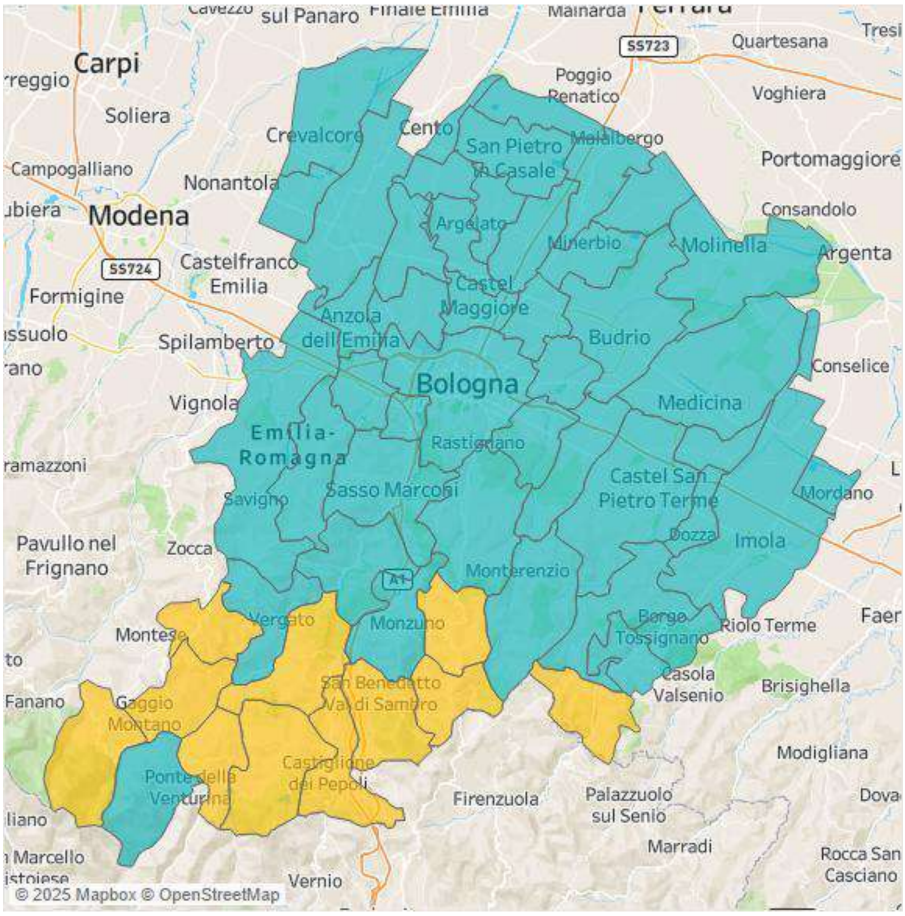

Figure16 Municipalities belonging to areas with "low priority demand" (Source: GO-Mobility analysis)

4.2. Methodology for calculating potential demand and defining service levels in areas with low demand

As indicated in Measure 3 of Resolution 48/2017, the effectiveness of planning choices depends on the ability to accurately identify the characteristics of demand in different segments of the territory, and in particular to recognize areas and relationships where demand is weak, discontinuous, or concentrated in specific periods or times. It is precisely in these contexts that it is crucial to identify flexible, integrated, and sustainable service modes that can guarantee accessibility while minimizing costs and externalities.

In order to allow for an objective and replicable classification of low demand areas, national legislation defines a methodological framework based on measurable technical criteria and territorial and mobility data. This section therefore describes the methodology used **to calculate potential demand and define service levels in areas with low demand in the metropolitan area of Bologna**, as well as the choices made to ensure consistency with regulatory references and adaptability to the local context.

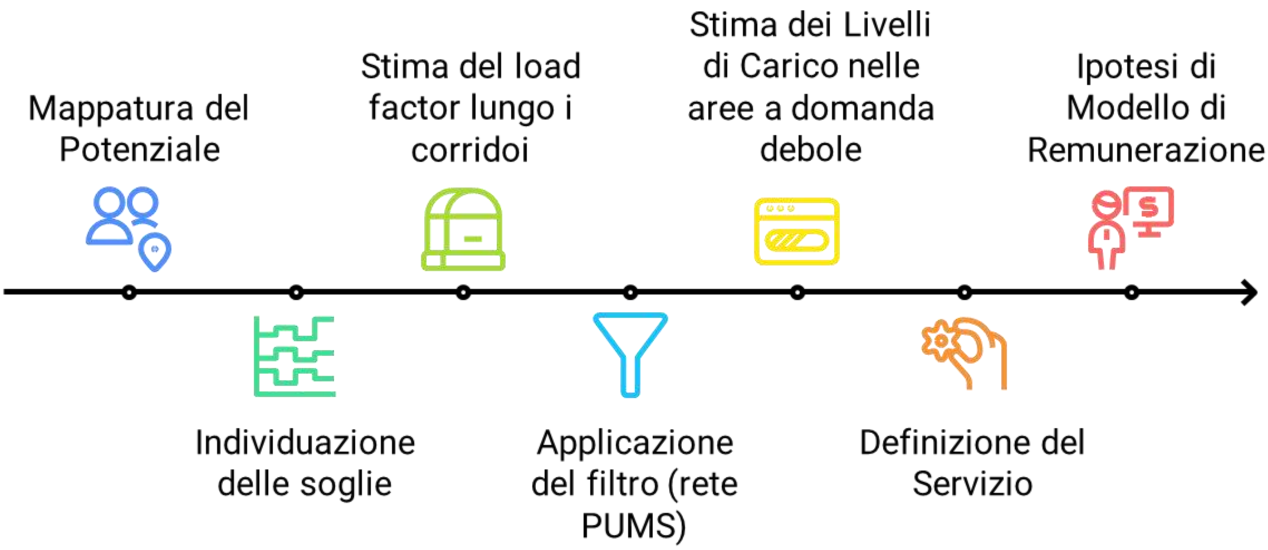

Figure 34 Graphical representation of the proposed methodology for calculating potential demand and defining service levels in areas with low demand (Source: GO-Mobility)

The identification and characterization of areas with low demand is carried out through a replicable methodological process, divided into several phases but readable as a logical and operational sequence (seeFigure 34).

1. ***Mapping of generative and attractive potential***: each area of the territory is analyzed in terms of the density of trips generated and attracted (in relation to the surface area), in order to construct a synthetic parameter of "potential demand";
2. ***Identification of classification thresholds***: **areas with very low potential demand** (e.g., less than 2-5 movements/km²) are distinguished from those with **high movement intensity** (e.g., over 60-80 movements/km²), corresponding to the main corridors of the public transport network. Intermediate areas are subject to specific assessment;
3. ***Estimation of load along the main corridors***: by calculating passenger*km, the expected volumes on board the services are assessed and compared with the available capacity (*load factor*) to estimate the number of trips required and the compatibility of the service with high-capacity (e.g., rail) or lighter (bus) modes;
4. ***Application of the filter to the existing network***: areas with low demand are reanalyzed in light of the public transport network provided for in the PUMS (Metropolitan Urban Transport Plan) of the metropolitan city of Bologna to assess its actual coverage and the frequencies offered. At this stage, areas served by the network provided for in the PUMS are excluded from the analysis;

5. ***Simulation of load levels in areas with low demand by type of relationship***: for each area with low demand, the expected number of passengers traveling to Bologna, to other municipalities, and within the same area is calculated. This defines the demand for calibrating the service;
6. ***Definition of the implementation and flexibility of the DRT service***:
    - *Operation*: a threshold is identified below which the service will not be activated (e.g., on routes where fewer than five passengers per trip are estimated);
    - *Flexibility*: spatial and temporal criteria are applied to decide whether the service should be fixed, regular, on demand, or on variable routes, depending on the concentration of demand.
7. ***Hypothesis for a DRT service remuneration model***: the methodology concludes with a preliminary indication for defining the economic model for the service, taking into account the estimated demand and the selected operating methods.

4.3. Guidelines for the replicable application of methodologies

Finally, this section provides some operational guidelines for replicating and adapting the methodologies developed in the analysis of mobility demand and service levels, with particular attention to contexts characterized by low population density and/or low demand.

Replicability concerns the two main methodological areas described in the document:

- on the one hand, ***the data fusion approach***, in terms of the integration of heterogeneous data sources with a view to producing a regularly updated and detailed picture of mobility behavior;
- on the other hand, the ***methodology for estimating potential demand and evaluating transport service levels in areas with low demand***.

Both methodologies can therefore be adapted to different territorial contexts, provided that up-to-date data is available, and represent replicable operational tools to support public transport planning at local and metropolitan level.

4.3.1. Data fusion process

The data fusion methodology described in this document has been structured from the outset to be ***replicable and updatable over time***, thus responding to the need to keep knowledge of mobility behavior in line with the evolution of socio-demographic, technological, and infrastructural contexts. In particular, the system developed allows both information outputs illustrated in paragraph §2.5 (overall matrix and detailed database for areas with low demand) to be regenerated whenever one or more information sources are updated or made available for more recent time periods. This flexibility is guaranteed by the modular nature of the process, which allows specific update phases to be inserted into the processing chain without the need to rebuild the entire data flow from scratch.

The information base may be updated in three different situations, each of which requires specific actions:

1. Updating socioeconomic data (e.g., new ISTAT estimates);
2. Updating the mobility survey (e.g., new campaigns in preparation for future updates to the PUMS);
3. Updating telephone data (which also involves a simultaneous update of FCD data to ensure consistency in the enrichment of data from the mobile network).

The following paragraphs describe the operating procedures to be adopted in the three scenarios, indicating for each one which steps of the methodology are involved, which additional processing must be carried out, and which measures must be taken to maintain consistency with previous processing.

In the event of an update of socioeconomic data

If updated socioeconomic data become available (such as new estimates of the resident population, updated data on employment or distribution by age and gender), the data fusion process can be easily adapted through targeted interventions in the early stages of the methodology. In such cases, it is assumed that the update only affects some of the available variables and that the other variables remain unchanged in order to maintain consistency in the reconstruction of flows.

- ***Updating census variables (phase 1)***: the demographic or employment base is recalculated based on the updated dataset. If the update is only available at the municipal level, an unchanged distribution is assumed at more granular levels (e.g., census tracts).
- ***Recalculation of outbound and return journeys (phase 2)***: the mobility indices by user profile calculated from the survey are kept unchanged and applied to the new updated socio-demographic data;
- ***Calculation of percentage changes by municipality (new step)***: the change in the volume of movements for each municipality is estimated compared to the previous version, and these changes are applied to the telephone matrix;
- ***Recalculation of the share of intra-zone trips (phase 3)***: the new demographic structure also affects the internal composition of the zones, requiring an update of the estimated share of trips not detected by the telephone data (intra-zone);
- ***Recalculation of the matrix from the homogeneous zoning survey (phase 3)***: the component derived from the survey matrix is recalculated on the new updated socio-demographic structure;
- ***Regeneration of the two final outputs (phase 3)***: both products of the methodology (both the matrix on aggregate zoning and the detailed database for areas with low demand) are updated, maintaining consistency with the new input bases.

This updating method therefore ensures methodological consistency and allows the evolution of mobility demand to be monitored over time in relation to demographic and socioeconomic changes in the area.

In the event of an update of the mobility survey

If a new mobility survey is conducted for a year following the original survey, the data fusion methodology allows for a consistent update of the knowledge outputs, maintaining the basic structure already developed.

- ***Recalculation of emission and return home indices (phase 2)***: the new survey allows for the re-estimation of mobility indices (average number of trips per person, broken down by socio-demographic profile), calculated on the population of the survey year. These indices represent the basis for estimating trips leaving and returning home;
- ***Calculation of percentage changes by municipality and updating of the telephone matrix (new step)***: the new volumes estimated by the new survey are compared with those of the previous version, estimating the percentage change for each municipality. This change is applied to the estimates of trips derived from mobile phone network data;
- ***Recalculation of the share of intra-zone movements (phase 3)***: the estimated share of movements within zones (not detected by the mobile radio network) is updated using the new survey data to calibrate the intra-zone component;
- ***Recalculation of the matrix from the homogeneous zoning survey (phase 3)***: the travel matrix constructed on the basis of the survey is also updated, taking into account the new zoning and the recalculated volumes, with redistribution on the basis of employees where necessary;
- ***Regeneration of information outputs (phase 3)***: both data fusion outputs are updated to describe the new mobility behaviors.

This updating method ensures that the outputs always remain consistent with the evolution of the behaviors measured through the sample of residents interviewed, maintaining the full reliability of the method even after its initial implementation.

In case of telephone data (and FCD) updates

If updated data from the mobile network and vehicle GPS tracking (Floating Car Data) become available, the entire analysis process can be updated, keeping the methodological structure unchanged and regenerating both outputs.

- ***Application of the bounce elimination algorithm (phase 2)***: the mobile data enrichment algorithm based on comparison with FCD is reapplied, which is essential for correcting any location errors in short-range movements measured through connection to cell towers;
- ***Calculation of variation indices by telephone zone (new step)***: compared to the data previously used, the percentage variations in travel volumes in each zone of the telephone grid are calculated;
- ***Recalculation of the share of intra-zone movements (phase 3)***: the share of undetected movements within zones is updated using the same estimation criteria applied in the initial phase, but recalibrated on the new data;
- ***Updating of correction coefficients for emission and return indices (phase 3)***: to maintain consistency between telephone data and survey matrices, the coefficients on the generation and attraction indices for each zone are recalculated in order to correctly calibrate the output based on the home-based movements of residents.
- ***Regeneration of information outputs (phase 3)***: based on the new information, both the aggregated database on telephone zoning and the high-granularity database for areas with low demand are regenerated, thus ensuring a complete and integrated update of the analytical evidence.

4.3.2. Methodology for calculating potential demand and service levels in areas with low demand

Thanks to its modular structure and full integration with the information outputs generated by the data fusion process, the methodology developed for calculating potential demand and defining service levels in areas with low demand is itself fully replicable and easily updatable.

The analytical framework, built on dynamic databases and fed by automated information flows, is designed to ensure maximum operational flexibility: each new update of information sources (telephone, socio-demographic, or survey) can be incorporated and reprocessed without having to redefine the underlying model, thus allowing subsequent territorial and temporal applications, even in different contexts. In particular:

- **the calculation of the generative and attractive potential** of areas (in terms of movements per km^2) can be updated based on new outputs from the data fusion process, reflecting the most recent developments in mobility behavior;
- **the thresholds for identifying areas with low demand and main corridors** can be kept stable or adapted according to the new mobility densities calculated;
- **the calculation of transported demand and passengers per kilometer** on corridors can be recalculated directly on the basis of the new updated mobility matrix;
- **the estimate of useful demand for the different types of relationship** (towards Bologna, inter-municipal, internal) is updated in line with the new flows, modifying the composition of demand for each area;
- **service activation thresholds** (e.g., minimum 5 passengers/bus) **and spatial and temporal flexibility criteria can remain unchanged** but will be applied to updated data, providing consistently coherent and up-to-date assessments.

This approach not only effectively supports the planning of public transport services in areas with lower demand, but also acts as a continuous monitoring tool, capable of detecting changes in mobility behavior and assessing the impact of policies, interventions, or changes in the settlement structure.

In this sense, therefore, potential demand analysis is not a mere static exercise, but an adaptive and up-datable process capable of accompanying the evolution of mobility needs and public service strategies over time.

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DREAM_PACE

BOLOGNA LIVING LAB - Study on DRT costs and the possibility of their inclusion in the Service Contract, referring to DM 157 of 28/03/2018 (Standard costs)

Final Version

06 2025

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1. Introduction

The objective of this paper is to **analyze the costs of DRT services**, identifying **criteria for a remuneration model** consistent with the standard cost system and the operational specificities of this type of service. The study also describes some useful elements to guide the **inclusion of DRT services in** Public Transportation **Service Contracts**, analyzing in particular economic sustainability and conditions of applicability. DM 157/2018 is used as a reference for cost analysis, with the aim of evaluating methodologies applicable to DRT and identifying criteria for its framing within the industry's remuneration models.

DRT (*Demand-Responsive Transport*) **services** are a particular form of *Flexible Transport Service* (FTS) that can be activated only on demand; they are not active when the mobility demand is absent, and they are dedicated to collective transport; specifically, DRTs include solutions without fixed patterns, which adapt routes and schedules to user demand with configurations that effectively meet spatial needs, articulating on three dimensions:

- *Routes and Times*: range from predefined routes with partially fixed schedules to totally flexible routes, optimized in real time.
- *Booking Modes*: range from direct access without reservation to immediate or scheduled booking, with different levels of planning.
- *Network Types*: depend on routes and stops, and are divided into:

  - **Networks with fixed routes and stops**, following rigid patterns;
  - **Networks with flexible routes and fixed stops**, adaptable to mobility demand but with predefined stops;
  - **Fully flexible networks** with variable routes and stops according to the demand.

In summary, DRT is distinguished by:

- **Operational flexibility**: the service is not rigid but adapts to actual user demand and can vary in real time, being particularly effective in contexts of weak or variable demand, such as rural areas, suburban territories, decentralized locations, or time slots with low ridership. *This flexibility of service makes the measurement of standard costs based solely on the concept of "ride-km" inadequate*;
- **Variable cost dynamics:** the DRT, depending on the type of network applied, may not have fixed routes or predetermined frequencies, so *costs are affected by daily variability of factors* such as demand density, distances traveled, waiting times, and number of passengers carried;
- **Diversity in operating models**: the DRT can operate with reservation in advance, in real time, on variable routes, or with collection points, requiring a *costing approach that takes into account the combination of multiple operating factors*;
- **Greater incidence of management and technology costs:** the DRT requires advanced reservation management systems through mobile applications, route optimization algorithms, and a dedicated IT infrastructure, *as elements that must be considered in the service remuneration model*.

The specificities of the DRT and the need for a dedicated model

Given their specificities, **the definition of a remuneration model for DRT services presupposes the adoption of a calculation method that allows their framing within the local public transport system**; at the same time, however, **the absence of a methodological reference and specific experience makes it complex to quantify the costs of DRT services in a manner consistent with other modes of public transport.**

In fact, as is well known, Ministerial Decree No. 157 of March 28, 2018 introduced the "***standard cost***" system for local and regional public transportation services, using specific methodologies for different modes of transportation:

- *Linear regression method*, applied to bus and railways;

- *Analytical method of calculation*, used for tramways and subways.

Although Art. 3(3) of DM 157/2018 provides for the use of the analytical method for services for which the regression method cannot be used, Art. 3(6) explicitly excludes on demand services, including DRT services, without defining an alternative economic method for their quantification.

This can be considered a **useful starting point for the development of a coherent standard cost system applicable to DRT services**, consistent with their operational characteristics and through a system that takes into account the specific processes and industrial activities related to their delivery. **This consideration, therefore, introduces the need for an alternative method that is more adherent to the flexible nature of DRT and its operational variability**.

Limitations of the classical model of remuneration per km for DRT

Given the purpose of identifying a model that complies with the efficiency and cost-effectiveness criteria of DM 157/2018, adapted to the specifics of the DRT, and that can be integrated into Service Contracts, it is inevitable to observe how the direct application of the classic mileage remuneration model entails a number of limitations for DRT services that depend on factors such as:

- **the amount of miles traveled varies daily**, without necessarily reflecting greater or lesser operator effort;
- **the operator must ensure the availability of the vehicle regardless of the mobility demand**, implying costs even when the vehicle is not in motion;
- **a model based only on distance traveled does not incentivize the efficient use of resources**, because an operator who optimizes routes to minimize travel would risk reduced remuneration.

The following Table 1-1 sets out the main elements of incompatibility between the traditional model and the operational and management nature of the DRT:

	Description of the limit
Variability of demand	Demand in the DRT is discontinuous and affected by temporal (schedules, seasonality, etc.) and spatial factors: it often operates in areas with low density or weak demand
Risk transfer	Remuneration occurs only if the vehicle is in active service
Unrecognized fixed costs	The DRT requires constant availability of vehicles and personnel, even in advance reservation models, regardless of actual rides
No-load transfers	In DRT services, the miles traveled to reach the user's pickup point do not coincide with an authorized "fixed" route and may not be counted as service miles in the classic mileage model
Efficiency penalized	DRT optimizes routes by reducing km and consolidating the mobility demand. But the km-based model remunerates more less efficient services (more km = more compensation).

Table 1-1 Limitations of the classical model of remuneration per kilometer in its application to DRT services

2. Elements of operating cost in DRT services

This chapter is devoted to **describing the** typical **operating cost elements** of this type of service.

A first, a relevant distinction is between **fixed costs** incurred regardless of the level of service provided and **variable costs**, which are linked to the actual operation of the service, depending on the kilometers driven, the hours of driving and the number of requests served. Therefore, this classification allows for a functional representation of the economic structure of the service, highlighting components with rigid versus modulable incidence. In the specific context of weak demand settings, where the weight of fixed costs can significantly affect the economic sustainability of the service, the distinction between fixed and variable costs is even more relevant.

For the purpose of providing a review of the main items, in the following paragraphs the analysis is organized by macro-families of costs, with the aim of classifying each cost element as fixed or variable based on technical and operational criteria.

2.1. Fixed operating costs

Fixed costs are the expense items that include all the resources that must be maintained on an ongoing basis to ensure basic operational capacity, regardless of the actual volume of service provided. In DRTs, their incidence can be high, as the service may be in idle condition or with a very low number of requests. A number of "**major macro-families**" are distinguished below:

Analysis and study costs

DRT services generally have a different complexity if compared with fixed-line services, generating higher assessment costs. These costs are generally absorbed by existing dedicated facilities.

Staff

This family includes **personnel directly and permanently involved in service delivery** on the basis of scheduled shifts or guaranteed attendance, including:

- **drivers assigned to the service**: a typically fixed item, as they are contracted according to predefined schedules (CCNL TPL) and paid for availability, not for rides made. Even in flexible DRT models, unless outsourced, their presence must be ensured. In the more flexible service models, drivers may already be operating in the territory for other activities (NCC or TAXI) but must still provide minimum availability that needs compensation; also to be adequately considered are the long pauses between rides that are non-productive waiting times between two consecutive services, due to gaps in demand, distance between points served, or time mismatch between requests. Although they are part of the fixed costs of driver compensation, they represent a consumption of resources that should be properly considered to maximize operational efficiency;
- **operational coordinators/local contact persons**: figures in charge of overseeing the service during operation, with tasks of monitoring operations, supporting the driving staff and managing any critical issues on the ground. They can intervene in case of anomalies, coordinate response to unforeseen situations, or facilitate interaction between vehicles on the road and the central management structure;
- **possible Operations Center staff:** if the system includes a human supervision component, such as telephone assistance or direct management of reservations via call center. The resources employed should be considered a structural fixed cost, as they must man the scheduled service time slots, regardless of the number of calls or rides actually handled. Sizing depends on the service model and the level of digitization of user interaction.

The “weight” of these items depends on the **type of DRT service**: in fixed-route or extended-coverage models, driving staff must be guaranteed regardless of the number of users. Only in fully on-demand and outsourced management models the fixed fee can be reduced, but this involves different structural choices.

Vehicle fleet and maintenance

This macro-family includes the costs required to keep a ready-to-operate fleet of vehicles active and consists of two distinct but interconnected components. The first relates to **vehicle availability**, understood as the minimum condition to ensure service activation, considering expense items such as:

- **Leasing** or **depreciation of** assets;
- taxes, insurance, ownership tax;
- Storage or parking **fees;**
- Availability of **spare means** to cover failures or unforeseen changes in demand.

The second component concerns **scheduled** and mandatory **maintenance**. These costs are independent of actual mileage, since they are defined by regulations, technical manuals or service standards. Even a sparsely used vehicle must undergo the scheduled interventions, which has a direct impact on the fixed annual cost per available unit:

- **cyclic servicing** as prescribed by the manufacturer (e.g., coupons, filter replacement, brakes, belts);
- Periodic reviews and **safety audits**;
- **Agreement** services (e.g., full service, subscription workshop).

Digital technologies and platforms

This macro-family includes all the technological components necessary for operational management of the service, both on the user side (reservation, confirmation, information) and on the manager side (monitoring, vehicle assignment, shift management). These are central tools in DRT services, necessary for organizing the flow of requests, monitoring the status of the service, and dynamically optimizing the distribution of vehicles across the territory.

Digital platforms can be acquired primarily in two ways: the first involves **third-party provision**, in *Software as a Service* (*SaaS*) mode in which the platform is granted for use through a **recurring fee**, usually on a monthly or annual basis, commensurate with the number of active vehicles or usage profile. The **costs** can be classified as fixed, **as they do not vary with the actual number of rides or bookings**. There may be contractual thresholds (e.g., maximum number of vehicles or requests that can be handled), but any price brackets do not change the structural nature of the item. This mode includes:

- fees for the use of the digital platform, including the user app, driver interface and operational management tools;
- user licenses, reservation services, upgrading, technical maintenance, and information security;
- Shift monitoring and management tools, including real-time tracking and visualization of rides.

In free-flow DRT services, the platform must also include **dynamic route recalculation** functions that allow real-time optimization of the sequence of stops and the distribution of rides among available vehicles, depending on the reservations received and their temporal evolution. This capability, which requires specific multi-passenger optimization algorithms and compatibility with operational constraints (vehicle capacities, time slots, distances), is **one of the most relevant components of the digital system** and justifies the presence of **fixed fees or price brackets commensurate with the complexity of the allocation logic built into the software.**

Alternatively, the operator can **develop or acquire in proprietary form its own platform**. In this case, a **higher initial cost** is incurred, including functional analysis, design, development, and testing phase. On the other hand, once implemented, the platform generates low recurring costs related to routine maintenance, regulatory and technological updates, and any functional adaptations.

Technologies include communication systems between the central system and the driver/vehicle necessary to communicate planned activities; this system must consider the quality of signal coverage and available on-board or personal equipment. In cases where coverage is not available, provision can be made for shift communication at a fixed point (driver's home the day before or depot prior to exit) but affecting the advance booking.

Overhead and logistics

Included in this macro-family are all items of indirect support, but essential for the operational continuity of the service, including:

- **Operational headquarters**, offices, logistics space and warehouses, including shared;
- **marketing of travel tickets** includes reseller fees or participation in MaaS platforms that provide for the sale of travel tickets;
- **utilities, maintenance, housekeeping, security**, where applicable;
- Non-vehicle-related business **insurance** (liability, third-party damage, cyber-risk);
- **administrative** and accounting **functions**, including reporting activities to the awarding agency;
- institutional **communication**, customer care, information materials and user tools; participation in MaaS platforms that communicate services.

These costs are generally **stable over time**, and do not vary with the number of rides or users. Where operators operate multiple services, these items may be allocated on **a pro-rata** basis, according to agreed allocation criteria (e.g., number of vehicles, shifts, economic weight of the service).

Summary of fixed operating costs

Macro-family	Cost item	Operational requirement	Operational Notes
Analysis and study	Surveys and service evaluations	Different complexity than regular line items	These costs are generally absorbed by existing dedicated facilities.
Staff	Drivers assigned to the service	Mandatory contractual availability (CCNL TPL), independent of rides made	In flexible models, they can operate multiple services (e.g., NCC, Taxi), but they must guarantee a minimum availability that needs compensation
Staff	Operational coordinators/local contacts	Monitoring of operations and real-time management of any critical issues	Stable figure, also useful in flexible models without continuous centralized supervision
Staff	Operations center / call center personnel	Guaranteed presence to cover interaction with non-digitized or assisted users	Constant in active time slots, modulated by service digitization
Vehicle fleet and maintenance	Leasing/amortization	Contract on an annual or multi-year basis, independent of use	Number of vehicles depends on hourly/geographic coverage
Vehicle fleet and maintenance	Insurance / tax disc	Fixed expenses per registered vehicle	Higher costs for special vehicles (e.g., 4x4, high accessibility)
Vehicle fleet and maintenance	Storage / parking	Constant fee, often on a monthly basis	Possibly shareable with other services

Macro-family	Cost item	Operational requirement	Operational Notes
Vehicle fleet and maintenance	Means of escort	Mandatory to ensure continuity in case of failure	They affect even when unused
Vehicle fleet and maintenance	Scheduled maintenance	Cyclic interventions independent of mileage	Mandatory by regulation and warranty
Digital technologies and platforms	Software fees, apps, management tools	SaaS contract or annual license, not dependent on rides made	Cost jumps only over thresholds (e.g., no. vehicles); includes central-driver communication, taking into account coverage and available equipment
Digital technologies and platforms	Path recalculation algorithms	Integrated function in the digital system, to be guaranteed for free-flowing DRTs	Central element in DRT logic, with impact on license price
Overhead and logistics	Marketing of travel tickets	Physical or digital ticket sales network and integrated channels	Includes resellers' premium or fee for MAAS platforms
Overhead and logistics	Communication, customer care, information	Presence of materials and information channels for users	It also includes participation in MAAS platforms that communicate services
Overhead and logistics	Operational headquarters, utilities, insurance, administration	Fixed structure to be kept active regardless of the level of demand	Possible pro-rata allocation if the operator covers multiple services

Table 2-1 Fixed operating cost summary

2.2. Variable operating costs

Variable operating costs are the expense items that **vary in proportion to the level of service provided** and are therefore triggered only in the presence of rides, kilometers traveled and reservations handled, thus being closely linked to the actual demand and mode of operation of the service.

Some items are directly proportional to the activity performed (e.g., fuel, maintenance due to wear and tear), others depend on efficiency factors and how demand response is organized (e.g., canceled rides, service breaks, reservation management).

Exercise and consumption

This macro-family includes cost items that are activated only when service is performed. They are proportional to miles driven, hours driven, or actual operating intensity:

- **mileage-related costs**, which include fuel or traction energy, materials subject to wear and tear (e.g., tires, brakes, lubricants), and extraordinary maintenance related to intensity of use. These costs vary with fuel technology, terrain morphological conditions, and service profile, and are increasing with average fleet age and actual operational use;
- **hours of availability and/or driving**, in cases of very flexible services (very low demand), the driver is activated and paid only in case of activation in which case the driving hour constitutes variable cost;
- **overtime hours of driving personnel**, which result from exceeding planned shifts in case of peak demand, congestion or organizational inefficiencies. Their incidence varies according to the quality of planning and the flexibility of the operating model adopted.

These costs are particularly relevant in DRT services operating over an extended operational area or in free-flow types, where vehicles are exposed to greater operational variability and less predictable conditions of use than in rigid-route services.

Information technology and systems

Digital platforms used in DRT services represent, in their basic configuration, a fixed cost. In some contract models, however, there is a **variable component**, linked to the actual use of the platform:

- **Incremental costs beyond contractual thresholds**: some SaaS providers may have predefined thresholds (e.g., maximum number of connected vehicles, number of monthly requests) beyond which additional costs are applied. In these cases, the excess becomes a cost proportional to the volume of service performed;
- **consumable services**, when certain platform features generate costs only when activated such as sending SMS notifications, electronic transactions, particular user support tools, or modules added for particular seasonal point-of-interest management (e.g., ski resorts, spas) or for reporting functions. Although marginal to the total, these items can have an impact in high user interaction scenarios.

This variable component should be considered in scenarios characterized by **increased demand, extension of service hours, or activation of new vehicles**, which may generate non-negligible extra costs compared to the base configuration. In economic planning, it is useful to estimate progressive usage scenarios to avoid underestimates in the case of operational expansion or service extension. In addition, **the level of digitization of the system and the availability of human oversight for managing reservations** (e.g., call center) can affect the variable cost structure; in fully automated models, this item is marginal while, on the contrary, in mixed services or those with a strong assisted component, it can represent a significant share, especially in the presence of fragile users or those with difficulties in accessing online channels.

Inefficiency and adaptations

This macro-family collects costs that do not result directly from the productive activity of the service, but from **deviations from ideal operation.** These are items that are triggered when demand is discontinuous, unpredictable, or poorly distributed, and can significantly affect overall efficiency, such as **uncompleted rides due to late cancellations or user absence** - when a user cancels a ride at the last minute or fails to show up, uncompensated costs are generated: empty miles, lost time, inability to reallocate the vehicle in a timely manner.

The incidence can be significant in individual call models, in the absence of a mandatory user confirmation mechanism or penalty tools. In many contracts, this type of ride is nevertheless remunerated by the contracting station, as it is considered part of the service made available, according to logics compatible with the remuneration model adopted;

These components are particularly relevant in DRT services operating in areas with irregular demand, where fragmented travel and the inability to fully optimize routes result in an **implicit efficiency loss**, which must be considered when estimating variable costs.

Summary of variable operating costs

Macro-family	Cost item	Operational requirement	Operational Notes
Exercise and consumption	Mileage-related costs	Dependence on the distance covered by the vehicle, even without passengers	Include fuel, wear materials and maintenance proportional to use
Exercise and consumption	Hours of availability and/or driving	Activation only on demand in very flexible models	Variable costs in the presence of timely activation, in contexts of weak demand
Exercise and consumption	Overtime hours of the driving staff	Exceeding planned shifts	Linked to peak demand or other externalities

Macro-family	Cost item	Operational requirement	Operational Notes
Information technology and systems	Costs over SaaS contract thresholds	Exceeding limits included in the base fee	Can activate with multiple vehicles, requests, or area served
Information technology and systems	Consumer services (SMS, transactions, forms)	Optional activation of advanced features	More relevant in digitized and tourism contexts
Inefficiency and adaptations	Unfinished rides (cancellations/absences)	Reservation not respected	Race often recognized in the contract anyway

Table 2-2 Summary of variable operating costs

2.3. Considerations

The operational cost elements identified in the preceding paragraphs may behave differently depending on the **DRT service model adopted**. Some items are configured as structurally fixed in each scenario, while others take on a variable nature, changing their weight or behavior depending on the degree of demand, the presence of minimum guaranteed shifts, or the mode of interaction with users. For example, **driver staffing** tends to be a fixed cost in fixed-route models, but may take on a more variable nature in ultra-flexible services or in low-demand contexts, where drivers are activated only when needed. Conversely, **driving hours can become a pay-as-you-go cost, just as hours of availability can be compensated based on activation**. Similarly, the **reservation system** has a basic fixed component, but can generate additional costs if the volume of requests or the area covered grows, especially with non-digitized users or assisted channels activated on demand.

One management choice that significantly affects the cost structure is that related to the **technology platform**: acquiring software on an "*as a service*" basis implies a recurring fee, generally fixed but scalable; **in** contrast**, in-house development or proprietary acquisition** involves a significant initial investment but can ensure a **significant reduction in variable costs** over time, limited to maintenance, upgrades and functional adaptations. In multi-year tenancies, this choice can foster economies of scale and greater technical control over reservation management and dynamic route recalculation.

The fixed/variable classification is therefore neither rigid nor definitive, but must be **read from a dynamic perspective**, evaluating **the temporal evolution of the service** and its possible expansion. Elements such as the progressive degradation of vehicles, contractual updates provided for in the CCNLs, or optimization of shifts and routes through operational experience can change the weight and configuration of individual items over time. For this reason, it is necessary that the cost analysis is not limited to an initial snapshot but is structured to **account for evolving dynamics**, so as to ensure the sustainability and economic balance of the service throughout the contract term.

3. DRT service remuneration models alternative to the standard cost method

As mentioned earlier, in order to identify a reference element for the quantification of economic compensation and fees to be put on the auction basis of local and regional public transport services, Ministerial Decree No. 157 of March 28, 2018 introduced the system of so-called ***standard costs***, using specific methodologies for different modes of transportation:

- *Linear regression method*, applied to bus and railways;
- *Analytical method of calculation*, used for tramways and subways.

Although Art. 3(3) provides for the use of the analytical method for services for which the regression method cannot be used, Art. 3(6) explicitly excludes on demand services, including DRTs, from this subset; it should be noted, however, that the decree does not provide an indication of an alternative economic method for their quantification.

That being said, it should be specified that the application of the classical model of remuneration based on distance traveled (€/km) to DRT services is not always adequate because it does not consider the possible operational characteristics of a flexible service, in which travel distances vary according to demand and the vehicle must be available regardless of actual use. In this context, the distance traveled is not a fixed parameter, but a consequence of user requests and the operational organization of the service.

In summary, the application of the mileage criterion to the DRT has objective application limitations that can be summarized by the following **three main critical issues**:

- the operator has to incur fixed costs to ensure the availability of the service (vehicles, drivers, IT infrastructure), but is only remunerated for the kilometers traveled, which can generate **economic imbalances** and undermine the sustainability of the service;
- the mileage model incentivizes **longer rather than more efficient routes**, penalizing those who optimize service to reduce empty mileage;
- remuneration per km may cause operators to limit coverage in areas of inconstant demand, reducing the very flexibility that is the added value of DRT.

3.1. DGR Lombardy No. X/4927/2016

To overcome these limitations, **alternative criteria** have been developed **for quantifying the volume of service provided in DRTs**, including the "***equivalent mileage***" system, introduced by Lombardy Regional Executive Resolution No. X/4927 of March 14, 2016. The aim is to **adopt a mechanism to measure the volume of DRT service in a standardized value of distance traveled**, making it comparable with scheduled public transport and providing a uniform basis for determining the economic compensation of flexible transport services.

As a conceptual premise, it should be specified that **the Lombard model does not directly define the remuneration of operators, but provides a criterion for converting DRT service activity into a standardized quantity of mileage.** The ***Peq*** therefore serves as the basis for calculating the economic consideration due to the operator and is **used to calculate the remuneration, applying a "*unit cost*"** determined according to the criteria established by DM 157/2018.

The approach adopted is based on equivalent mileage (referred to as "equivalent mileage"), **which transforms the service time made available, into a value expressed in kilometers, through the application of an average commercial speed and correction coefficients.** This method allows DRT services to be integrated into local public transport service contracts, ensuring payment criteria consistent with those adopted for scheduled services.

The equivalent distance system introduced by Lombardy Regional Decree No. X/4927 of March 14, 2016 is applied to the different operating configurations of DRT, which differ in route structure, the presence or absence of fixed stops, and booking methods.

DRT network type	Service time table	Method of reservation
Service to basic routes and fixed stops	Scheduled and modifiable schedules with limited advances/postponements	Off-line
Base-route service, with the possibility of detours and fixed stops	Unscheduled hours	Combined Off-line/On-line
Free-route service between a predefined set of points	Unscheduled hours	Combined Off-line/On-line
Service to free routes between any set of points	Unscheduled hours	Combined Off-line/On-line

Table 3-1Type of Service - Time Table - Booking Mode. Source: ANNEX A- CONVERSION OF SERVICES'S SUPPLY "ON CALL" IN EQUIVALENT PERFORMANCE, DGR Lombardy X/4927/2016

Booking methods are distinguished into:

- **Off-line**, with booking made before the start of the duty shift and centralized management of requests;
- **Combined Off-line/On-line**, which can enable reservation requests to be captured even while in service, reprocessing them in real time.

This articulation allows equivalent mileage to be determined **in** a manner consistent with the operational characteristics of each service. In particular, the way in which the service is booked and organized affects the availability required of the operator and the variability of the route, which are key aspects in converting hours of service into equivalent mileage.

Peq is calculated according to different methodologies depending on the type of network adopted by following three key parameters:

- **the hours of vehicle and personnel availability (*OREus*)**, which represent the actual time the service is active;
- **the average commercial speed (*Ve*)**, used to convert service time into a standardized measure of travel time;
  - ***Ve*** is **between** 17 and 20 km/h for **urban services**;
  - ***Ve*** is **between** 27 and 33 km/h for **suburban services**.
- An **adjustment coefficient (*c*)**, which considers the actual operation of the service and the probability of actual delivery.

For "basic route services and fixed stops."

$$Peq = Pprog$$

Where:

- ***Peq*** "equivalent mileage for contract purposes" are the equivalent mileage to which the unit fee should be applied;
- ***Pprog*** "scheduled mileage" are the mileages that the service operator makes available for the implementation of DRT services in lieu of scheduled services

According to the Lombardy Region's proposed model for this type of DRT, the equivalent mileage for contractual purposes coincides with the scheduled mileage, without the need for conversions.

This means that, **in terms of calculating the unit fee**, these services are treated in the same way as ordinary scheduled services, **without recognizing any management or operational specificity**. This is a critical point in the current approach, which deserves attention when revising the model, as it **does not value the**

structural differences between DRT and traditional LPT, nor the costs associated with flexible demand management.

For "basic route services with detours and fixed stops" and for those with "free routes between predefined points."

$$Peq = OREus \times Ve \times c1$$

Where:

- ***OREus*** are the "driver+vehicle service unit hours" actually made available in the daily service span;
- ***Ve*** represents the average commercial speed of the service (km/h);
- ***c1*** is a correction coefficient that takes into account the probability of actual service delivery and the higher unit operating costs compared to scheduled services, and in the present case is a value between 0.80 and 0.85.

This method accounts for **greater operational variability than fixed-route services** by recognizing an equivalent number of kilometers that considers actual service time.

For "free-route services between any set of points."

$$Peq = OREus \times Ve \times c2$$

Where the variables are similar to those expressed above while ***c2*** is a higher coefficient (between 0.90 and 0.95), reflecting **higher operating costs and lower service predictability**.

For services activated "*with digital reservation*" (online):

$$Peq = OREus \times Ve \times c^{1} \times 1,2$$

In this case, an **additional multiplier of** 1.2 is applied **to incentivize the use of digital** booking **tools** and improve service efficiency.

3.2. Possible developments

In terms of what has been said so far, the remuneration model based on ***equivalent distance traveled***, introduced by Lombardy Regional Executive Resolution No. X/4927 of March 14, 2016, is a first technical-operational reference within the regional regulation of local public transport. In its "*Coordination Guidelines for the awarding of LPT service and the drafting of service contracts*," the Lombardy Region has defined a criterion for converting DRT into a unit of measure comparable with scheduled services, providing **a useful starting point for the integration of DRT into service contracts**, although **this Resolution does not represent current legislation at the national scale**.

The proposed methodological framework is consistent with the logic of standard costs and allows for parameterization of operators' activities although it has some critical application issues: the equalization between fixed-stop DRT and traditional scheduled services does not enhance the managerial specificities of DRT, while the use of an insufficiently structured "*c*" coefficient limits the model's ability to represent actual operating conditions.

[1] "***c***" takes a value of "***c1***" for basic-route services with fixed detours and stops and for those with free routes between predefined points, while it takes a value of "***c2***" for free-route services between any set of points.

Precisely with a view to providing potential useful references for dealing with such critical application issues, the following paragraphs discuss some possible evolutions for developing alternative criteria for quantifying the volume of service delivered in DRTs.

Overcoming the equating of DRT service "*with basic routes and fixed stops*" with scheduled LPT

For *DRT services* operating on predefined routes and stops, equating them with scheduled travel does not adequately represent the reservation-based nature of the service.

One possible evolution of the model is to reclassify this configuration to what is provided for the "*fixed lines with detours and fixed stops*" typology. Such a reclassification would make it possible to overcome the assimilation to scheduled LPT, through a correction coefficient that takes into account demand-conditional activation, thus maintaining a basis for calculation consistent with standard cost logic, but adapted to the managerial specificities of the service.

The introduction of a **theoretical activation coefficient**c_0 can promote recognition of the value of the organization and guaranteed availability, while avoiding an overestimation of the recognized mileage compared to the actual service performed.

Adaptation mechanisms for "*basic route* services *with detours*"

The approach proposed by the Lombard model for the calculation of *Peq* **does not distinguish between configurations with low and high incidence of deviations** on the base path, treating even very different cases uniformly. Integrative **mechanisms** can be introduced to improve the adherence of the calculation to actual operations:

- a first assumption involves the **application of an adjustment coefficient to the scheduled** mileage, based on the historical average of observed mileage deviations;
- a second way is to **introduce a variable component at the end of the day**, calculated on the actual kilometers more than the base route.

Both options tend to rebalance the relationship between theoretical availability and actual operational commitment, while maintaining the principle of contractual predictability.

Uniform correction coefficients for broad categories of service

The model has two average correction coefficients (*c1 and c2*) applied to basic-route services with fixed detours and stops and free-route services between predefined points (*c1*) and free-route services between any set of points (*c2*), respectively. This approach, while simplifying the calculation of equivalent travel distance, **does not distinguish between the different levels of operational and management complexity** that may exist within the same network types. In the case of weak-demand services, the level of effort required to deliver the service can vary significantly depending on factors such as:

- The frequency and mileage incidence of deviations from the base route;
- The territorial extent of the area served and its morphology;
- The hourly pattern of service (evening, holiday, night coverage);
- The technological level of the management system (digital platforms, optimization algorithms, advanced user interfaces).

These variables, while directly affecting the organization and costs of the service, are not reflected in the adopted correction coefficients, and this may result in an incorrect estimate of the recognized equivalent volume when determining the *Peq*, with consequent distorting effects on the operator's remuneration.

In a logic of greater adherence to the actual management, **the value of the coefficient *c* could be determined ex ante on the basis of objective parameters detectable at the service planning stage**. In this way, while maintaining the simplicity *of Peq* calculation, an element of greater customization and proportionality would be introduced; the coefficient could therefore be structured according to a composite logic:

$$c = c_{base} + \Delta_{flexibility} + \Delta_{technology}$$

Where:

- c_{base} represents the reference value for the category;
- $\Delta_{flexibility}$ reflects the expected intensity of detours or route variability;
- $\Delta_{technology}$ considers the level of digitization and automation of the management system.

This *c-value*, which is defined in the contract, would remain constant throughout the contract period, unless expressly provided for updates in case of significant changes in the service.

Presence of a single technological corrective, applied indiscriminately

The Lombard model provides for the application of a **multiplicative coefficient of 1.2** for the calculation of *Peq* in cases where the service is activated through a digital platform (**web or app booking**). This is a corrective designed to enhance the contribution of technologies in service optimization. This mechanism is applied **uniformly**, without distinguishing between the different technological configurations that can be adopted by operators:

- Integrated systems with digital payment tools and real-time routing algorithms;
- Intelligent booking platforms with advanced user interfaces;
- call center with extended coverage or mixed online/offline management;
- solutions based on manual or poorly digitized tools.

In the face of this heterogeneity, **the application of a single standard correction does not allow for the true differences in costs** incurred in implementing and managing service technologies to **be reflected**. One possible evolution may be to provide, at the contractual level, a **breakdown of the coefficients according to the level of technology actually adopted**. For example, specific adjustments could be introduced for:

- Automatic route optimization systems;
- Digital platforms with real-time tracking;
- Reservation channels with continuous telephone presidium.

Absence of a service performance-related component

The model proposed by the Lombardy Region does not provide for any direct recognition of service quality since the economic consideration recognized to the operator is determined exclusively on the basis of the volume of service available (*Peq*), without any modulation linked to indicators of efficiency, operational regularity or user satisfaction. However, this approach runs the risk of not valuing virtuous operations, uniformly treating services with even very different levels of quality.

To overcome this limitation, it may be appropriate to introduce a **quality coefficient**, to be applied **when calculating the final fee** (and not directly on the *Peq* calculation), that values the operator's operational performance. The coefficient, to be contractually defined, can vary within a predefined range and be activated if certain service quality thresholds, measured through objective indicators, are met. Such **performance indicators (KPIs)** may include, for example:

- The percentage of correctly fulfilled requests compared to the total received;
- The regularity of the service in relation to booking times;
- The degree of asset utilization, relative to available capacity;

- The quality perceived by users, detected through periodic monitoring tools.

The quality coefficient (α) once activated, enters the fee calculation formula according to the following expression:

$$Final\ payment\ = Peq\ \times Unit\ Cost\ \times (1+\alpha)$$

Where α represents a reward factor, whose magnitude and trigger thresholds are defined in the service contract, also depending on the operating environment and local policy objectives. A mechanism of this magnitude makes it possible to reward efficient operations, without altering the basic function of *Peq* as a measure of service volume, by introducing quality elements within the economic structure of the contract.

Uniformity of costs in the face of different operating environments

The economic value applied to each *equivalent km* tends to be homogeneous, even with services with profoundly different cost profiles. Particularly onerous operating conditions, such as service coverage during evening, night or holiday hours, can also be considered in defining the unit cost applied to *Peq*. These situations entail a higher incidence of fixed and availability costs (personnel, vehicles, rostering), and their timely recognition can help ensure a sustainable economic balance for the operator, especially in contexts of weak demand.

Although Lombardy DGR No. X/4927/2016 differentiates the average commercial speed between urban (17-20 km/h) and suburban (27-33 km/h) services, this parameter only acts on the calculation of *Peq*, affecting the amount of travel recognized but not the economic value assigned to each equivalent kilometer. **Therefore, the unit cost applied to *Peq* tends to be uniformly defined in service contracts, without fully considering the actual cost structure of different contexts**.

It is easy to deduce, in fact, how DRT services operating in mountainous areas, during evening or holiday hours, or in territories with very low population density, present significantly different operating costs than those exercised in urban daytime or high aggregate demand areas. In these scenarios, a possible development may be to **differentiate the unit cost applicable to *Peq***, based on objective and contextual parameters, such as:

- services in mountainous or suburban areas with low density and high spatial dispersion;
- night or holiday services, involving additional shifts and higher incidence of unproductive hours;
- services with very low demand, with very high fixed costs relative to the miles driven.

One solution could be to differentiate the unit cost of *Peq* by applying **parametric grids based on the type of service and operating context** to recognize a value more consistent with the costs incurred.

Such articulation could help improve the fairness of the remuneration system, ensuring a better fit between the costs incurred and the remuneration recognized, especially in services operating under conditions of greater operational fragility or with a territorial garrison function.

Alternative approach based on hourly value of service

In contexts of weak demand, characterized by high spatial dispersion, low demand density and high incidence of fixed costs, the determination of economic compensation through a mileage-only parameter may not be fully representative of actual operational effort.

An alternative methodological option is to calculate the hourly value of DRT service from existing contract parameters. Specifically, given a local public transport contract expressed in €/km and knowing the average operating speed of the service (km/h), it is possible to derive the base value of an hour of service:

$$€/h_{DRT} = \left(\frac{contract\ cost\ \ €/km}{avarange\ speed\ \ km/h}\right)$$

Parameterized adjustments can be applied to this hourly value to adapt it to the specific service configuration:

- A reduction factor when using light vehicles or vehicles with lower depreciation costs;
- a surcharge related to the presence of advanced technological infrastructure for service management (digital platforms, automatic routing systems);
- an additional increase to cover the costs of more onerous booking channels, such as dedicated call centers or extended telephone support.

The overall formula can then be represented as follows:

$$€/h_{DRT} = \left(\frac{contract\ cost\ €/km}{avarange\ speed\ \ km/h}\right) - \%\Delta cost + \%technology\ platform\ cost + \%call\ center\ cost$$

In the formula the **depreciation differential** is **subtracted** because the €/km reference value comes from traditional LPT contracts, in which depreciation costs refer to large buses, typical of high-capacity lines. In DRT services, on the other hand, especially in areas of weak demand, smaller vehicles with lower acquisition costs are used, necessitating a downward adjustment of this component. Conversely, the adoption of **advanced technologies for service management**, such as digital reservation platforms, route optimization algorithms, or dedicated call centers, introduces **new cost items** that are not covered in traditional line contracts, and thus must be considered as **surcharges** on the standard hourly value.

This methodology allows for an **estimate that is more closely aligned with the actual costs** incurred by the operator, proving particularly useful in contexts in which a theoretical service mileage cannot be defined a priori, such as in fully flexible DRTs or those operating at marginal times and territories. In addition, the adoption of an hourly parameter makes it possible to **stabilize remuneration**, partially decoupling it from the volume of kilometers traveled and recognizing the value of **service availability**, even in the presence of discontinuous demand.

Mixed models for very low demand services

In some specific spatial contexts, such as rural areas, mountainous municipalities, or marginal time zones, transportation demand may be so discontinuous that even the *Peq-based* model is inadequate. In these cases, the operator must ensure service availability against a very limited number of rides or requests actually met, with a high incidence of fixed costs.

One possible configuration in such scenarios is the adoption of a mixed remuneration model, structured on two components:

- **a fixed fee**, parameterized on an hourly or daily basis, which remunerates the availability of the vehicle, staff and operations center, regardless of the kilometers driven;
- **a variable fee**, linked to the number of requests served, rides made or passengers carried, which values the actual activation of the service.

This scheme makes it possible to ensure the economic sustainability of the service even in the absence of high volumes of use, preserving the social and territorial function of DRT.

4. DRT service remuneration models applied in the Metropolitan City of Bologna

This section analyzes **four** demand responsive services (DRT) **contract models** activated by SRM in the Bologna Metropolitan City basin with the aim of documenting and comparing the different experiences in the area, including in terms of **remuneration model** configurations based on the contract clauses applied in the respective periods of operation.

The cases considered, which differ in their operational configuration, service activation methods and fee determination criteria, are:

- reservation service in the ***Borgo Panigale*** district (***Col☎BUS***, 2009-2010).
- ***ProntoBus of Pianura*** (as of September 15, 2011);
- ***Apennine ColBus*** (summer 2021 and winter 2021-2022);

The models are presented in comparative form, highlighting the characteristics of each service and its remuneration model.

4.1. Borgo Panigale District reservation service (Col☎BUS)

The Borgo Panigale Neighborhood Reservation Service was activated by SRM in 2009 with experimental purposes, as a **pilot project of Demand Responsive Transport in urban areas.** The service, active in Bologna, was aimed at undifferentiated users residing in a weak demand area, with the goal of facilitating **access to the LPT carrier network and the main public poles** in the neighborhood.

Operational configuration of the service

The Col☎BUS operated as a **variable-route** DRT service **with rides between predefined stops** and operated through a call center.

The service adopted a configuration of stops divided into two groups: "*central*" and "*widespread*." Rides were allowed between stops belonging to different groups, in an **adduction** logic **towards the carrier network and the main interchanges**. The articulation into groups of stops and the absence of rigid routes allowed operational flexibility, yet maintained controllable minimum service standards.

Remuneration model

The service contract adopted a **remuneration model** in which the operator assumed part of the responsibility for the economic sustainability of the service. The compensation structure included a **fixed fee** and a **variable fee** closely linked to ticketing receipts related to booked trips:

- the **fixed** annual **fee**, remunerated the guaranteed operational availability for the entire span of the service regardless of the number of rides actually booked;
- **the variable quota**, subject to a cap, depended on the ticketing revenue certified by the foster carer and referring only to booked trips.

In contrast to the full compensation models, tariff collection was valued and directly contributed to the calculation of the total fee. In this scheme, **the operator retained the traffic revenue** and assumed part of the commercial risk.

A distinctive feature of the contract concerned the **management of unreserved access**, i.e., passengers who spontaneously boarded: the contract stipulated that the operator had to accept them, consistent with capacity and the already optimized itinerary. **The income from** these users did not count toward the variable fee recognized by the contract, but **remained entirely at the disposal of the entrustee**. This generated a form of "**ancillary revenue**" that, while not formally valued in the contractual fee, contributed to increasing the overall economic return for the operator. In other words, each access without a reservation, while not affecting the recognized variable fee, contributed to enhancing the operational effectiveness of the service, improving the utilization rate of the vehicles and generating additional revenue for the operator.

Considerations

The Borgo Panigale Neighborhood Reservation Service introduced a contractual and operational configuration that was distinguished by the balance between managerial flexibility and regulatory oversight:

- from the point of view of **operation**, the **articulation between** "*central*" and "*diffuse*" **stops**, with constraints on crossing between groups, **represented a mechanism for directing demand to trips of greater functional relevance, avoiding localized or fragmented use**. The reservation system was complemented by a logic of access even without a reservation, consistent with the capacity of the vehicle and the defined route, providing greater flexibility and operational inclusiveness;
- In terms of **remuneration**, the contract adopted a **hybrid structure** in which the operator retained ownership of the fare revenue and assumed part of the economic risk. The variable portion of the fee was directly linked to ticketing revenue, while revenue from passengers who boarded without a reservation did not contribute to the determination of the fee, remaining at the disposal of the operator and constituting an ancillary revenue component.

Overall**, the remuneration model** adopted for the Borgo Panigale Neighborhood Reservation Transportation Service **combined elements of managerial flexibility** and **economic empowerment**. The operator was incentivized to maximize service utilization and ticketing, within a framework governed by well-defined contractual thresholds and limits; at the same time, demand-related risk was not fully transferred, making the system more **responsive to real demand** and geared toward sustainable use of public resources.

4.2. Pianura ProntoBus Service

The ProntoBus service in Pianura has been operated by SRM since September 2011, through a **supplementary contract to the service contract** for LPT bus services in the Bologna basin. The service was established to ensure **accessibility in the municipalities of the Pianura metropolitan area, which are characterized by low settlement density and dispersed demand**, and in which the activation of regular frequency rides is not sustainable from an economic-operational point of view.

Operational configuration of the service

The service configuration includes both:

- **reservation lines**, with a fixed route that can be activated only at the request of the user;
- **regularly exercised fixed lines**.

The service is configured to support **relationship mobility**, connecting smaller centers to interchanges and strategic destinations during peak periods. Operationally, drivers remain available on the entire scheduled time belt, with breaks built into the probability of non-activation of booked rides.

Remuneration model

The contract provides for a **fee** paid to the operator **in proportion to the actual mileage delivered**, with a full service compensation system. The value of the public **subsidy** is **commensurate with the share of kilometers performed** compared to the theoretical schedule, **according to a reference threshold**, on which the minimum and maximum compensation values are based. **Fare revenues** are retained by the operator and **do not contribute to the calculation of the fee**.

The total annual quota is determined on an assumption of a defined percentage disbursement of planned mileage by providing:

- a **maximum threshold of** consideration in the case of making 100% of the mileage;
- a guaranteed **minimum threshold** to cover the fixed costs incurred by the operator to ensure the continuous availability of the service.

Considerations

Pianura's ProntoBus contract provides for a **remuneration model linked to the service provided**, with remuneration commensurate with actual mileage and rides operated.

The model adopted focuses **remuneration on the activation of requested rides, regardless of the number of passengers carried**. Thus, the operator's willingness to cover the entire planned service is paid for, not efficiency in terms of filling vehicles or increasing ridership.

4.3. ColBus service in the Bolognese Apennines

ColBus services activated in the Bolognese Apennines represented an **on-demand public transportation** network **in the suburban** area, developed by SRM to serve suburban areas with discontinuous demand

The service was implemented in a territorial context classified as an "*Inland Area*" under the National Strategy for Inland Areas (SNAI) and Emilia-Romagna Regional Executive Resolution No. 512/2022, which confirmed and updated the perimeter for the 2021-2027 programming cycle.

Operational configuration of the service

ColBus service in the Bologna Apennines has been activated by SRM in two distinct seasonal configurations: *summer 2021* and *winter 2021-2022*, as a reservation-based LPT service on suburban lines, with differentiated operational and contractual characteristics.

ColBus summer 2021

The summer configuration was mainly intended for tourist users, with operation on weekends and holidays, corresponding to the main mountain resorts and isolated hamlets in the Bolognese Apennines:

- the service, which was organized on **fixed-route lines that could be activated by reservation**, also allowed partial routes to be operated according to requests received;
- **reservations** had to be made at least one day in advance, allowing the operator to plan the exercise consciously and adjust its organization according to actual demand.

the purpose was to guarantee the connection between marginal areas and the rail network, ensuring access to primary LPT hubs on days when ordinary supply was most reduced.

ColBus winter 2021-2022

During the winter period, the ColBus service was activated in two distinct operational configurations.

- **route 965**, operating **weekends and holidays**, was aimed at occasional non-commuter users heading to mountain and ski resorts. The service was based on **flexible routes** with no fixed schedules, articulated **over a network of widespread stops**. **Reservations** had to be made **by the previous day**, allowing the operator to plan the operation based on actual demand collected;
- **route 966**, on the other hand, operated on **weekdays** on **fixed routes and stops**. The service also provided the possibility of booking partial routes and was accessible with a **minimum of two hours notice of** the desired time. This configuration was designed to provide local mobility in low-demand areas where there was no regular line supply.

Remuneration model

The contract stipulated, for both seasonal configurations, a **maximum fee** defined over the entire period of validity. **The actual amount** recognized **varied daily**, **according to a formula** that distinguished between days with at least one activated ride and days with no reservations. In these two cases, a contractually predefined "*full share*" or "*reduced share*," respectively, was recognized. **Revenues** from ticketing were retained by the concessionaire and **did not contribute to the calculation of the** contractual **fee**.

ColBus summer 2021

The fee was **calculated daily**, depending on service activation:

- **€/day** for each vehicle used in at least one ride (activated vehicle);
- **€/day**, lesser value, for each vehicle prepared but not activated (stand-by vehicle).

ColBus winter 2021-2022

The **maximum consideration**, with two separate remuneration models for the two activated lines.

- **Line 965**, active weekends and holidays, the system adopted replicated the summer logic:
  - **€/day** per activated medium;
  - **€/day**, lesser value, for each means prepared and not activated.
- **Line 966**, which operates on weekdays, the contract provided for a **more articulated structure**, consisting of:
  - **hourly fee** $€/h$ for each hour of scheduled availability;
  - **variable kilometer fee** $€/km$ for each kilometer driven with at least one passenger on board;
  - **up to** a **maximum daily fee** per vehicle$€_{max*veicolo}$ /day.

The number of trips was limited to consider the maximum number of permissible driving hours for a driver. Through this last scheme, **a criterion of selectivity** was introduced **in the variable remuneration**, as the **mileage was valued only if it was done with the presence of users on board**.

Considerations

The two contracts include **specific operational conditions** for reporting and recognition of consideration:

- **in both contract seasons, remuneration was contingent on daily reporting according to a formula** that distinguished between days with at least one activated ride and days with no reservations;

- limited to **line 966** (ColBus winter 2021-2022), a selective clause was introduced that tied the **recognition of the mileage fee to the actual presence of users on board**: mileage was recognized only if it was done with at least one passenger, while mileage done without users did not activate this surplus mileage fee.

Overall, the Apennine ColBus adopted a **hybrid remuneration model**, which combined **fixed items** (daily and hourly availability) and **variable items** (activation, kilometers traveled with users), according to a logic that integrated **delivery incentives** and **partial transfer of operational risk**. In both periods, compensation was tied to a contractual ceiling, and the calculation logic introduced an initial form of user-based remuneration. The model:

- recognized operational readiness even in the absence of demand;
- rewarded effective activation and the presence of passengers;
- shared some of the demand-related business risk with the operator.

4.4. Comparison and general considerations

The analysis of the service contracts applied to DRTs in the Bologna area shows a diversification of remuneration models, defined according to the operating context, activation mode and the degree of economic risk attributed to the operator. The comparison is articulated along two lines:

- the operational **pattern of** operation, between fixed reservation lines and flexible area-based services;
- the **structure of the fee**, with fixed or variable components, dependent on tariff revenues.

Table 4-1 below summarizes the main characteristics of the services examined above:

	Col☎BUS Borgo Panigale	ProntoBus Pianura	Apennine ColBus Summer 2021	Apennine ColBus Winter 2021-2022
Operating scheme	Variable route between fixed stops divided into two groups; rides occur between different groups of stops	Fixed reservation lines and ordinary fixed schedule lines	Reservation-based suburban lines, operating on weekends and holidays, on a fixed route with the possibility of partial routes	Line 965 (weekends and holidays): flexible routes on network of widespread stops Line 966 (weekdays): fixed route with possibility of partial routes
Form of contract	Fixed annual availability fee + variable fee linked to ticketing revenue related to booked trips	Full compensation based on actual mileage disbursed	Maximum fee over the entire period, with full or reduced fee based on daily activation	Maximum fee over the entire period, with: Line 965: same summer pattern Line 966: hourly rate, mileage rate (with passengers only), daily maximum per vehicle
Method of reservation	Reservation required, with free access allowed if compatible with availability and route	Reservation required for dedicated lines	Reservation at least one day in advance	Line 965: by the previous day Line 966: at least 2 hours before the desired time
Method of calculating the fee	Fixed fee for operational availability + variable fee calculated on revenue from tickets sold for booked trips, subject to a ceiling	Proportional to the mileage performed, relative to a maximum threshold	Fee €/day per activated vehicle + reduced fee per standby vehicle	Line 965: as summer Line 966: €/h fee per availability + €/km with at least one passenger on board, up to a maximum €/day per vehicle
Revenue Management	Retained by the contractor. Only revenues from booked trips contribute to the variable fee; those from access without booking remain with the operator but are not contractually valued	Withheld by the contractor, do not contribute to the calculation of the fee	Withheld by the contractor, do not affect the calculation of the fee	Withheld by the contractor, do not affect the calculation of the fee

	Col☎BUS Borgo Panigale	ProntoBus Pianura	Apennine ColBus Summer 2021	Apennine ColBus Winter 2021-2022
Incentives for the operator	The operator is incentivized to maximize ticketing on booked trips; Ancillary revenues generated from unbooked accesses remain with the operator	The fee is related to the activation of the requested rides, not to the efficiency in terms of filling	Daily service activation incentive to maximize days with active service	Line 965: as summer Line 966: operational efficiency incentive, with mileage remuneration recognized only when there are passengers
Risk distribution	The operator assumes part of the economic risk; variable fee depends on ticketing revenue	Partial sharing: guaranteed a minimum threshold to cover fixed costs, fee increases according to actual mileage	Partial sharing: a share is provided even in the absence of activations	Line 965: as summer Line 966: risk related to the actual presence of users

Table 4-1 Comparison of DRT services carried out in the Bologna area.

Comparative analysis of contracts shows a diversification of remuneration models, with varying degrees of tariff risk transfer to the operator. The choice of model appears to be closely related to the type of service, territorial context and level of demand predictability.

In addition to economic aspects, a significant difference emerges in terms of **operational flexibility**, understood as the ability of the service to adapt dynamically to actual demand. Services configured with variable routes, flexible booking, and free access (as in the case of Col☎BUS Borgo Panigale or ColBus Summer Line 965) offer greater adaptability, but require an evolved management system and a more articulated contract structure. In contrast, services structured on predefined routes and stops (such as ProntoBus in Pianura and winter ColBus and summer Line 966) allow for more stable contractual management and simplified determination of the fee.

Hybrid contract models therefore offer tools to **empower the operator**, **incentivize efficiency** and **optimize the use of public resources**, but require a careful balance between **service flexibility**, **economic sustainability** and **regulatory quality**.

5. SWOT analysis of remuneration models for DRT services

This section analyzes the remuneration models applied in Demand Responsive Transport services, with reference to both the equivalent distance system (*Peq*) defined by DGR Lombardy X/4927/2016 and the operational experiences in the Bologna basin (Borgo Panigale, ProntoBus, ColBus Appennino). The analysis also includes proposals for methodological evolution, aimed at introducing corrective elements and quality indicators.

Each model is first summarized in its remuneration and management parameters (Table 5-1) and then evaluated according to a SWOT matrix (Table 5-2), with the aim of highlighting:

- The consistency between fee structure and service delivery mode;
- The balance between operational flexibility, economic risk and efficiency incentive;
- The potential for adaptation to weak demand contexts.

	Remuneration model	Elements of operation and management
***Peq* (Equivalent Mileage)**	*Peq* = service hours × average speed × correction coefficient (c); *Peq* = Pprog for fixed routes	- Operation pattern: fixed to fully flexible; - tools: variables (call centers, platforms, or both); - reservation: off-line or combined; - Driver: available on the full schedule; - Revenues: retained, but not always valued; - goal: integration into the LPT and territorial presidium
***Peq* evolutions**	*Peq* with adaptive coefficients (*c*), quality bonus (*a*), contextual costs	- exercise model: consistent with *Peq*, but with adjustments; - Tools: digital platforms, KPIs, tracking; - reservation: digital and combined; driver: available; - Revenues: possibly valued based on performance; - goal: efficiency, quality, equity
Col☎BUS Borgo Panigale	Fixed annual fee + variable fee linked to the income coming from booked trips	- Exercise model: variable route between stops of two groups; - tools: call center; - reservation: mandatory + conditional free access; - driver: available; - revenue: withheld; - goal: adduction to urban carrier network
ProntoBus	Proportionate share of mileage traveled, with guaranteed minimum threshold	- Operation model: fixed lines and reservation lines; - Tools: call center, centralized management; - reservation: mandatory for dedicated lines; - Driver: available throughout the time slot; - Revenues: withheld, not valued; - goal: relationship mobility in low-density areas
Apennine ColBus Summer 2021	Fixed daily fee per activated vehicle + reduced fee per standby vehicle	- Operation model: fixed routes with the possibility of partial routes; - Tools: offline booking in advance; - Reservation: at least 1 day in advance; - driver: available; - Revenues: retained, not valued in the consideration; - goal: tourism mobility in mountain areas

	Remuneration model	Elements of operation and management
Apennine ColBus Winter 2021-2022	Line 965: as a summer model; Line 966: hourly rate + mileage rate with passengers only + daily cap	- Operation model: 965 flexible; 966 fixed route with possibility of partial routes; - Tools: mixed reservation, variable advance; - reservation: 965 within day before, 966 min. 2h before; - driver: available; - revenue: withheld, but not valued in the calculation; - goal: minimum mobility in inland areas

Table 5-1 Summary of remuneration model and elements of operation and management

	Strengths	Criticality	Opportunities	Threats
***Peq* (Equivalent Mileage)**	- Standardization of criteria in service contracts; - Compatibility with existing TPL models; - Recognition of availability as a basis for calculation	- Correction coefficient not calibrated to real operating conditions; - Equalization with TPL for fixed routes does not value flexibility	- Expansion of services included in TPL service contracts; - simplification for awarding entities	- Mismatch between activity performed and remuneration; - Risk of underfunding in contexts of weak demand
***Peq* evolutions**	- Greater proportionality between consideration and operational effort; - Opportunity to reward efficiency and service quality	- Increased contractual complexity; - need for structured monitoring systems	- Customization according to context and service profile; - Introduction of KPIs as a regulatory lever	- difficulty in defining objective and verifiable parameters; - possible interpretive conflict between operator and foster caregiver
Col☎BUS Borgo Panigale	- Ticket sales incentive; - Operator empowerment; - flexible demand management	- Income from non-reservation accesses not contractually valued; - Variable quota subject to ceiling	- Enhancement of operational efficiency	- Commercial risk partially borne by the operator; - uncertainty about the volume of demand
ProntoBus	- Simplicity of fee calculation; - guarantee of minimum coverage of fixed costs	- Poor incentive for management efficiency; - Share recognized unrelated to level of utilization	- Integration into the main TPL contract; - guarantee of garrison in smaller centers	- Failure to enhance the demand served; - low contractual flexibility
Apennine ColBus Summer 2021	- remuneration of availability; - service activation incentive	- Absence of correlation between demand volume and consideration; - Stiffness of the model in case of unexpected demand	- Applicability to seasonal or tourist services; - simplicity in accounting management	- Risk of inefficiency in case of low demand; - mismatch between utilization and compensation
Apennine ColBus Winter 2021-2022	- Selective remuneration on the actual presence of passengers; - combination of availability and actual activation	- Complexity in reporting; - Risk of unrecognized rides in the absence of passengers	- Possible extension to fragile contexts with low demand; - Enhancement of actual utilization	- Increased operator exposure to the risk of empty rides; - Increased administrative burden on the commissioning entity

Table 5-2 SWOT analysis of remuneration models for the DRT.

6. Qualitative cost estimation by type of service

The objective of this chapter is to provide a **structured reading and estimation of individual elements of operating costs** in public transport services (detailed in chapter §0), distinguishing between traditional LPT and DRT services.

The proposed approach is **qualitative:** no numerical quantification is proposed, but a **comparative estimation of the relative weight of** the main **macro-families of costs**, divided between **fixed** and **variable**, in order to:

- highlight **the structural differences** to understand **which items affect** the economic model of the two types of services the **most**;
- support the construction of **differentiated remuneration models** consistent with the operational characteristics of DRT services.

6.1. Qualitative cost weight in standard TPL services

In traditional local public transport, service is planned with routes, schedules and frequencies established at the planning stage determining a **cost structure** mainly oriented on **fixed components** and allowing **predictive and programmable** management of variable components, which are contained and relatively homogeneous over time.

Fixed costs

Fixed costs in standard LPT represent the **predominant part of the economic commitment**. They are related to the continuous availability of vehicles, personnel and infrastructure, regardless of actual demand or kilometers traveled. This is why their **incidence is high and difficult to compress**.

Macro-family	Cost item	Qualitative weight	Operational Notes
Staff	Drivers with fixed shifts	High	Attendance guaranteed by TPL collective bargaining agreement, pay not linked to rides made
	Coordinators/operational supervisors	Medium	Needed for continuous service monitoring
Vehicle fleet and maintenance	Leasing/amortization	High	Multi-year contractual costs independent of utilization
	Insurance/ownership tax	Medium-High	Fixed item for each registered vehicle, even if unused
	Storage / parking	Medium	Monthly/annual fees possibly shareable among multiple services
	Means of escort	Medium	Necessary to ensure continuity of service in case of failure
	Scheduled maintenance	Medium	Mandatory cyclical interventions required by manual or regulation
Technologies	TPL management systems and software	Low	Generally shared, with low recurrent costs and little influence
General expenses	Locations, logistics, administration	Medium-High	Centralized structure, stable garrison for management and reporting
	Marketing of travel tickets	Medium	Includes reseller vig or fee for MaaS platforms

Table 6-1 Fixed costs in standard LPT services

Variable costs

The variable components of standard LPT are, on the other hand, linked to the actual performance of the service (trips made, kilometers traveled), but within a planned framework that allows for **good predictability and control of expenses**:

Macro-family	Cost item	Qualitative weight	Operational Notes
Exercise and consumption	Mileage-related costs	Medium	Proportional to km; predictable through stable scheduling
	Hours of availability and/or driving	Null	Not applicable in TPL. Driver is already provided in fixed shifts (fixed cost)
	Overtime hours of the driving staff	Low	Limited to emergencies or disruptions; infrequent in regular operation
Information technology and systems	Costs over SaaS contract thresholds	Null	Rarely found in TPL; restrained and static use of digital technologies
	Consumer services (SMS, transactions, forms)	Null	Generally absent or marginal
Inefficiency and adaptations	Uncompleted rides (cancellations/absences)	Null	Not applicable: service guaranteed regardless of the users present
	Long breaks between rides	Null	Absent due to fixed scheduling and defined frequencies

Table 6-2 Variable costs in standard LPT services

6.2. Qualitative weight of costs in DRT services

The operational configuration of DRTs results in an **articulated cost structure**, characterized by the coexistence ***of fixed components***, related to system availability, and ***variable costs*** influenced by **fluctuating external factors**, such as the distribution of demand and the actual activation of rides.

The weight of individual items may change depending on the type of service and spatial context, **but some components are recurring and outline a specific economic profile** that distinguishes DRT from standard LPT services.

Fixed costs

Fixed costs arise mainly from the **need to ensure service availability**, even in the absence of active demand. This availability involves structural burdens on means, personnel, technology and logistics:

Macro-family	Cost item	Qualitative weight	Operational Notes
Staff	Drivers assigned to the service	Medium-High	Mandatory contractual availability (CCNL TPL), independent of the trips made. In flexible models, they can operate multiple services (e.g., NCC, Taxi), but must guarantee a minimum availability that needs compensation
	Operational coordinators/local contacts	Medium	Stable figure, also useful in flexible models without continuous centralized supervision
	Operations center / call center personnel	Medium-High	Guaranteed presence to cover interaction with non-digitized or assisted users. Constant in active time slots, modulable according to the digitization of the service
Vehicle fleet and maintenance	Leasing/amortization	High	Contract on annual or multi-year basis, independent of use. Number of vehicles proportionate to hourly/geographic coverage

Macro-family	Cost item	Qualitative weight	Operational Notes
	Insurance / tax disc	Medium-High	Fixed costs per registered vehicle, higher for special vehicles (e.g., 4x4, accessible)
	Storage / parking	Medium	Constant fee, often on a monthly basis. Possibly shareable with other services
	Means of escort	Medium	Mandatory to ensure continuity in case of failure. They affect even if unused
	Scheduled maintenance	Medium	Cyclic servicing independent of mileage, mandatory by regulation and warranty
Digital technologies and platforms	Software fees, apps, management tools	High	SaaS contract or annual license, not dependent on rides made. Includes central-driver communication
	Path recalculation algorithms	Medium-High	Central function in free-flow DRTs, impacting the software fee
Overhead and logistics	Operating locations, utilities, administration	Medium	Fixed structure to be kept active regardless of demand level. Allocable pro-rata if over multiple services
	Marketing of travel tickets	Medium	Includes reseller vig or fee for MaaS platforms
	Communication, customer care, information	Medium	Presence of user information materials and channels. Includes institutional communication and support services

Table 6-3 Fixed costs in DRT services

Variable costs

They depend on the **actual level of service provided**, which can vary significantly over time and space. In more flexible models, the **variability of routes** and the dispersion of mobility demand also have an impact. This category includes items proportional to the activity performed, such as fuel, materials subject to wear and tear, and driving hours, but also components related to user interaction or operational inefficiencies. These conditions reduce the possibility of an estimate and increase the operator's exposure to economic risk related to demand instability:

Macro-family	Cost item	Qualitative weight	Operational Notes
Exercise and consumption	Mileage-related costs	High	They include fuel, wear materials, and maintenance proportional to use. The level of activity is not programmable a priori, but depends on actual demand, with variations due to irregular mileage and mileage dispersion
	Hours of availability and/or driving	Medium	In weak-demand models, they may activate only when reservations are made; variable component especially in ultra-flexible services
	Overtime hours of the driving staff	Medium	Triggered in case of unplanned peaks, congestion, or operational misalignments
Information technology and systems	Costs over SaaS contract thresholds	Medium	Incremental costs associated with exceeding contractual thresholds on number of vehicles, requests, or hourly/geographic extent
	Consumer services (SMS, transactions, forms)	Medium	Activated only when there are high volumes of user interaction, typical of tourism settings or with seasonal services
Inefficiency and adaptations	Uncompleted rides (cancellations/absences)	Medium	Rides often recognized in the contract anyway. They involve non-recoverable out-of-pocket costs (empty miles, time, missed reallocation)

Table 6-4 Fixed costs in DRT services

6.3. Comparison and general considerations

With the same cost items, TPL and DRT have different economic structures in terms of flexibility, predictability, and sustainability.

The following is a qualitative comparison articulated between **fixed** and **variable costs**, highlighting **structural differences**, **rigidities,** and **possible levers of modulation** for each, consistent with the macro-families and operational items identified.

Fixed costs

Macro-family	Cost item	TPL weight	DRT weight	Comparative Notes
Staff	Drivers	High	Medium-High	- Fixed voice in both services; - In DRTs, even in the most flexible models, a minimum guaranteed provision is required unless outsourced. In some cases it can be supplemented by already active NCCs or cabs
	Coordinators/referents	Medium	Medium	- Needed in both services; - In the DRT, territorial presence may be lighter or partial, depending on the operational organization
	Operations center / call center	Absent	Medium-High	- Item absent in standard TPL; - In DRTs, it is central to reservation management, particularly for non-digital users
Vehicle fleet and maintenance	Leasing/amortization	High	High	- Fixed costs in both services; - In DRTs, fleet size is often proportional to coverage area rather than ride volume
	Insurance/ownership tax	Medium-High	Medium-High	- Constant voice in the two services; - Costs associated with the number of vehicles available regardless of their actual use
	Storage / parking	Medium	Medium	- Fees present in both services; - In the DRT they can be shared or decentralized depending on the logistic configuration
	Means of escort	Medium	Medium	- Needed in both services; - In DRTs they may be required in extended or fragmented contexts to ensure continuity in case of simultaneous activations or failures
	Scheduled maintenance	Medium	Medium	- Mandatory interventions in both services; - Costs independent of actual mileage as defined by regulations, technical manuals
Digital technologies and platforms	Management systems/digital platforms	Low	High	- Marginal item in standard TPL; - In DRTs, it is an indispensable structural component for service operation
	Path recalculation algorithms	Absent	Medium-High	- Not present in standard TPL; - In DRTs with free flow, they are critical for dynamic path generation
Overhead and logistics	Locations, logistics, administration	Medium-High	Medium	- More established structure in standard TPL, with offices and functions often centralized; - In DRTs, requirements may be lower, but remain necessary to ensure administrative and support management
	Marketing of travel tickets	Medium	Medium	- Present in both models; includes reseller vig or fee for MaaS platforms dedicated to sales

Table 6-5 Fixed cost comparison: LPT vs. DRT

- in **standard LPT**, the **fixed cost** structure is by its very nature rigid: the main items are related to service continuity and are **difficult to compress**;
- in the **DRT**, although there is less regularity in delivery, the need to still ensure operational availability means that a **stable share of fixed costs** is maintained, **even in the absence of activated rides**.

Some formally fixed items in the DRT may have room for operational flexibility, depending on the management model adopted. This is the case with driver personnel, whose allocation may be reduced in fully outsourced models or integrated with resources already operating in the territory (such as NCCs or cabs), while still ensuring a minimum level of availability to be compensated. The operations center can also be partially automated, or downsized, in the presence of more advanced digital interaction. Finally, logistics and administrative functions can be organized **in a lighter, decentralized or shared form**, while still maintaining the activities essential to service management.

Variable costs

Macro-family	Cost item	TPL weight	DRT weight	Comparative Notes
Exercise and consumption	Mileage-related costs	Medium	High	- In standard LPT, consumption is proportional and planned; - In the DRT, it depends on the service actually activated, with irregular rides and greater dispersion
	Hours of availability and/or driving	Absent	Medium	- Not present in standard TPL; - In the DRT they may be a variable cost in flexible models, activated only on request
	Overtime hours of the driving staff	Low	Medium	- In standard TPL they are limited; - In the DRT they may increase due to the uneven distribution of mobility demand over time
Information technology and systems	Costs over SaaS contract thresholds	Null	Medium	- Absent in standard TPL; - Present in the DRT when contract thresholds are exceeded (e.g., vehicles connected, requests handled)
	Consumer services (SMS, transactions, forms)	Null	Medium	- Incremental costs in DRT related to digital user interaction; more relevant in tourism or high seasonality settings
Inefficiency and adaptations	Uncompleted rides (cancellations/absences)	Null	Medium	- In standard LPT, operation is guaranteed regardless of the users present; - In the DRT they generate uncompensated out-of-pocket costs, often partially recognized by contract

Table 6-6 Variable cost comparison: standard TPL vs. DRT

In **standard LPT, variable costs** are generally programmable, since they depend on a volume of service established at the planning stage and **tend to be constant over time**. The regularity of trips and predictability of demand allow for controlled management of key variable items, such as costs related to miles traveled, wear and tear materials, and corrective maintenance.

In **DRT**, the same components are **less predictable and more sensitive to operational conditions**. Discontinuous demand distribution, route variability, mileage dispersion, and the frequent presence of operational inefficiencies - such as uncompleted rides or long breaks between rides - make ex ante planning more complex and increase exposure to economic risk. Added to this are variable costs associated with consumable technologies, such as activating extra modules, sending SMS or incremental use of platforms beyond contractual thresholds.

7. Economic and management strategies for sustainability of DRT services.

DRT services involve a high exposure to operational risk and management variability that necessitates careful economic planning. This chapter proposes a concise representation of the economic sustainability of DRT, declined according to the **four main operational configurations**, each discussed in a self-contained section:

- **Service 1** - Basic route with fixed stops
- **Service 2** - Basic route with detours and fixed stops
- **Service 3** - Free routes between a predefined set of points
- **Service 4** - Free routes between any set of points

For each service, the possible **strategies that can be activated by the contracting station** with the aim of ensuring the minimum conditions for service delivery and efficient use of public resources are framed, as well as the **management strategies that can be implemented by the operator**, aimed at containing costs, ensuring business continuity and accessing the forms of remuneration provided by the contract.

7.1. Service 1 - Basic route with fixed stops

	Strategy - Contracting Station	Strategy - Operator	Possible tariff arrangements
Fixed costs	- Provide an availability recognition mechanism (e.g., fixed daily or monthly fee), with the aim of ensuring business continuity even in the absence of demand and ensuring a stable economic base for the operator; - Establish multi-year contracts to encourage sustainable investment in vehicles and infrastructure; - Evaluate the adoption of a single or shared digital platform for reservation management, integrated with existing TPL systems; - Prefer interoperable solutions to minimize fixed costs - Recognize an annual flat administrative fee in the PEF, with the aim of covering management expenses independent of production and limiting improper discharges to variable costs	- Integrate vehicles and personnel across multiple compatible services (e.g., school, shuttles) to maximize utilization rates and amortize fixed costs; - Schedule cyclic maintenance work on non-service days to avoid costly downtime - Merging management functions among multiple services and contiguous territories to reduce overhead costs and rationalize the organization	- Apply integrated tariff with urban LPT as a service in adduction to the main network; - During soft bands, provide low surcharge to compensate for lower saturation
Variable costs	- Recognize in the contract only the miles actually traveled with users on board, with the goal of aligning remuneration with production; - Establish a cap on remunerable daily mileage to avoid inefficient behavior	- Optimize ride and schedule scheduling based on historical usage data, reducing empty rides and increasing hourly efficiency	- Maintain uniform base fare for major routes; - Provide slightly increased fare for secondary or low demand routes, especially in non-core time slots

Table 7-1 Economic and management strategy for DRT service with fixed route and predetermined stops

7.2. Service 2 - Basic route with detours and fixed stops

	Strategy - Contracting Station	Strategy - Operator	Tariff adjustments
Fixed costs	- Provide a fixed fee for daily operational availability of the service, even in the absence of activated rides, to ensure coverage on all points of the network; - Provide for co-financing among multiple entities in the case of a distributed network; - Integrate into the contract the availability of a digital platform for booking and routing, choosing between SaaS or centrally developed and managed system - Recognize in the contract a flat fee for administrative management, calculated according to network size and operational complexity; - Provide for annual update based on change in points served	- Organize the availability of assets and personnel over planned time and geographic windows to avoid operational dispersion; - Use the indicated platform to aggregate requests and optimize routes; - Integrate cyclical maintenance during non-operational periods - Merge management functions with other similar services to contain overhead costs; - Automate booking and support functions with shared digital tools	- Base rate proportionate to the average distance between network points; - Apply fixed surcharge for requests involving major deviations from the most direct route - In general, good organization reduces overhead costs and avoids repercussions on the rate charged to users
Variable costs	- Calculate the actual miles traveled with users on board as the basis of the variable consideration; - Monitor empty miles and average stroke saturation using digital KPIs; - Define in the contract minimum standards for routing optimization and aggregation software required	- Use dynamic dispatching system to reduce empty miles and improve load factor of vehicles; - Optimize shifts and schedules based on data collected in operation	- Rate proportional to actual miles; - Introduce increased tariff in case of single, non-aggregable request, with ex ante information to the user

Table 7-2 Economic and management strategy for DRT service with fixed route and detour on demand

7.3. Service 3 - Free routes between a predefined set of points

	Strategy - Contracting Station	Strategy - Operator	Tariff adjustments
Fixed costs	- Provide a fixed fee to ensure the daily availability of the service even when there are no rides; - Integrate the availability of a digital platform for booking and routing (SaaS or central system) into the contract; - Provide for co-financing among multiple entities in the case of a distributed network; - Include costs for planned cyclical preventive maintenance - Recognize a flat fee for administrative management, updated annually based on points served and operational complexity	- Arrange the availability of vehicles and personnel on predetermined time windows and areas to avoid dispersion; - Use the digital platform to aggregate requests and optimize routes; - Schedule maintenance work during periods without service - Merging management with other services to contain overhead costs; - Automate operational and administrative functions with shared tools	- Basic rate proportionate to the average distance between network points; - Apply fixed surcharge for requests involving major deviations from the most direct route - In general, an efficient organization avoids passing on overhead costs to the user rate
Direct operating costs (variable)	- Calculate the miles traveled with users on board as the basis of the variable consideration; - Monitor empty km and saturation through KPIs; - Set minimum standards for the efficiency of optimization software	- Use dispatching systems to reduce empty miles and improve average load per ride; - Adapt shifts and rotations based on collected data	- Rate proportional to km; - Introduce increased rate for non-aggregate single requests, communicated to the user at the booking stage

Table 7-3 Economic and management strategy for DRT service with free routes between defined points

7.4. Service 4 - Free routes between any set of points

	Strategy - Contracting Station	Strategy - Operator	Tariff adjustments
Fixed costs	- Provide a fixed fee to ensure service availability even when there is no demand; - Integrate a high-capacity digital point-to-point management platform into the contract, choosing between SaaS or centralized development; - Provide inter-municipal co-financing for services in large area; - Include coverage of cyclical preventive maintenance; Evaluate mixed models that include participation of licensed operators (NCC, cabs) on call - Recognize a flat fee for service management, related to the territorial extent and degree of customization required; - Fostering administrative aggregation among awarding entities; - Provide for the possibility of centralized management by inter-municipal areas	- Use non-fixed means and personnel that can be activated only on demand, including through agreements with external operators, to reduce costs associated with the continuous availability of own resources; - Use the planned digital platform to aggregate requests and optimize routing; - Schedule cyclic maintenance during downtime; - Avoid exclusive use of dedicated means or personnel unless necessary - Merging administrative functions among multiple areas served; - Automate reservations, request management, and billing through single platform; - Use centralized or shared back-office	- Apply point-to-point tariff proportional to the distance traveled; - Introduce dedicated fare for single requests or non-aggregate rides, informing the user at the booking stage; - Charging a surcharge or limiting service delivery during night hours or outlying areas unless predefined minimum conditions are met (e.g., multiple reservations, minimum advance payment, significant distance) - Digital and inter-municipal management can reduce overhead costs and contain the impact on rates charged to users
Variable costs	- Monitoring of empty mileage and aggregation rate using digital KPIs; - Inclusion of minimum routing efficiency indicators in the contract (e.g., average users per ride)	- Use intelligent real-time dispatching systems to optimize load distribution and reduce unproductive miles; - Adapting shifts and vehicles to the most in-demand areas and time slots, including with "dynamic on-demand" logic	- Rate proportional to the distance traveled; - Apply increased fare in case of individual rides or those with low aggregation rate; - Provide a threshold fare structure (band/suburban/suburban) if consistent with the area served

Table 7.4Economic and management strategy for DRT service with free point-to-point routes

8. Integration of DRT services into the service contract

The inclusion of DRT services in service contracts requires the analysis of certain technical and managerial elements that make their integration into the LPT system possible. Compared to regular scheduled services, in fact, DRTs present greater operational complexity requiring more complex evaluation activities. This chapter provides some aspects to be properly taken into account to reduce these burdens.

8.1. Priority elements to consider

Coordination between DRT and TPL services.

Effective integration between DRT and existing TPL network reduces inefficiencies and maximizes benefits for users and the awarding agency:

Principle of integration	Description
Avoid overlap with fixed services	- Integrated DRT planning to cover areas and times not served by traditional LPT; - Avoid duplication of fixed line routes; - Reduce wasted resources and unnecessary costs
Ensuring tariff integration	- Provide for integrated travel tickets between DRT and TPL; - Offer concessions to LPT subscribers
Unify communication and booking channels	- Integrating the DRT into the digital platforms of the LPT; - Allow combined scheduling and booking between fixed lines and DRT; - Avoid the use of separate, confusing applications; - Ensure consistency in information (schedules, fares, travel solutions); - Reduce operating costs and simplify staff activities
Integrating DRT into path construction and user experience	- Include DRT rides in route calculation systems; - Offer truly intermodal travel solutions; - Ensure continuity among services in travel planning; - Strengthen the role of the DRT as an adduction service to the main grid

Table 8-1 Coordination between DRT services and LPT network

Compliance with personnel contract regulations

The organization of the DRT service must ensure **full compliance with labor regulations** applicable to the personnel employed, especially drivers. Limits on driving hours, rest periods, and shift duration are established by European standards[2] , national legislation[3] , and the CCNL Autoferrotranvieri[4] . The service contract must set operating conditions and constraints compatible with these provisions, to avoid excessively fragmented or unpredictable shifts.

Service monitoring and technology KPIs

DRT monitoring must be continuous and based on technologies already adopted in LPT. Tools such as GPS/AVM, electronic validation, and digital reservation records must be used for specific purposes and linked to measurable performance indicators. Any technology implemented must produce data useful for

[2] Regulation (EC) 561/2006, as amended, Regulation (EU) 2024/1258

[3] Law 138/1558 and D. Lgs. 66/2003, as well as specific provisions for the local public transport sector

[4] National Collective Bargaining Agreement for Motor Carriers 2024-2026

the contracted KPI system. Indeed, the digital solutions available today, including platforms for DRT management and integrated ticketing systems, are an essential tool for service control:

Monitoring tool	Operational purpose	Associated KPIs (examples)
Vehicle Localization (GPS/AVM)	Track DRT vehicles in real time, verify adherence to schedules and routes, track mileage	- % on-time rides - Average delay (min) - Miles traveled out of service
Electronic validation of tickts	Investigate passenger accesses and ticketing, integrating them into the TPL fare system	- Total passengers by time slot - Average occupancy rate - DRT introductions per km (€/vett-km)
Digital reservation register	Record travel requests, advance booking, cancellations, and non-fulfillments. Enable analysis of mobility demand and performance	- Service rate (requests fulfilled/total) - Average time confirmation and pick-up - Average passengers per ride

Table 8-2 Monitoring technologies and associated KPIs

Data collected through these tools enable the contracting entity to verify compliance with agreed quality and productivity standards. For example, joint analysis of AVM data allows the identification of operational inefficiencies while validation data can support the monitoring of the fill ratio. Each technology should contribute to the construction of KPIs that are clear, measurable and linked, if provided, to incentive or penalty mechanisms, in line with what is already applied for scheduled services.

In **territorial contexts with low tel.co. network coverage**, a service model may be adopted that provides for compulsory booking by the previous day, allowing for certain planning of the exercise. In these cases, the contract may provide for a **predetermined daily fee** on actual service activation, without distinguishing between fixed and variable costs, as in the examined case of Colbus in the Bolognese Apennines.

Optimization and reduction of fixed costs

Fixed costs are critical to DRT economics and should be managed from the start:

- integration of the service into the LPT can facilitate the containment of these items through the **shared use of existing resources**, optimization of the vehicle fleet, and flexible management of support staff;
- special attention should be paid to **booking platforms**, which are a major fixed cost item. The choice between SaaS (*Software as a Service*) solutions and internally developed platforms significantly affects overall costs: it is important to evaluate the most efficient option in terms of initial investment, maintenance costs, and scalability, while also considering the possibility of sharing these platforms with other TPL services to maximize economic efficiency.

Fixed cost item	Optimization strategies
Dedicated vehicle fleet (purchase/lease)	- Sizing the fleet according to demand, avoiding underutilized vehicles; - Give preference to small or low operating cost vehicles that are compatible with the expected loads; - Also use DRT vehicles on regular low-frequency rides, during times when they are not booked, to improve their economic performance
DRT booking and management platform	- Evaluate SaaS solutions versus in-house development based on cost and scalability; - Integrate the platform with the existing TPL system to avoid duplication; - Share the platform among multiple agencies/operators if the service serves multiple areas; - Evaluate interoperable and shared inter-municipal or regional solutions to standardize service and reduce costs
Infrastructure and support staff	- Use existing facilities (e.g., operations center, call center), avoiding duplication; - Train staff to manage both DRT and TPL, increasing operational flexibility; - Share fixed costs among multiple entities in the case of inter-municipal or supra-municipal services

Table 8-3 Main DRT fixed cost items and optimization strategies

Optimization and reduction of variable costs

The variable costs of DRT **depend directly on the volume of service delivered**. To contain the economic impact of the model, it is essential to intervene with organizational and technological solutions that improve operational efficiency without compromising effectiveness:

Variable cost item	Optimization strategies
Operation and consumption (mileage, vehicle wear and tear)	- Carefully plan areas and times of operation early in the service design phase to optimize demand coverage; - Optimize routes through routing (*dispatching*) software. These tools allow more efficient routes to be planned, reducing empty distances traveled and improving vehicle utilization; - Optimize preventive maintenance processes on actual vehicle usage. This approach reduces corrective interventions, helping to contain overall operating costs, reducing breakdowns and extending the useful life of components - Employ fuel-efficient or high-efficiency vehicles, consistent with the service required
Employment of personnel (driving hours)	- Adjust shifts according to actual demand, avoiding unnecessary deployments in low-demand slots; - Employ part-time or flexible shift staff, always in compliance with current regulations; - Allow staff to be deployed on other TPL services as well, optimizing the use of human resources

Table 8-4 Main DRT fixed cost items and optimization strategies

Financial and tariff sustainability

When defining the financing model for DRT service, it is also important to consider the tariff structure to be applied to users, as it represents a **major component of service revenues**. Indeed, the setting of tariffs affects the overall economic balance, affecting the share of financial coverage that can be generated directly through users and, consequently, the extent of any compensation to be paid to the operator.

The flexible and customizable nature of DRT may result in differential operating costs compared to scheduled LPT, making it appropriate to provide for tariffs that can be modulated according to the type of service provided. **It is appropriate for the service contract to provide clear and regulated tariff conditions** that distinguish between standard situations and services with greater individualization, maintaining objective and transparent criteria for the user and the awarding entity.

Service or user characteristics	Applicable tariff criterion
DRT in adduction to the main TPL network (up/down at stops on the main network)	- Integrated LPT fare (ordinary ticket or season ticket), since it is a complementary service to the main network.
Point-to-point DRT (custom origin and destination)	- Dedicated or additional rate, commensurate with the higher level of customization (e.g., mileage or fixed surcharge).
Users entitled to concessions (LPT subscribers, the disabled, the elderly, students)	- Reduced or symbolic fare, aligned with TPL facilities to ensure equity and accessibility.

Table 8.5 Tariff differentiation by service or user characteristics

8.2. Possible integration strategies in the service contract

As for how **DRT services can be integrated** within local public transport **service contracts**, some possible **strategies for incorporating DRT into the service contract** are outlined below

The integration of DRT services into local public transport service contracts can be implemented in different ways, chosen according to network design, contract structure and territorial coverage objectives. Two distinct approaches are noted in national contexts, corresponding to as many operational configuration models:

- **Direct inclusion of** the DRT in the service contract as an integral part of the minimum service;
- **Separate** contracting of DRT services through stand-alone contracts, external to the main LPT contract.

Each approach involves specific contractual choices, particularly about:

- DRT's contractual schedule, specifying the areas served, operating modes, and recognized service volumes;
- The method of determining and settling the fee;
- The articulation of the performance monitoring system;
- The application of any reward or penalty clauses.

8.2.1. Direct integration

The direct incorporation of DRT into the service contract takes the form of a mode in which DRT is recognized for all intents and purposes as an ordinary mode of operation of local public transport, subject to the same planning, entrustment and control criteria as for scheduled services. The service contract incorporates its specific characteristics, including it in the general network with functions of adduction, replacement or coverage of low demand areas, through consistent planning and unified reporting. In this scenario, the **DRT** is therefore not configured as an additional or experimental service, but **as a structural component of the network**.

Consistent with the provisions of the Transportation Regulatory Authority in Resolution No. 48/2017, the integration of DRT into the contract presupposes the existence of spatial planning that explicitly defines the treatment of areas of weak demand and their articulation within the local public transport system. Specifically, the planning:

- identifies **weak demand areas** based on objective and measurable criteria, such as population density, distribution of demand, and accessibility to essential services, consistent with potential demand parameters;
- identifies **the most appropriate mode of operation for each area**, including the adoption of DRT or other flexible solutions, taking into account observed demand and sustainable operating costs;
- allows the establishment of differentiated economic targets, with cost coverage thresholds compatible with the operating conditions of the areas concerned, subject to minimum service obligations;
- directs planning toward transportation solutions other than fixed-route scheduled services, where these are more likely to meet the expressed demand, according to a **public service** logic **built on the basis of actual user needs**.

Planning must therefore be supported by an **analysis of transportation demand** broken down by zone, time slot, and user profiling. The location of DRT service cannot be defined in the abstract or as an exclusive function of existing supply, but it requires a timely analysis of mobility needs not covered by the ordinary network. **In the presence of an integrated planning system** (*Basin Plan, PUMS, territorial operating plans*), **the inclusion of DRT in the contract can take place with a high degree of functional consistency, avoiding duplication, overlap or gray areas of responsibility**.

In the direct integration model, the DRT is explicitly described in the body of the service contract or in a technical annex, with elements defining its operational and management characteristics. In particular, the following must be specified:

- **The areas covered by the service**;
- **operational arrangements**, including reservation systems, hours of availability, type of vehicle used, and associated information infrastructure;
- **the recognized service volumes**, expressed in equivalent kilometers or other parameter compatible with the adopted cost model;
- **the expected fee**, which can be dedicated or integrated into the total fee recognized for the minimum service.

The DRT, where integrated, is subject to the same rules applied to other minimum services, including mechanisms for reporting, performance monitoring, penalty or reward system, as provided in the dedicated sections of the service contract.

8.2.2. Separate contracting

Another way of integrating DRT into the local public transport system is through **separate contracts**, through **contracts or conventions independent of the main service contract**. This strategy is adopted when DRT service is **marginal, experimental or punctual in nature**, and it is more effective to manage it with dedicated contractual instruments, while maintaining external coordination with the LPT operator.

In the separately entrusted model, DRT **is not included in the scope of the standard LPT service** and **is not regulated within the main operating contract**. The service operates as an **ancillary intervention**, often at the initiative of local authorities or the LPT governing authority, and is intended to **cover portions of the territory, time slots or users** not adequately served by the standard network. Positioning with respect to the system may vary according to scope:

- **complementary**, if integrated on the information or tariff plan;
- **residual**, if managed in total autonomy from the ordinary system.

The activation of services through separate contracting **does not necessarily presuppose a systemic framing in planning tools** (PUMS, Basin Plan, etc.), although such consistency is desirable. More often, such services arise from:

- specific local needs not covered by the general contract;
- external funding opportunities (e.g., European funds, regional measures);
- experiments promoted by municipalities or agencies in an autonomous form.

The temporary and circumscribed nature is a common feature of many separate contracts in which the duration is often **limited in time**, partly due to the availability of funding or the pilot nature of the intervention. In the absence of explicit renewals or later formalization in the general contract, such services remain **external interventions with limited validity**.

Fostering can be done through:

- **autonomous service contract**, with definition of fee, operating conditions, duration and minimum obligations;
- **temporary concession or regulated authorization**, in which the managing entity operates under defined conditions, but with wider organizational margins;
- **direct agreements between local government and third-party operators** (e.g., cooperatives, NCCs, collective cabs), with regulation of economic flows and responsibilities in a simplified manner.

In some cases, services may be operated by entities already active in the area, but outside the scope of the main contract. Contracting may include **minimum forms of integration** with the existing system (e.g., electronic ticketing, publication of schedules on institutional portals, shared reservation systems), without implying formal inclusion in the service contract.

Although not included in the service contract, **these procurements may provide for forms of technical coordination with the local public transport system**, such as using the same electronic ticketing platform, publishing hourly information on official entity channels, and adopting compatible digital tools for booking. These forms of coordination do not change the contractual nature of the service, which remains external to the main contract and does not fall under the definition of a minimum service.

8.2.3. Comparison and general considerations

The two strategies for integrating the DRT into public transport systems have differing configurations **from contractual, operational and institutional** perspectives**.** To facilitate the reading of the following Table 8-6, the elements of comparison are grouped into **four thematic areas**, reflecting the logical sequence of building and operating a DRT integration model:

1. *Institutional and contractual framing*: placement of the DRT in relation to the service contract and how it is legally formalized;
2. *Planning and economic regulation*: reference tools and criteria for determining consideration:
3. *Operational and time management*: service duration, entrusted parties and organizational configuration;
4. *control, coordination and digital tools*: monitoring systems, technical interoperability and degree of integration into the existing network.

Subject area	Parameter	Direct integration	Separate custody
Institutional and contractual framework	Contractual classification	Included in the main service contract as a minimum service component	Autonomous contract, out of the main CdS
	Contract formalization	In the body of the main contract or in technical annex with full validity	In separate contract or deed, with independent regulation and simplified structure
Economic planning and regulation	Technical formalization	Detailed in the contract documents and technical annexes	Regulated in separate acts, concessions or direct agreements
	Reference planning	Consistent with the basin plan and/or superordinate documents	Sometimes external to official planning, activated by local initiative
	Fee and how it is calculated	Included in total consideration or defined by separate item	Self-defined, on a mileage or flat-rate basis
Operational and time management	Duration of service	Stable for the entire duration of the contract	Temporary or tied to specific resources
	Service manager	Same operator holding the CoS	Internal or external parties (cooperatives, NCCs, other operators)
Control, coordination and digital tools	Monitoring and KPIs	Included in the contract control system	Variable, often unstructured or delegated to the local authority
	Technology/information integration	Full (ticketing, mobility info, reservation)	Possible but optional, does not imply inclusion in the CoS
	Placement in the network	Integral part of the ordinary network, programmed upstream	Ancillary service, complementary or parallel to the main network

Table 8-6 Comparative table - Strategies for integrating DRT into the service contract.

The strategies described respond to different operational and institutional needs:

- **direct integration** is indicated in contexts where the DRT is a stable and planned part of the network, with full contractual regulation and inclusion in the LPT service. It requires a sound planning framework and control tools already in place;
- **separate contracting** is an agile and adaptable solution, useful for punctual interventions, in marginal contexts or those not covered by the CoS. It is easier to activate, but less structured in terms of governance and long-term sustainability.

In summary, it is good that the choice among strategies should consider the **spatial configuration**, the **relevant institutional structure**, the **current planning**, and the **contractual capacity of the awarding**

entity, evaluating the balance between operational efficiency, service inclusiveness, and economic sustainability.

8.3. Performance indicators (KPIs) to be included in the contract of service

In the context of this paper, the inclusion of *performance indicators* (KPIs) in service contracts represents a **tool for defining measurable criteria for evaluating, monitoring and controlling service delivery.** KPIs assume particular relevance in DRT services as an operational mode that, due to inherent characteristics, **does not lend itself to the immediate application of traditional line standards**.

This section is therefore devoted to suggesting some possible **performance indicators** (KPIs) specific to DRT services by classifying them into four functional areas: **service quality, operational efficiency, economic sustainability and integration with the LPT.** For each area, **measurable metrics** and **criteria for contractual application** are proposed, with a comparison between **indicators provided by current regulations and KPIs proposed ad hoc for the DRT**, compared to the minimum set provided by ART Resolution No. 64/2024.

8.3.1. Service Quality KPIs

Quality indicators measure the **ability of the service to meet user needs**, both in subjective (perception) and objective (regularity, accessibility) terms. In dial-a-ride services, these KPIs assume an important role, as they allow the evaluation of the quality actually delivered in services that are not structured on fixed schedules or routes.

User satisfaction

This indicator is collected through periodic surveys, including sample surveys, which return a summary index (*Customer Satisfaction Index*) representative of the **judgment expressed by users**. The contract may provide a threshold value to be met on an annual basis, expressed as a percentage of satisfied users or as an average score on a defined scale. The most common areas of survey include service availability, ease of booking, punctuality, comfort on board, and quality of interaction with staff. The indicator allows assessment of perceived quality and, if well structured, can support decisions on targeted corrective action.

Service rate and reliability

The service rate expresses the **percentage of rides performed, compared to those booked**. This KPI is particularly relevant in the DRT, where each ride is activated upon individual request and failure to deliver can undermine confidence in the system.

$$\left(\frac{trip\ made}{trip\ booked}\right)\%$$

The contract may establish minimum reliability thresholds and provide for the exclusion of trips canceled due to external causes or lack of demand. The indicator makes it possible to monitor the **operational regularity of the service and its effective responsiveness to expressed demand**.

Accessibility

This indicator assesses **the extent to which the service is accessible** to all users, both in terms of physical accessibility (e.g., the presence of vehicles enabled to transport people with disabilities or reduced mobility - PRM) and in terms of digital accessibility. Measurement can be based on data such as the percentage of rides made with accessible vehicles, the percentage of reservations made via telephone (relevant for non-digitized users), and the share of requests processed via apps or online platforms. Inclusion of this KPI in the contract allows **the service to be aligned with the principles of universality, equity, and usability** expected for LPT.

8.3.2. Operational Efficiency KPIs

Operational efficiency indicators measure the **relationship between the resources deployed and the results achieved in terms of service production and utilization**. In the case of DRT, these KPIs make it possible to assess the adequacy of the adopted model with respect to actual demand, the balance between cost and utilization, and the ability of the service to operate in a timely and functional manner.

Load factor

Load factor expresses the **average vehicle load factor**, calculated as the **ratio of passengers carried to available seats**. In DRT services, where vehicle composition may vary (minibuses, M1 vehicles, etc.), the value can also be expressed in normalized form through the ratio of passenger-km to seat-km offered:

$$\frac{passenger\ km}{seat\ km\ offered}$$

This indicator allows monitoring the **adequacy of service sizing relative to the demand served** and can be disaggregated by area, time slot, or type of vehicle. Persistently low values indicate possible oversizing or misallocation of availability.

Productivity

Productivity measures the **intensity of service use**, i.e., the number of passengers carried in relation to kilometers traveled or hours of service provided.

$$\frac{passenger}{km} \quad \text{oppure} \quad \frac{passenger}{service\ time}$$

In the DRT, where the service is activated by reservation, this indicator makes it possible to **compare the efficiency of different** operating **schemes** (fixed, semi-dynamic, dynamic) **and to support possible recalibrations of the model**. Productivity can vary significantly depending on the spatial context and the reservation mode adopted.

Efficiency of service utilization

The indicator measures the **degree to which the service is used compared to the contracted availability**. It is defined as the ratio of hours of service provided to the total hours in which the service could have been active, according to the agreed operating plan or time window:

$$\left(\frac{actual\ hours\ of\ service}{total\ hours\ available}\right)\%$$

The indicator makes it possible to **highlight the unused time that still burdens fixed costs** and provides a useful benchmark for optimizing operational organization, assessing any over-availability of resources, and calibrating service delivery to actual demand.

Punctuality and regularity of operation, user waiting time

This indicator assesses **the ability of the service to meet the pickup time stated at the time of booking**. It can be expressed as an average wait in minutes or as the percentage of requests served within a predetermined time threshold (e.g., 15 or 20 minutes). An additional useful parameter may be the average delay per ride compared to the scheduled time.

In the service contract, punctuality can be declined depending on the service configuration (fixed points, time window, flexibility margin) and must be compatible with available tracking technologies. This KPI makes it possible to assess the actual quality of the user experience in the DRT.

Demand response capability

Measures the ratio of projected demand to actual demand served, and allows for **an assessment of consistency between planning and operational capacity**. The value can be estimated on an aggregate basis (e.g., basin or area served) or disaggregated (by time slot or user type). In a DRT system:

$$\left(\frac{requests\ fulfilled}{total\ requests\ received}\right)\%$$

The indicator is useful for identifying situations of overload, lack of resources or organizational inefficiencies. In experimentation, it can be associated with minimum acceptable thresholds, above which operational revisions are triggered.

8.3.3. Economic Sustainability KPIs

Indicators of economic sustainability make it possible to **assess the balance between the costs incurred in providing the service and the revenues generated, as well as the overall economic efficiency of the operating model**. In DRT services, economic measurement requires adaptation of traditional LPT parameters, depending on demand variability, service flexibility and the structure of the contract applied (net or gross cost).

Cost per passenger carried

Represents the ratio of **total operating cost to the number of passengers carried in each period**. It can be calculated gross or net of traffic revenues, depending on the contract configuration.

$$€_{passenger} = \frac{operating\ costs}{passengers\ carried}$$

This indicator makes it possible to **assess the overall efficiency of the service** and can also be used in experimentation to compare different operational solutions on a consistent basis.

Operating cost per km

Measures the **average operating cost per kilometer produced**, including the main expense items: fuel or energy, maintenance, personnel, vehicle depreciation, management and overhead.

$$€_{vehicle-km} = \frac{operating\ cost}{km\ traveled}$$

Alternatively, it can be calculated on a €/seat-km basis, which is useful in the case of variable capacity vehicles. **The definition of the parameter should be consistent with the cost structure in the contract** (e.g., in gross or net cost cases). This KPI finds application in integrated models where DRT is part of the minimum service.

The indicator is affected by service optimization, shorter routes result in a higher unit cost.

Cost per equivalent km offered

Measures the **unit cost related to the theoretical amount of service made available**, expressed in scheduled equivalent kilometers.

$$€_{km\_eq} = \frac{total\ operating\ costs}{equivalent\ km\ offered}$$

The indicator enables ex ante assessments of sustainability and comparisons between models with different service intensities, assuming a standardized conventional metric.

This KPI **is applicable** only to **DRT services** that have a **semi-fixed configuration** or guaranteed coverage on a spatial and hourly basis (e.g., basic routes with detours or network of points served with hourly availability), while **it does not lend itself to fully dynamic point-to-point models with** no predefined service structure.

Traffic revenue per km

Indicates the amount of **revenue generated from the sale of tickets** (including any refunds for fare concessions/exemptions) **per kilometer produced**:

$$€_{vehicle-km} = \frac{traffic\ revenue}{actual\ km\ (reported)}$$

The indicator provides an element of **assessment of economic performance in terms of attractiveness and fare participation by users**. It can also be used to compare different areas or successive time periods.

Cost coverage rate

It expresses **the degree to which the service is self-supporting**, that is, the proportion of costs covered by traffic revenues.

$$coverage\ ratio = \frac{traffic\ revenue}{operating\ cost}$$

The value can be defined as a minimum threshold to be achieved or as an indicator for informational use only, depending on the type of contract applied and the purposes of monitoring. It is consistent with the provisions of Article 19 of Legislative Decree 422/1997.

8.3.4. KPIs of Integration with TPL

Although not included among the minimum indicators provided for in Annex 7 of ART Resolution 64/2024, KPIs of integration with the local public transport network may be particularly **relevant** in the case of DRT services, where they are conceived as **complementary or adduction systems to the structured network**. The inclusion of these indicators in the service contract is intended as a proposal in an operational key, functional to verify the DRT's contribution to the overall coherence of the mobility system.

Intermodality of users

This indicator assesses **the extent to which DRT passengers also use other public transport services from the same trip**. It can be measured by integrated travel data, O/D analysis, or dedicated surveys.

The data collected make it possible to estimate the proportion of users who make at least one interchange between DRT and LPT (road or rail), indicating **whether DRT actually functions as a complementary mode to the structured network**. The value can be expressed as the percentage of DRT users who use, on the same route, at least one other TPL service.

Number of DRT-TPL interchanges

Indicates the amount of **interconnections recorded between the DRT and the LPT network** in a given period, at the node or origin/destination level. The survey can be done by:

- Analysis of travel sequences on integrated electronic ticketing systems;
- Tracking on digital platforms (travel planner, booking apps);
- Estimates from shipboard surveys or external surveys.

The value can be expressed as an absolute number or related to the total volume of passengers carried.

O/D monitoring for integrated DRT services

For integrated services, it may be useful to have an **indicator based on origin/destination matrices** to analyze the **actual flows generated by the DRT and their functional connection to the LPT network**.

This analysis makes it possible to **show whether DRT actually intercepts first- or last-mile demand** and whether **connection points are functionally located** with respect to prevailing mobility flows.

8.3.5. Comparison and general considerations

The comparison between the proposed indicators for DRT services and those contained in Annex 7 of ART Resolution No. 64/2024 should not be understood as a direct overlap. In fact, Annex 7 defines a minimum set of KPIs for local public road transport, referring mainly to services with fixed timetable and predefined route.

In the case of DRT, the application of these indicators requires **methodological adaptations**, **semantic reformulations** or, in some cases, **the introduction of specific indicators**, depending on the dynamic nature of the service. For example:

- the KPI "**regularity of rides**," defined in Attachment 7 as "*percentage of rides made on scheduled rides*," is reformulated in the DRT as the *percentage of requests honored versus reservations received*, changing the reference universe;
- the "**energy efficiency**" KPI, expressed as "*energy consumption per seat-km*," is difficult to apply in DRT services, where the vehicles used, the load carried and the routes vary dynamically;
- indicators such as **digital accessibility**, **demand-response capacity**, **intermodality**, or **connection to the TPL network**, while not provided for in Annex 7, are key to assessing the effectiveness and systemic integration of DRT services. Their introduction is an extension consistent with the principles of monitoring and transparency promoted by the Authority.

Functional category	KPI	Presence in Resolution ART 64/2024 Annex 7	Notes and specifics for DRT services.
Quality of service	User satisfaction	Present	Minimum standard KPI, directly applicable

Functional category	KPI	Presence in Resolution ART 64/2024 Annex 7	Notes and specifics for DRT services.
	Service rate/reliability	Adapted to the DRT context	Reformulated according to reservations, not on a fixed hourly basis
	Accessibility (physical and digital)	Adapted to the DRT context	Physical component provided; digital one is relevant addition for DRTs
Operational efficiency	Load factor	Present	Standard average load indicator, already included
	Productivity (passengers/km or hour)	Present	Included among the minimum indicators of the ART
	Efficiency of use	Not present	Useful for assessing the degree of actual utilization versus contracted availability. Highlights costs associated with downtime
	Punctuality and waiting time	Adapted to the DRT context	Rephrased punctuality: measured as meeting response time, not arriving on time
	Demand response capability	Not present	Proposed to assess the share of fulfilled requests in the total
Economic sustainability	Cost per passenger carried	Not present	Useful in comparisons between different DRT network types
	Operating cost per km / seat-km	Present	Planned among the essential economic KPIs
	Cost per equivalent km offered	Not present	Applicable only to DRT models with semi-fixed structure or guaranteed availability; useful for ex ante comparisons on a conventional basis
	Traffic revenue per km	Present	Included as revenue on a €/vehicle km basis
	Cost coverage rate	Present	Explicitly provided, consistent with Article 19 of Legislative Decree 422/1997
Integration with TPL	Intermodality of users	Not present	Proposed to measure the proportion of users who also use other TPL services
	Number of DRT-TPL interchanges	Not present	Indicator of effective modal connection
	O/D analysis for functional connection verification	Not present	Can be used in integrated or adduction-function models

Table 8-7 Functional comparison table between KPIs for DRT and ART indicators.

The "*adapted to DRT context*" KPIs and those proposed from scratch are therefore a **functional extension of the monitoring system**, aimed at ensuring the alignment of DRT service with the goals of accessibility, efficiency and economic balance required for integration into the LPT network.

The comparison presented confirms that a significant part of the KPIs provided for in Annex 7 of ART Resolution 64/2024 can also be applied to DRT services, **including through consistent and targeted reformulation with the on-demand logic and dynamic structure of these flexible services.** In other cases, the effective evaluation of DRT performance requires **specific indicators** not provided for in the national minimum framework, but fully **justified by the nature of the service** and its integrative function with respect to the ordinary network.

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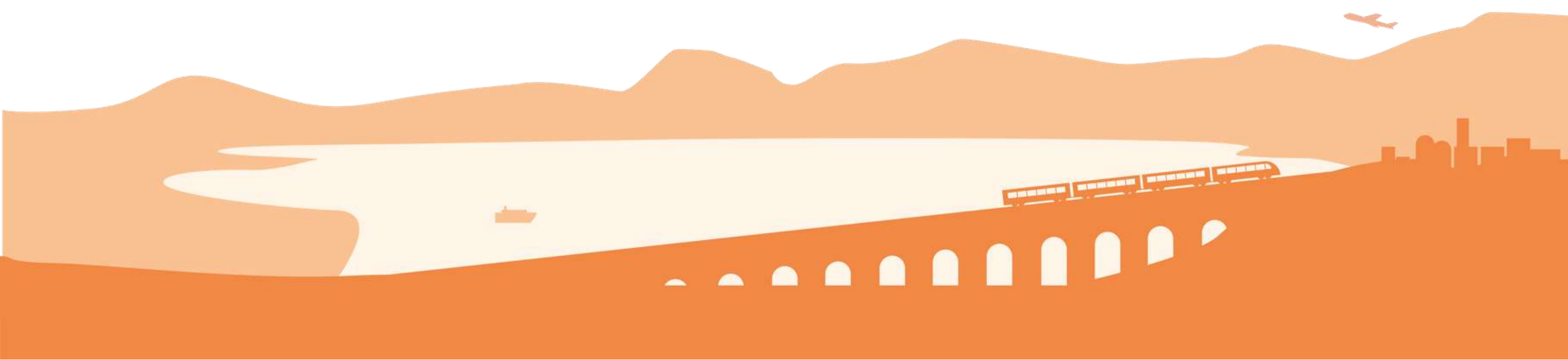
DREAM_PACE

BOLOGNA LIVING LAB - Study on potential integrations between demand assessment methodologies and parameters (and related tools, if any) and citizen and metropolitan planning tools (e.g., the future SUMP)

Final Version

07 2025



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1. Introduction

This document is part of the process developed with the DREAM PACE project, with the aim of ***exploring possible integrations between mobility demand analysis methodologies and urban and metropolitan strategic planning tools***, such as the SUMP (Sustainable Urban Mobility Plan) of the Metropolitan City of Bologna. In particular, it explores the potential use of the results obtained through an advanced *data fusion* and multilevel demand estimation approach, in order to objectively and effectively support the planning of public transport services, particularly in areas with low demand, with a specific focus on demand-responsive transport (DRT) services.

The initiative responds directly to the guidelines of **ART Resolution No. 48/2017**, which, especially in Annex 1 to Measure 3, emphasizes the need to link demand characteristics to service models and corresponding levels of supply for areas with low demand. In this context, this document aims to contribute to the construction of a **coherent and replicable methodological framework** that can be used to systematize the key dimensions of DRT service planning: demand, service levels, and economic sustainability. The approach adopted is divided into five main phases:

- **the identification of the service levels to be guaranteed**, depending on the intensity of demand, which is estimated in detail (both in the methodological and analytical parts) in Document B (;Analysis of potential demand and definition of areas with weak demand at the metropolitan level (in terms of geographical, socio-economic, temporal, and inter-territorial characteristics), with the identification of a methodology and parameters for defining the different degrees of demand and, where appropriate, the implementation/indication of tools to replicate this analysis at different times and in the future);
- **objective identification of areas with weak demand**, based on socio-demographic and territorial indicators and estimates of potential demand, through the proposal of a methodology capable of enriching the provisions of Ministerial Decree 157/2018 where applicable;
- the **definition of the** most suitable **operating model** for each area (fixed routes, on-demand, mixed), also assessing booking methods and integration with the existing local public transport network;
- **the identification of the salient features of the DRT service**, i.e., costs, revenues, and ideas for integration into the Service Contract (detailed in Document C - Study on DRT costs and the possibility of their inclusion in the Service Contract, with reference to Ministerial Decree 157 of March 28, 2018, Standard Costs), outlining the economic and financial scope of this type of service;
- the **assessment of possible remuneration models** based on the different estimated levels of demand and a preliminary economic and financial sensitivity analysis to guide the overall sustainability of the proposal.

On the basis of the above, the document is structured as follows:

- **Chapter 2** presents the methodological approach used to define potential demand and service requirements in areas with weak demand;
- **Chapter 3** illustrates the results of the practical application of the methodology to the metropolitan area of Bologna with regard to the definition of areas with weak demand;
- **Chapter 4** proposes an operational model for the organization of DRT services in relation to the characteristics of demand in the identified areas;
- **Chapter 5** introduces some preliminary hypotheses on service remuneration models, consistent with the operating conditions and expected demand.

2. Summary of the methodological approach for defining areas with low demand and service requirements for DRT services

Defining a truly efficient public transport system requires tools capable of reading mobility demand in a comprehensive, dynamic, and adaptable way to different territorial contexts. With this in mind, this chapter summarizes the methodological approach (detailed in Document B and described in chapter §2.4 of this document) adopted **to identify areas of low demand** in the Metropolitan City of Bologna and to **define appropriate service requirements**, with particular attention to demand-responsive transport (DRT) services.

The methodology is based on an innovative process of integration between different data sources – traditional and big data – which, through a *data fusion* approach, allows the construction of a multi-level knowledge base of mobility in the territory. This base supports the estimation of potential demand with a view to classifying the territory according to levels of mobility intensity and guiding service planning choices.

In order to reconstruct the operational logic underlying the results obtained from the application of the methodology, this chapter first summarizes the data integration process (§2.1), and then describes the method adopted to calculate demand and determine the thresholds and decision-making criteria useful for modulating supply in areas with low travel density. As described in Document B, this approach has been designed to be replicable and adaptable, providing a useful reference for contexts other than that of Bologna.

2.1. The data fusion process for calculating potential demand

As mentioned above, the demand analysis process in the Metropolitan City of Bologna adopts a ***holistic and integrated approach based on data fusion*** (detailed in Document B in its more methodological parts). This allows for the combination of multiple traditional and innovative information sources in a complementary and consistent manner, overcoming the limitations of individual sources and exploiting their specific strengths. The aim is to dynamically and accurately represent the mobility behavior of residents and city users, both for systematic and occasional reasons.

The methodology is divided into several operational phases, each with a specific function:

- ***Harmonized zoning***: creation of an ad hoc territorial base, with over 1,000 sub-municipal zones, to standardize the different sources and allow for their integration;
- ***Integration by sociodemographic profile***: breakdown of the population into combinations of age, gender, and occupation, useful for projecting mobility behavior;
- ***Double level of analysis***:
  - one focusing solely on residents, based on SUMP surveys and ISTAT data;
  - one global analysis of all users (including non-residents), based on telephone big data and integrated with Floating Car Data (FCD);
- ***Different outputs***:
  - a basis for comprehensive analysis of mobility dynamics (by seasonality, weekdays, Saturdays, and holidays, and in the presence of events);
  - a basis for detailed analysis of areas with low demand, focusing on residents;

This system allows for a layered analysis of systematic and occasional mobility, internal flows, exchanges, and crossings according to an approach in which each source contributes differently to the reconstruction of the overall mobility picture:

- **Socio-demographic data (ISTAT and Metropolitan Atlas):** essential for characterizing the population and for expanding the sample data. They offer high spatial granularity and frequent updates only with a high level of aggregation;
- **SUMP survey**: allows analysis of the motivation, mode, and socio-demographic profile of trips limited to the average weekday. Essential for estimating intra-municipal flows and assigning mode and reason to observed trips, although available with poor spatial granularity;
- **Telephone data (mobile network):** wide coverage (30% of the population) and unique ability to detect city users, exchanges, and crossings. It does not include reason and mode of transport, but provides excellent temporal and socio-demographic detail;
- **Floating Car Data (FCD):** enriches vehicle information, measures speed and travel times based on GPS, and improves the quality of estimates. It is essential for enriching certain estimates of telephone data, especially for short-range trips and in areas undergoing continuous urbanization.

2.2. Summary of the analysis of estimated demand on an average weekday in November 2024

The **average weekday in November** is the preferred reference for analyzing mobility demand in the metropolitan city of Bologna, as it provides the most complete and structured picture of typical travel behavior. On this '*typical* day' in November 2024, over 3.6 million trips were estimated, fully reflecting the pressure on the mobility network and its ability to respond to predominantly systematic demand.

An analysis of **the reasons *for travel*** confirms the central role of ***work-related*** travel, which accounts for around 30% of the total and exceeds 45% of flows to/from Bologna, with peaks of 54% leaving the capital. Alongside this, ***social activities*** account for around a quarter of journeys, especially within individual municipalities. This is followed by trips for ***personal reasons*** (accompanying others, errands), with a share of between 10% and 15%, while ***study*** accounts for 4.5%, but reaches 11% in flows into Bologna, in line with the presence of important educational centers.

The **modal split** shows strong territorial differences: ***private vehicles*** dominate on a metropolitan scale (over 59%), but their share falls to 42% for journeys within Bologna, where ***urban public transport*** (17%) and ***soft mobility*** are growing. Conversely, on radial routes towards the capital, cars account for over 90%, while ***extra-urban and rail transport*** account for just over 8% and 11% respectively. ***Pedestrian mobility*** accounts for around 24% of journeys, with higher peaks in denser urban areas, while ***cycling*** remains at an average of 5%, with slight increases in small and medium-sized municipalities.

In terms of **regularity**, only a minority of journeys are repeated ***regularly*** (between 4 and 12 times per month): 31% in the capital, 20% in internal metropolitan exchanges and 19% in flows with the outside. Cross-town travel is almost entirely ***non-systematic*** (1.4% between 1 and 3 times per month), indicating an episodic component linked to transit or occasional reasons. ***Systematic*** trips (more than 13 times per month) are mainly concentrated in the early morning hours and 85% originate from residents of the metropolitan area, confirming the high incidence of local commuting.

Bologna remains an attractive center and a crucial hub: it alone generates 28% of metropolitan travel and has over 470,000 daily exchanges with the rest of the metropolitan area, particularly with the municipalities in the inner belt. On a national scale, the capital city records approximately 95,000 arrivals and 95,000 departures per day, equivalent to 40% of the basin's external exchanges, strengthening its role as a strategic hub even beyond the metropolitan boundaries.

2.3. Methodology for calculating potential demand and defining service levels

This section illustrates the methodology developed to estimate potential mobility demand in different areas of the metropolitan area in a replicable manner and to define the most appropriate service levels in areas with low demand. This approach is designed to support DRT service planning decisions in line with the provisions of ART Resolution No. 48/2017, particularly in contexts where demand is discontinuous, dispersed, or concentrated at specific times of the day or week.

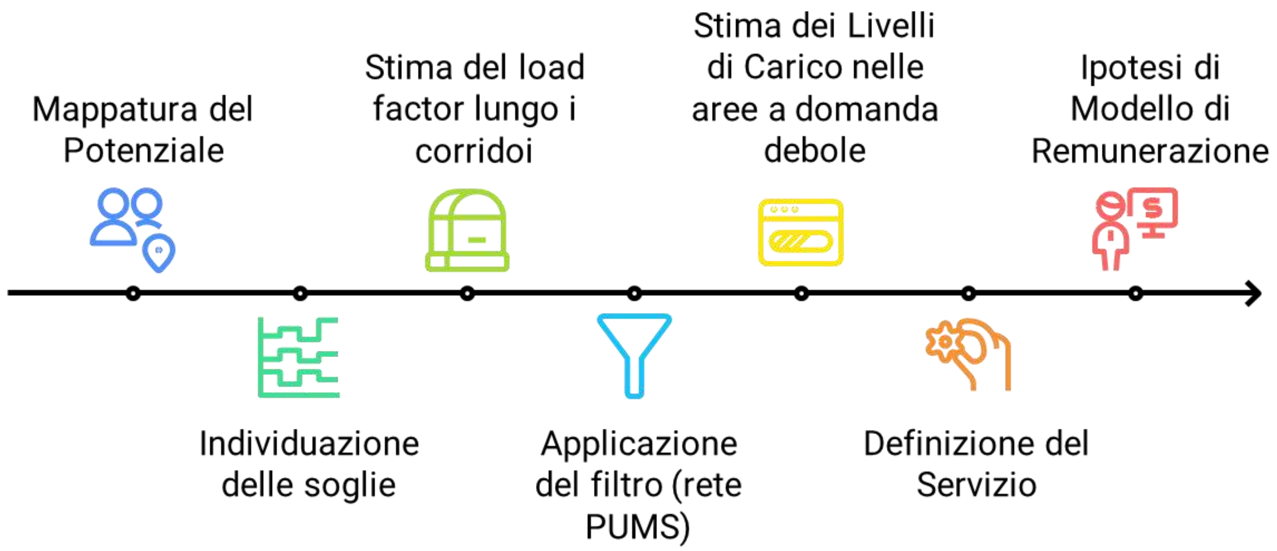

Figure 1 Graphical representation of the proposed methodology for calculating potential demand and defining service levels in areas with low demand (Source: GO-Mobility)

The methodology adopted (Figure 1) is based on a **quantitative and territorial reading of demand**, constructed through steps that allow the areas that are actually weak to be distinguished from those that are served or have structured demand. The entire process is structured as a logical sequence of analyses: from mapping the generative and attractive potential of trips, to assessing compatibility with the planned network, to estimating actual demand for different mobility relationships.

The aim is to provide a useful framework for selecting the areas in which to intervene, but also for calibrating the offer in terms of frequency, flexibility, and service configuration. The methodology also includes an initial orientation towards the DRT service remuneration model, directly linking the demand analysis to possible economic sustainability scenarios.

As mentioned above, the approach is designed to be transferable to other territorial contexts, providing a solid technical basis for integrated local public mobility planning.

2.4. The TPM network provided for in the SUMP

The SUMP for the Metropolitan City of Bologna devotes considerable attention to strategies for extra-urban bus services with a view to reorganizing the bus service in order to strengthen its strategic role within the entire Metropolitan Public Transport network (including the SFM and Bologna tramways). The main points that emerge from a strategic perspective are:

- **Rationalization and structuring of the service**: the new suburban bus network is designed to avoid functional overlaps and territorial inconsistencies, ensuring more equitable and functional coverage of the entire metropolitan area. The emphasis is on a service that is well distributed throughout the day and tailored to actual mobility demand;

- **Integration and network effect**: the aim is to build a coherent and interconnected system, with timetables, infrastructure, and information that facilitate modal interchange (e.g., with SFM and tramways), promoting more effective use of public transport and improving accessibility, including for potential users;
- **Strategic territorial function**: the suburban bus service is valued as the backbone of the TPM in areas not served by rail, with the ambition of contributing to the competitiveness and attractiveness of the metropolitan area;
- **Information and recognizability**: particular attention is paid to network communication, to make it easily understandable even to non-regular users and to encourage a modal shift towards local public transport.

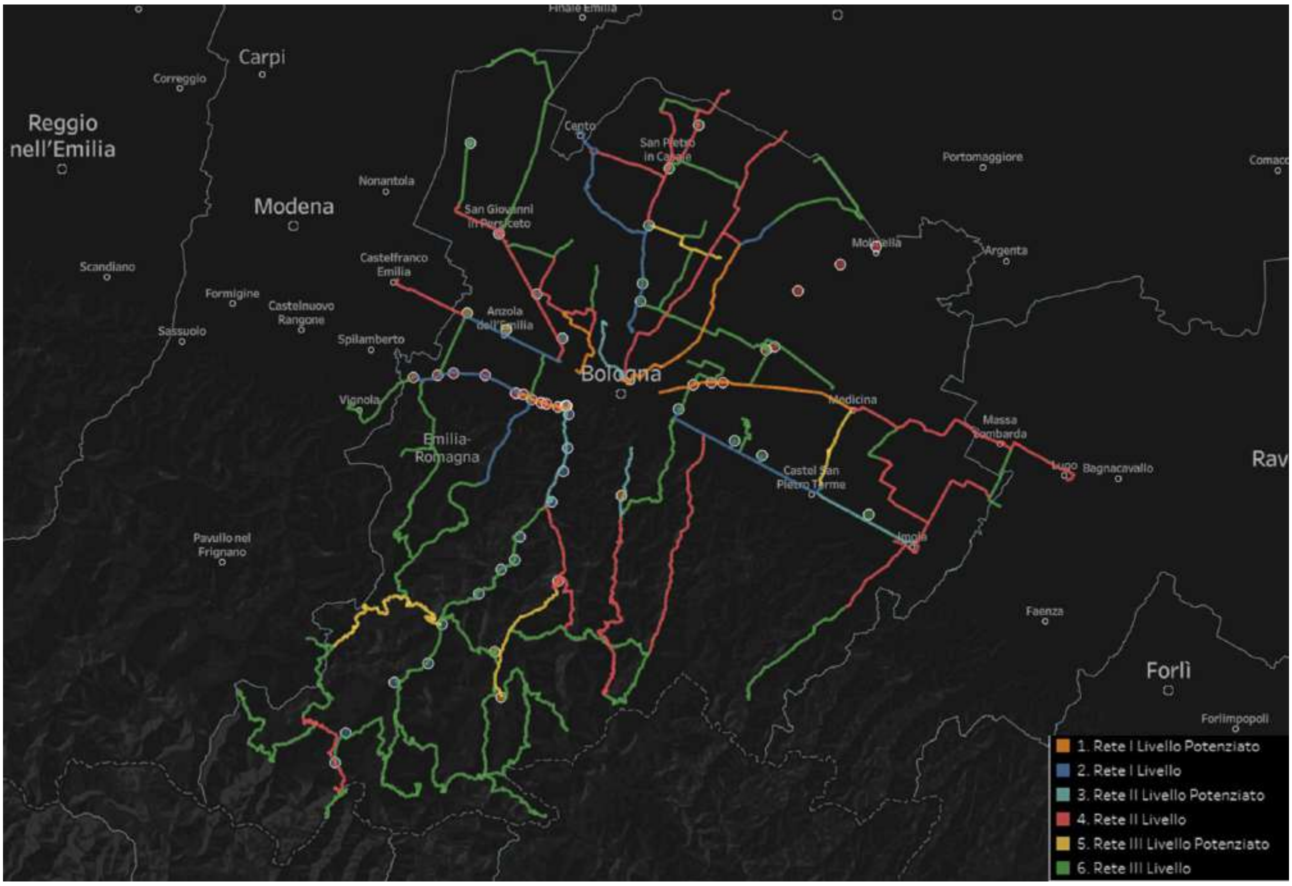

Figure 2 Classification of the suburban bus network into levels I, II, and III (Source: GO-Mobility analysis of SUMP data for the metropolitan city of Bologna)

Based on the above, within the strategic framework of the SUMP of the Metropolitan City of Bologna, the extra-urban bus network is reorganized into three functional levels (Figure 2), each with distinct service characteristics, with the aim of structuring a regular service that is consistent with mobility demand, in particular systematic demand:

- ***Rete di I Livello (Metrobus)***: this is the backbone of the TPM network and consists of high-demand inter-municipal connections, mainly radial and converging on Bologna. It provides high-frequency services, from 30 minutes to 15 minutes during peak hours or throughout the day in cases of higher demand. It is designed to operate on high-potential routes, often in competition or coordination with the SFM, and BRT (Bus Rapid Transit) systems are planned for use on some routes;
- ***Rete di II Livello***: this network connects the main secondary urban centers to the Level I network or the rail system. Frequencies range from 60 to 30 minutes, with additional services during peak hours. This level plays a crucial role in ensuring accessibility to areas not directly covered by the Metrobus or SFM, and is characterized by a territorial connection logic, including through Mobility Centers;

- ***Rete di III Livello***: includes inter-municipal and feeder connections for municipalities not served by the Level I and II networks and new cross-connections between municipalities with a mobility demand of more than 2,000 trips/day. Frequencies range from 120' to 60', with a minimum level of 8 trips/day for less-used lines.

At the top of the TPM structure is the ***Metropolitan Railway Service (SFM)***, which represents the highest level of public transport and forms the backbone of high-capacity services in the metropolitan area. Finally, ***an*** additional ***Rete di IV Livello*** has been identified as an integrated network that includes 'targeted services' such as school services, flexible services, and strictly local, tourist, or seasonal connections. This is the most suitable level for integration with DRT solutions and, in general, on-demand services, and is particularly relevant from a polycentric perspective of the territory.

This TPM network framework is a fundamental reference point for interpreting the structure of the services provided for in the SUMP and for guiding the planning of road transport services in a manner consistent with the characteristics of the territory and the estimated levels of demand. Within this document, the **methodology applied takes the SUMP TPM network as a key element for identifying areas with low demand,** i.e., those territories that are **not served by the Metropolitan Public Transport network** and which, at the same time, have **sufficient mobility generation potential to justify the activation of a public transport service.**

In this sense, therefore, the TPM network is not only a benchmark for verifying current and planned coverage, but also a **filtering and guidance tool** for the design of DRT services, to be activated precisely where potential demand exists but is not sufficient to support a regular scheduled service. The methodology thus allows for a combination of planning consistency and operational adaptability, identifying areas that are marginal to the main network but strategic in terms of accessibility and territorial inclusion.

2.5. The modal split targets set out in the SUMP

The Sustainable Urban Mobility Plan for the Metropolitan City of Bologna sets ambitious targets for modal shift, ***aimed at significantly reducing private car use and strengthening active mobility and public transport***. The quantitative target is to shift **440,000 daily car trips to other modes by 2030,** equal to 28% of current private vehicle demand. In particular, the SUMP identifies increasing the attractiveness and competitiveness of public transport compared to cars as a priority lever, setting medium- to long-term objectives that include:

- an overall increase in the modal share of public transport, especially in low-density areas that are currently served inefficiently;
- a reduction in car ownership and individual car use, including in inter-municipal travel;
- the strengthening of modal and fare integration between urban, suburban, and rail services.

Specifically, the 2030 Plan Scenario identifies the following targets at the metropolitan level (Figure 3):

- the share of trips by public transport (**TPM**) increases from 13% to **19%**;
- the share of **bicycle travel will increase** from 5% to **14%**;
- the share of **walking will increase** from 22% to **23%**;
- while **private car** use will be reduced from 57% to **41**%.

As a result of this shift:

- **38%** of trips taken by car are expected to be absorbed by public transport,
- **54%** by bicycles;
- **8%** by walking.

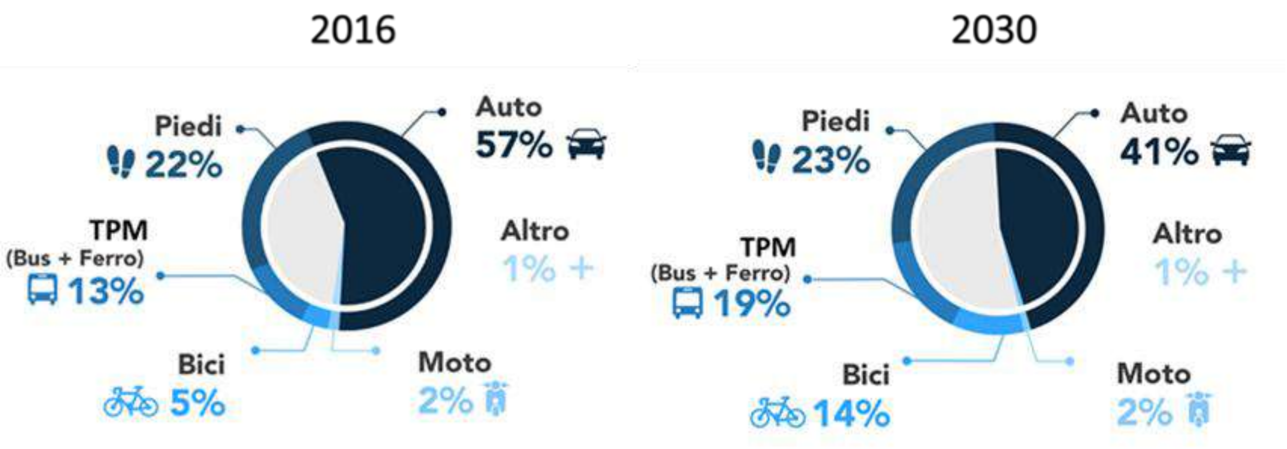

Figure 3 Comparison of modal split between 2016 and the metropolitan targets of the SUMP-2030 scenario (Source: SUMP of the Metropolitan City of Bologna)

MACRO AREA	CAR	MOTORCY-CLES	PUBLIC TRANSPORT	BIKE	FOOT	OTHER
BOLOGNA Municipality	22%	4%	28%	18%	27%	1%
BOLOGNA Center	13%	3%	31%	20%	33%	1%
BOLOGNA outside the city center	27%	4%	27%	17%	25%	1%
IMOLESE	52%	0%	8%	19%	21%	0%
FLAT	56%	0%	11%	14%	19%	1%
WAIST	55%	1%	15%	6%	23%	0%
HILL-MOUNTAIN	64%	0%	12%	2%	22%	0%
EXTERNAL	70%	3%	20%	1%	1%	5%
MODAL RIP (%)	41%	2%	19%	14%	23%	1%

Table 1 Modal split targets by macro-area in the SUMP scenario - 2030 - Targets (Source: SUMP of the Metropolitan City of Bologna)

It should be noted that the modal shift targets within the SUMP have also been calibrated at the level of individual macro-areas (as detailed in Table 1), in order to take into account the specific settlement, morphological and infrastructural characteristics of the different territories of the metropolitan city.

In general, these targets also represent the strategic reference framework for this document: the method-ology illustrated in this document integrates the SUMP targets into the assessment of potential demand, using the target values as a reference to estimate, on a spatially homogeneous basis, the demand on which to base the medium- to long-term planning of the local public transport network. In particular, the modal target ' ' have guided the sizing of **expected load levels** and constitute the reference for assessing **the advisability of activating DRT services in areas with low demand**, where traditional services would not be sustainable.

In summary, therefore, this document reaffirms the role of the SUMP as a framework tool and integrates its modal objectives into the construction of an operational tool that aims to translate strategies into concrete mobility solutions.

3. Results of applying the methodology for identifying areas with weak demand

The methodology proposed and applied in this document represents a structural link between the **three main measures provided for in Annex 1 of ART Resolution No. 48/2017**. On the one hand, it provides the multi-level knowledge framework required by ***Measure 1***, which is useful for representing potential demand and constructing fundamental quantitative bases for service planning. On the other hand, it provides the analytical basis for the objective classification of areas with weak demand as required by ***Measure 2***, through the identification of replicable thresholds and criteria. Finally, it integrates the results of the analyses into the definition of service levels consistent with the characteristics of demand and the related operational and remuneration models, in line with the requirements for areas with weak demand set out in ***Measure 3***.

The methodological proposal introduces significant innovative elements that strengthen its descriptive and operational capacity in complex contexts such as metropolitan areas. The first distinctive element concerns the use of innovative **data fusion** and the resulting opportunity to integrate heterogeneous sources to build a knowledge base on mobility demand at the metropolitan scale. This approach fully exploits the information assets developed in the project, overcoming the limitations of individual sources and improving the quality of potential demand estimates.

The second innovative element is the adoption of **sub-municipal zoning**, which divides the metropolitan area into over 1,000 homogeneous zones. This approach allows for a more granular reading of demand and more effective support for service planning that goes beyond the municipal scale provided for by Ministerial Decree 157/2018, allowing for greater adherence to actual accessibility conditions.

Finally, the methodology introduces a **selective focus on residents**, consistent with the objectives of the SUMP and with planning criteria geared towards the stable population, ensuring greater consistency in the assessment of structural mobility needs.

3.1. Mapping of generative and attractive potential

The first phase of the methodological application involves constructing a **synthetic indicator of potential demand** for each area of the metropolitan territory, obtained by combining the values of **generated and attracted** trips, normalized with respect to surface area. Since public transport must serve users as adequately as possible in terms of both space and time in order to be attractive, the key parameter calculated is the **demand density expressed in trips/km^2**, which allows for a homogeneous representation of the intensity of potential mobility on a spatial basis by identifying the average number of trips that take place in an area with a radius of approximately 500 meters.

The added value of this approach lies in **the combination of actual observed demand** (estimated using the **data fusion** procedure on a daily working day basis) and the **SUMP reference targets**, i.e., the levels of demand that the future Metropolitan Public Transport network is expected to meet. This integration has two objectives: on the one hand, to enhance current empirical knowledge of mobility, derived from the cross-referencing of heterogeneous sources (telephone data, sample surveys, FCD, sociodemographic data); on the other hand, it ensures **strategic consistency** with medium- to long-term planning objectives aimed at increasing the modal share of local public transport, providing an 'intuitive' reference value for **the journeys of residents** who are to be attracted to public transport.

This combination therefore makes it possible to estimate the **potential demand for public transport** not only on the basis of what is happening today but also in relation to **the desired demand**, providing a more useful representation for planning purposes. Furthermore, as mentioned, the analysis was carried out on **the 1,050 sub-municipal areas** into which the metropolitan area was divided, going beyond the traditional municipal scale and allowing for a much more granular reading of mobility dynamics that is better suited to public transport planning.

The output of this phase is a **thematic map of potential demand density** (Figure1), which highlights areas with higher and lower mobility intensity with spatial continuity. This tool provides the first objective basis for the subsequent classification of areas, in particular to identify contexts where the activation of DRT services may be functional in bridging accessibility gaps and achieving the plan's objectives.

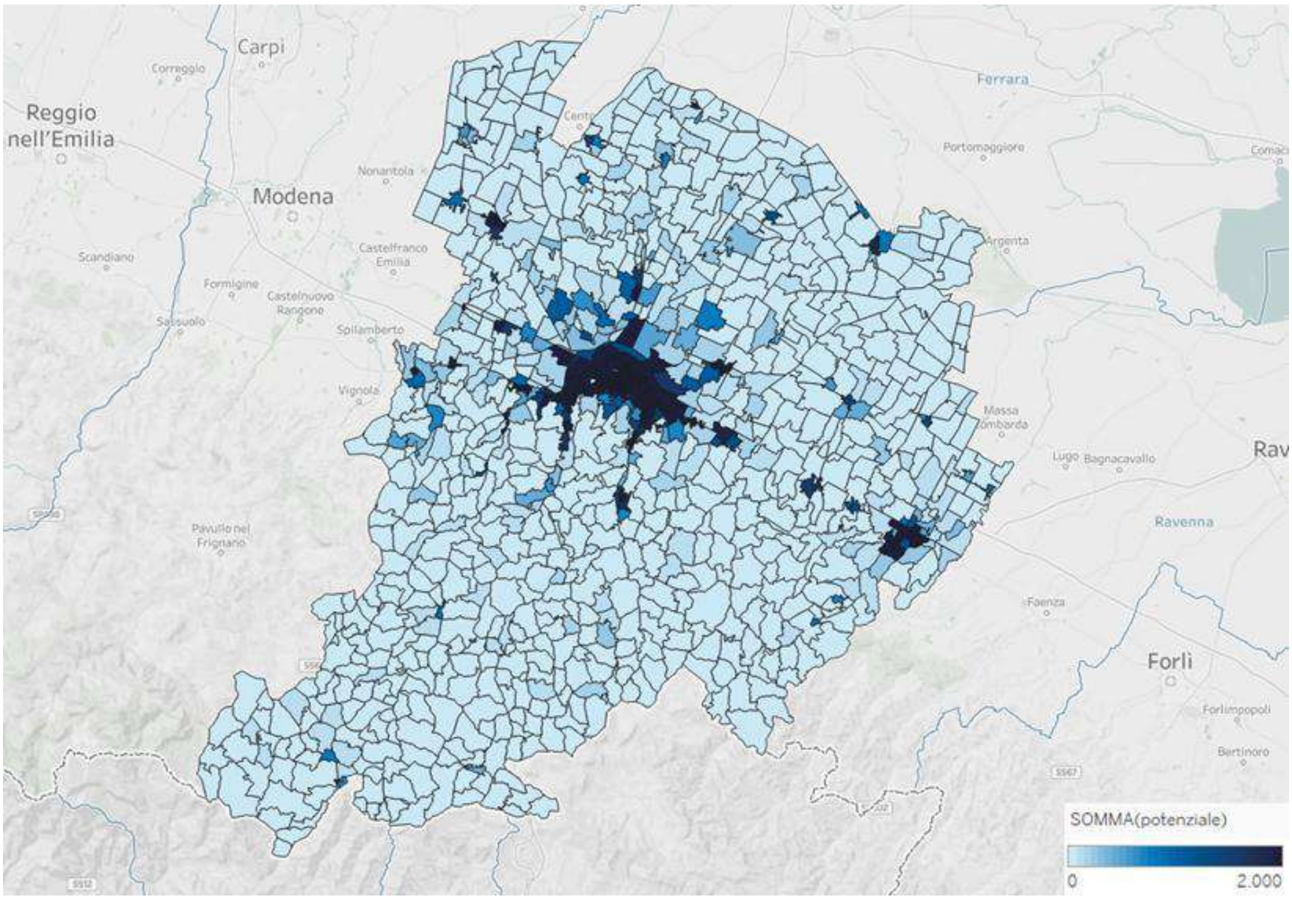

Figure1 Mapping of generative potential based on potential demand data from target SUMP (Source: GO-Mobility processing)

Among the main highlights that emerge from the mapping are:

Maximum concentration in the capital and along the main radial axes

The area of the Municipality of Bologna and part of its inner suburbs (Casalecchio, San Lazzaro, etc.) show the highest potential demand density values, with very dark shades (close to 1,000). This indicates a high intensity of trips generated and attracted per km², consistent with the presence of multiple attractors (work, study, services, intermodal hubs) and strong urbanization.

Presence of high-intensity secondary poles distributed throughout the territory

In addition to the provincial capital, high-density demand centers can also be observed in other areas, such as:

- Imola and neighboring municipalities (in the east);
- The first belt of Bologna (Casalecchio, San Lazzaro di Savena, Castelmaggiore, etc.);
- Castel San Pietro and the Medicina area (to the east).

These hubs represent urban or suburban agglomerations with a local role in generating demand, potentially candidates for structured or semi-structured local public transport services.

Widespread areas with very low demand in hilly and rural areas

The lighter shades (values close to 0 on the legend scale) are widespread:

- in the southern Apennines (e.g., municipalities such as Castel d'Aiano, Monzuno, etc.);
- in the northeastern lowlands (towards the borders with the provinces of Ferrara and Ravenna).

These areas have low population density and limited appeal, and are therefore the main candidates for the definition of flexible DRT services on a territorial basis.

3.2. Identification of classification thresholds

Starting from the potential demand density map developed in the previous phase, this methodological step aims to **classify areas of the metropolitan territory** according to estimated mobility intensity. The method adopted is based on the application of **progressive thresholds of trips per km²**, which allow areas with **very low**, **intermediate**, or **high demand** to be distinguished.

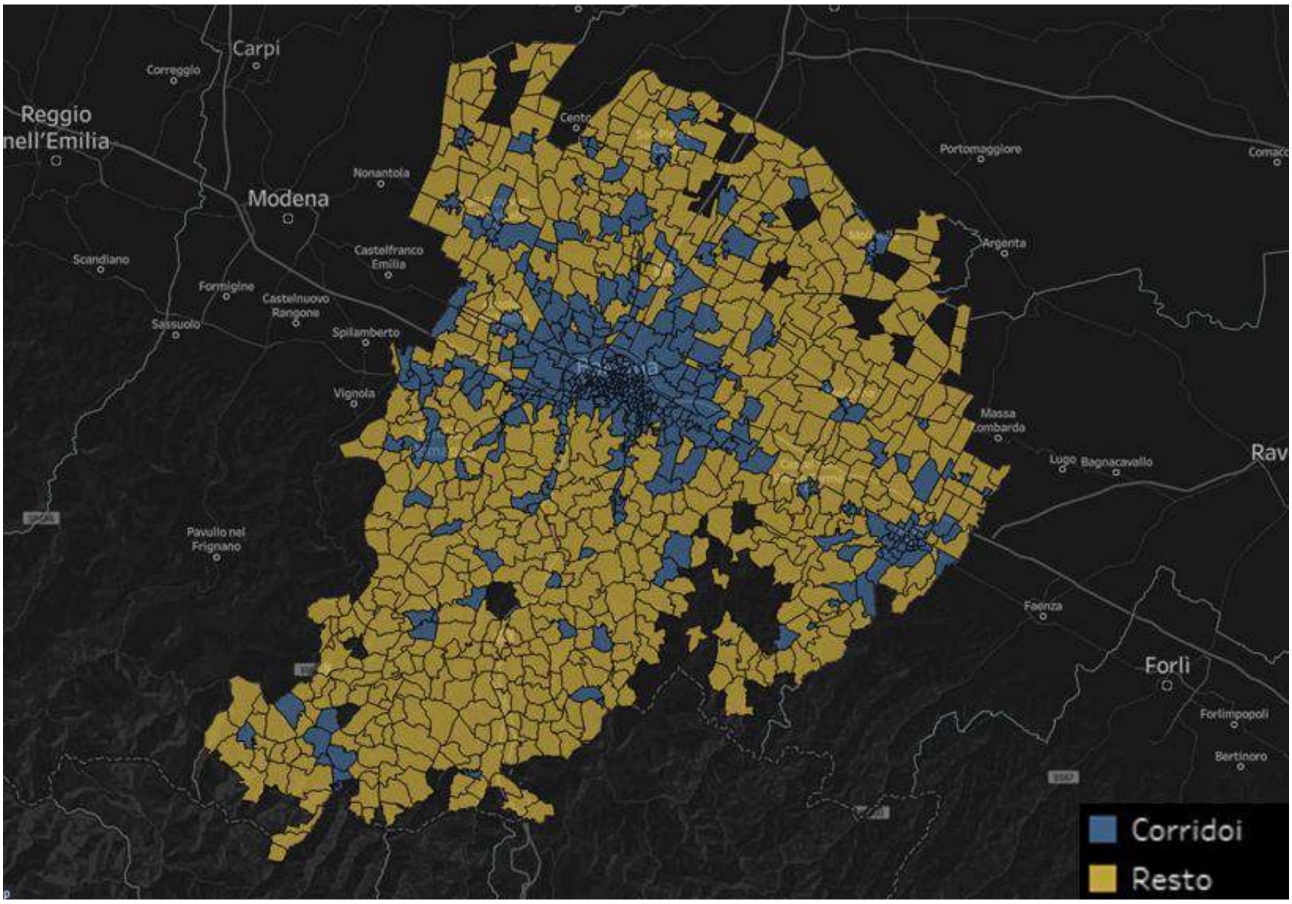

Figure 5 Subdivision of the territory according to classification thresholds for potential travel density in absolute terms (Source: GO-Mobility analysis)

Specifically, two main thresholds have been identified:

- a **lower** reference **threshold** of **2 trips/km² per day**, below which areas are considered to have very low demand, where the activation of a regular service may not be economically or functionally sustainable;

- an **upper threshold** of **80 trips/km² per day**, representing the maximum intensity range typical of the main public transport corridors on a metropolitan scale.

The map at Figure 5 shows the results of the classification of the metropolitan area according to **the estimated absolute density of demand**: the areas colored in **blue** indicate the nodes of **the high-mobility "corridors," while** the areas in **yellow** represent the **rest of the territory**, with values below the threshold of 80 trips/km^2 while those **in black** are areas where the activation of a public transport service is not considered sustainable and reasonable (potential demand density of less than 2 trips/km^2 per day). The distribution of the corridors highlights:

- a **strong linear and radial concentration around Bologna**, consistent with the hierarchical organization of the existing transport network;
- the presence of **a number of secondary centers** (Imola, San Giovanni in Persiceto, Castel San Pietro, etc.) with local attractions;
- **discontinuity in peripheral**, hilly, and mountainous **areas**, where demand appears fragmented or very diluted.

This classification makes it possible to clearly distinguish the **consolidated areas of the local public transport network**, where service must be guaranteed or strengthened, from **the weaker or more dispersed areas**, which will be the subject of subsequent phases of simulation, calibration, and DRT service proposals. It should be noted that the thresholds shown can be modified as desired depending on the level of demand to be served, and the tool allows for reasoning about specific service time slots by defining different thresholds on a case-by-case basis.

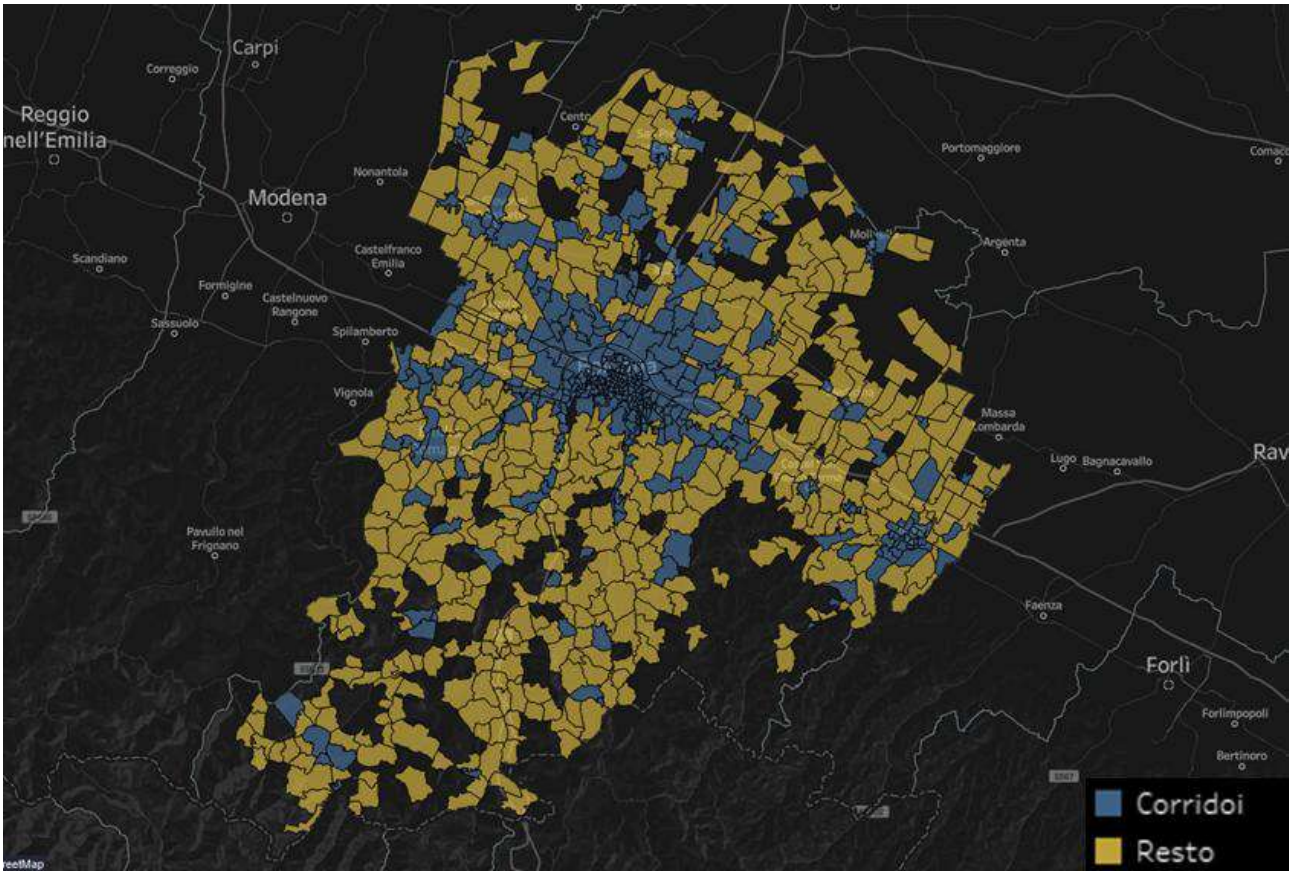

Figure2Division of the territory according to classification thresholds for potential travel density in terms of time (Source: GO-Mobility analysis)

It should also be noted that the **intermediate thresholds** were established using an incremental logic of **+5 passengers/km²**, in order to assess the **extensive convenience of the service** throughout the entire territory. This approach allows for a **progressive reading of the network**, which is useful for identifying with greater precision:

- **high-demand corridors**, where the existing service should be strengthened or consolidated;
- **marginal or fragmented areas**, where it may be appropriate to reorganize the service or introduce flexible solutions (e.g., DRT).

Therefore, all areas with density values between the two extreme thresholds (2–80 trips/km² per day) constitute the set of areas where it is potentially possible to introduce DRT services: These will be analyzed in greater depth in subsequent phases in order to assess the actual coverage provided by the SUMP network, the estimated spatial and temporal load, and consistency with the activation of flexible services.

Finally, in addition to the classification based on absolute thresholds, a **temporal** component has been introduced, which is useful for distinguishing areas with demand concentrated only in certain time slots or spread throughout the day and therefore difficult to serve. The parameter used was obtained by dividing the number of daily trips by the number of hours in which these trips take place, making it possible to identify situations where, despite overall demand being low, there are localized peaks that may justify a targeted or partial service.

3.3. Estimating load along main corridors

After identifying the corridors with the highest demand, the third step is to **estimate the expected load volumes along these main routes** to assess the compatibility between estimated demand and potential public transport supply.

The method applied is based on calculating the **load expressed in passenger*km**, obtained by multiplying the estimated number of passengers by the distance traveled for each segment of the network. This indicator makes it possible to estimate the total volume of demand traveling along each route and **compare it with the available capacity**, assessing the average **load factor** (i.e., the degree of saturation of the service offered).

The analysis was carried out with reference to **the network assumptions and the level of service of the Metropolitan Public Transport (TPM) provided for in the SUMP** (detailed in paragraph §2.4), allowing the results of the demand modeling to be compared with the planning choices already adopted during the planning stage. This initial comparison is a useful step in **further refining the planned supply in relation to actual demand**. The analysis (Figure 7) highlights **some significant results:**

- **Confirmation of the main radial corridors to Bologna**, which maintain a central role in the network structure, although in some cases there is a possibility of reconsidering the hierarchical levels assigned by the SUMP. In particular, some sections currently classified as Level I could be reconsidered as Level II, based on actual simulated demand;
- **Level upgrade for specific corridors**: two routes show higher than expected demand and therefore greater compatibility with more intensive service levels:
  - the **Bologna-Monterenzio-Monghidoro corridor**, along the Idice Valley, which shows a more solid demand structure than expected, thanks in part to its role as a feeder to the central node;
  - the **Imola-Castelfiumanese corridor**, which is an intermediate axis of local interest but with volumes that justify a transition to a more stable and regular service level.
- **Load factors are low in the Apennine areas**, where estimated demand is low in terms of passenger*km. When comparing the service levels planned by the SUMP, it is also worth considering other factors, such as the role of public transport in serving the local area, which makes a lower load factor acceptable given the fragmentation of demand.

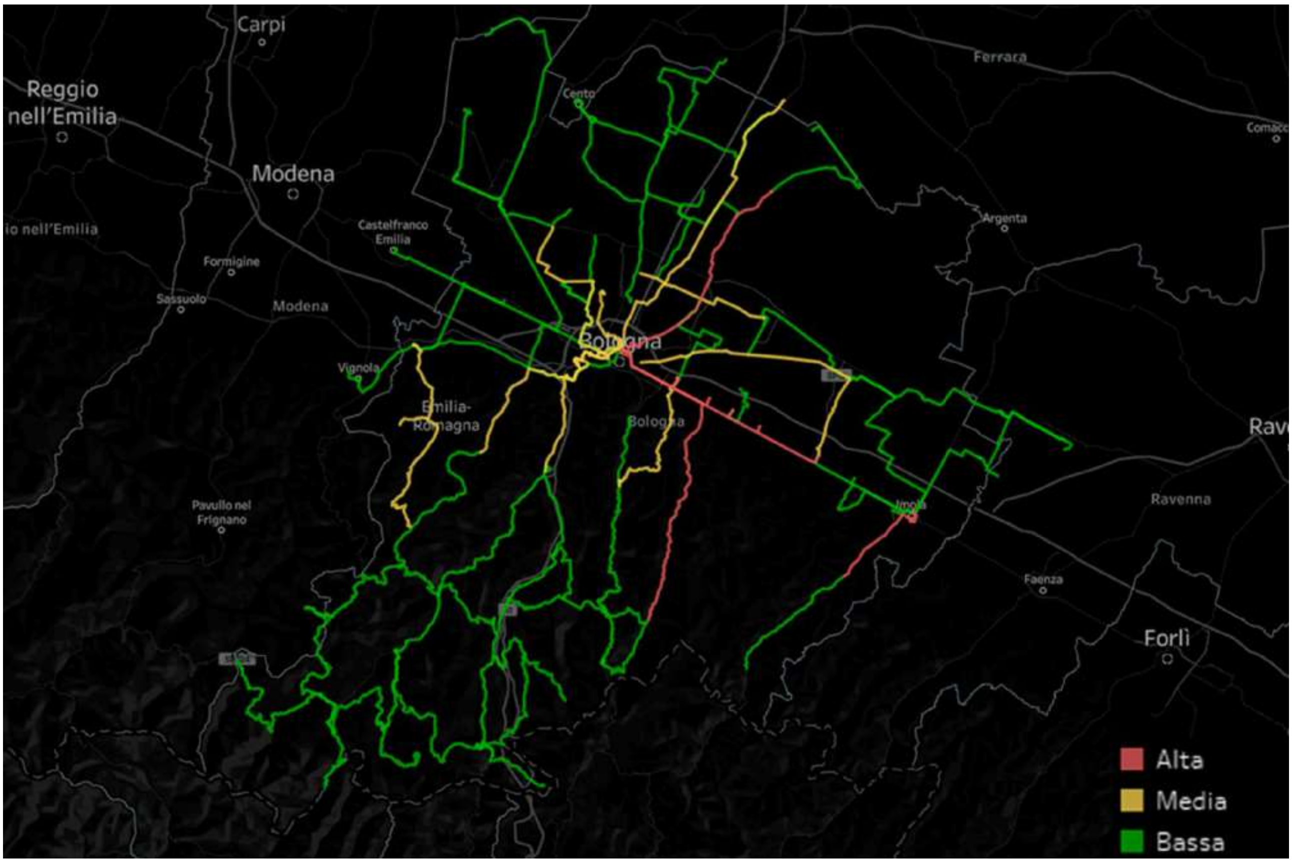

Figure 7 Estimated load factor of the SUMP-planned suburban bus network (levels I, II, and III) following application of the methodology (Source: GO-Mobility analysis of SUMP data for the Metropolitan City of Bologna)

Overall, therefore, this phase ensures maximum **consistency between the planned network and estimated demand**, while identifying **further opportunities for optimization** and thus forming a bridge between the SUMP strategies and the operation of services along the TPM network corridors.

3.4. Application of the "filter" to the existing network and identification of areas with weak demand

3.4.1. Application of the 'filter' across the TPM network

Once demand has been estimated and the main high-mobility corridors have been identified, the methodology involves a cross-checking phase with the **TPM network already planned in the SUMP (up to level III)**, in order to isolate areas that are not actually covered by a structured service (from level IV down). This phase is essential to **distinguish areas where it is appropriate to consider the introduction of new flexible services (DRT).** From a theoretical point of view, this operation has several roles:

- **it delimits the scope of intervention for DRT services**: the planned TPM network constitutes the structural perimeter within which to identify areas excluded from ordinary public transport coverage, allowing attention to be focused on areas where the absence of regular service may justify the introduction of flexible solutions;
- **it guides the rationalization of supply in marginal areas**: the analysis of potential demand, filtered with respect to the existing or planned network, makes it possible to objectively identify areas where the current supply is not economically sustainable, paving the way for a reconfiguration of supply on a DRT basis;

- **supports the identification of strategic catchment areas**: corridors to the main hubs of the metropolitan system (such as Bologna) also make it possible to identify weak areas which, although marginal in terms of local demand, play a crucial role in connecting to the main network and which, for this very reason, can benefit from targeted on-demand solutions;
- **it ensures consistency between demand analysis and existing planning**: thanks to the granularity of sub-municipal zoning, the methodology makes it possible to accurately isolate areas not covered by the TPM network but with potential mobility of interest, providing a solid basis for designing DRT services in a coherent, effective, and targeted manner.

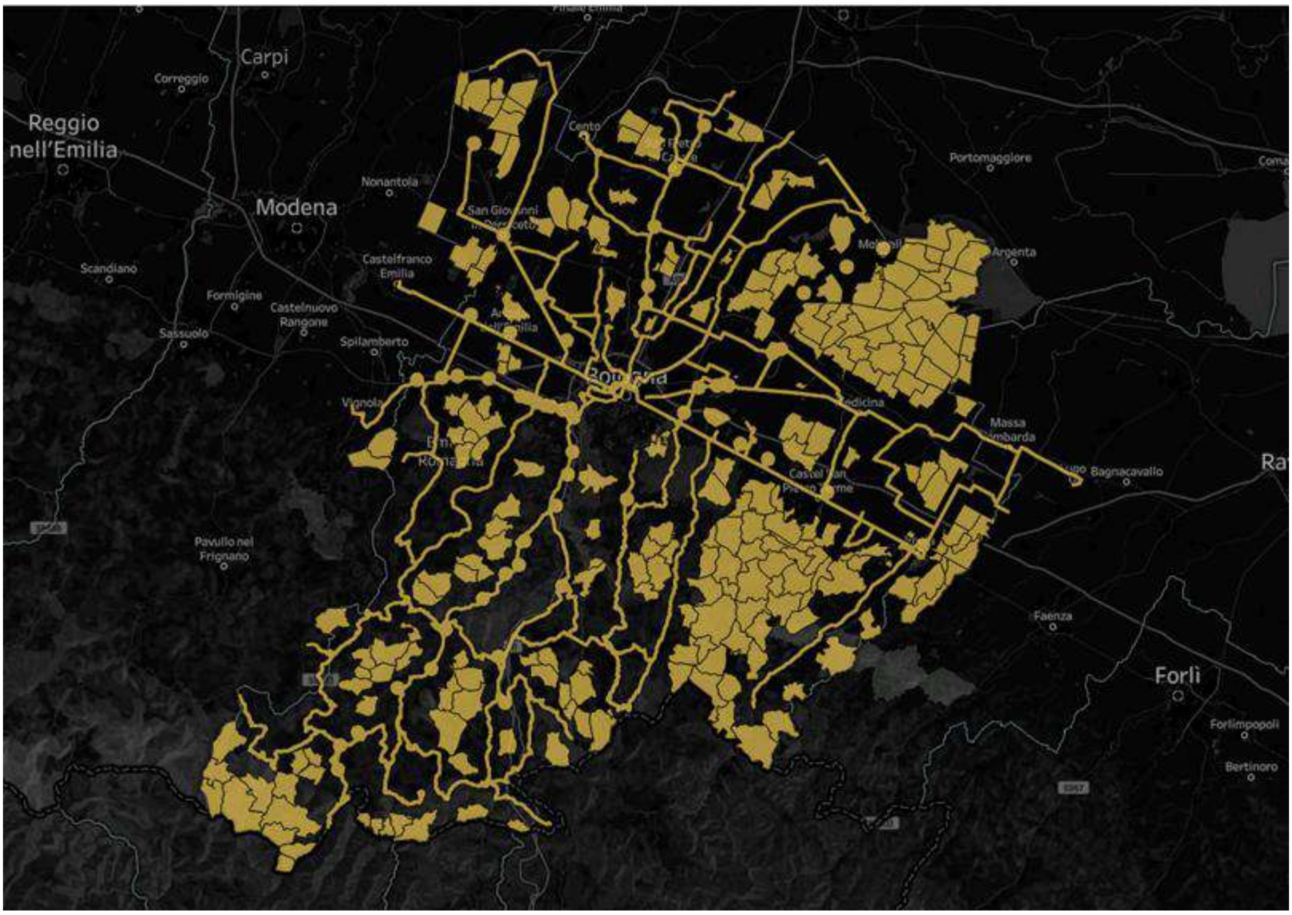

Figure 8 Areas excluded from the TPM network service provided for in the SUMP (Source: GO-Mobility analysis of SUMP data from the Metropolitan City of Bologna)

From an operational point of view, the 'cleaning' process was carried out in three steps:

1. **exclusion of areas already covered or crossed by the planned TPM network**, using differentiated spatial buffers: 250 meters for bus lines and 800 meters for railway stations. This step (Figure 8) ensures a cautious but realistic assessment of actual accessibility;
2. **elimination of areas with very low generative potential**, i.e., areas (shown in black inFigure1) where the estimated demand is so low that it does not justify, even in a flexible form, the activation of a TPL service;
3. **isolation of residual areas**, i.e., those **not served by current planning** but with a **significant minimum generative potential**, which are the actual subject of analysis for the possible design of DRT services.

The result of this phase is a **clean and targeted territorial base** on which subsequent load simulations and supply calibration are concentrated, representing the core of the decision-making process for the introduction of flexible services in areas with weak demand. The result is a **highly articulated and widespread distribution of areas with weak demand,** which includes not only the Apennines but also **portions of the**

plain and peri-urban areas, often distant from the main corridors or isolated in terms of accessibility. This approach therefore provides **a realistic and operational geography of weak demand,** highlighting critical issues in areas that still require flexible and sustainable transport solutions.

Much wider territorial distribution than a municipal-level analysis

The areas identified are also widely distributed on **the Bologna plain** and along the edges of the main routes. This confirms that the adoption of a **sub-municipal scale** makes it possible to identify **areas of weak demand even in more central** and densely populated **areas**, which would otherwise escape a municipal-level analysis.

Persistence of large weak areas in the south-western Apennines

As expected, **the hilly and mountainous area to the south-west** confirms the presence of large areas with potentially low demand, poorly covered by the structured network. However, it should be noted that **not all of the Apennines can be classified as weak**: some main valleys (e.g. the Reno valley) show greater coverage and continuity with the TPM network.

Areas with weak demand also present in the northeastern plains

An interesting feature is the presence of large residual areas in **the lower Bologna area** (between Budrio, Molinella, and Medicina towards the border with the provinces of Ferrara and Ravenna), which are typically flat but characterized by **scattered settlements** and low levels of **traffic density**, making them similar to areas with weak demand even though they are not mountainous.

Evidence of weak demand in the Imola area

The Imola area deserves special attention, as it is a prime example of territorial heterogeneity and discontinuity in public service coverage. Despite good accessibility along the flat Via Emilia, the map shows a significant number of areas with weak demand both *towards the border with the province of Ravenna* (towards Massa Lombarda and Conselice) **and towards the Apennines** (in the San Martino in Pedriolo area).

3.4.2. Identification of areas with low demand

Starting from the map of the remaining areas with potentially weak demand (Figure 8), a territorial reorganization process was carried out to define coherent areas for the design of DRT services. The guiding criterion was twofold:

- ***to ensure spatial continuity between the selected areas***, avoiding isolated and fragmented solutions that are difficult to manage from an operational point of view;
- ***achieving a minimum territorial dimension*** to justify a flexible service on a daily or on-call basis.

The result of this process can be seen atFigure3 , where the zones have been aggregated into **23 functional areas**, each characterized by its own geographical context and estimated demand homogeneity. The elimination of isolated zones was therefore in favor of contiguous and structured territorial areas, more suitable for supporting the planning and organization of a continuous or on-demand DRT service.

It should be noted that, **despite consistently ranking among the areas with low demand in all methodological steps, the Bologna hills area was deliberately excluded from the final perimeter**: this is an area which, due to its morphological characteristics, density, and proximity to the compact urban fabric, is more appropriately managed with specific parameters for the urban area and not as an extra-urban service, in line with the current governance structure and the SUMP strategies. l numbering applied to each cluster (from 1 to 23) forms the basis for subsequent load simulations and economic-operational analysis of the scenarios.

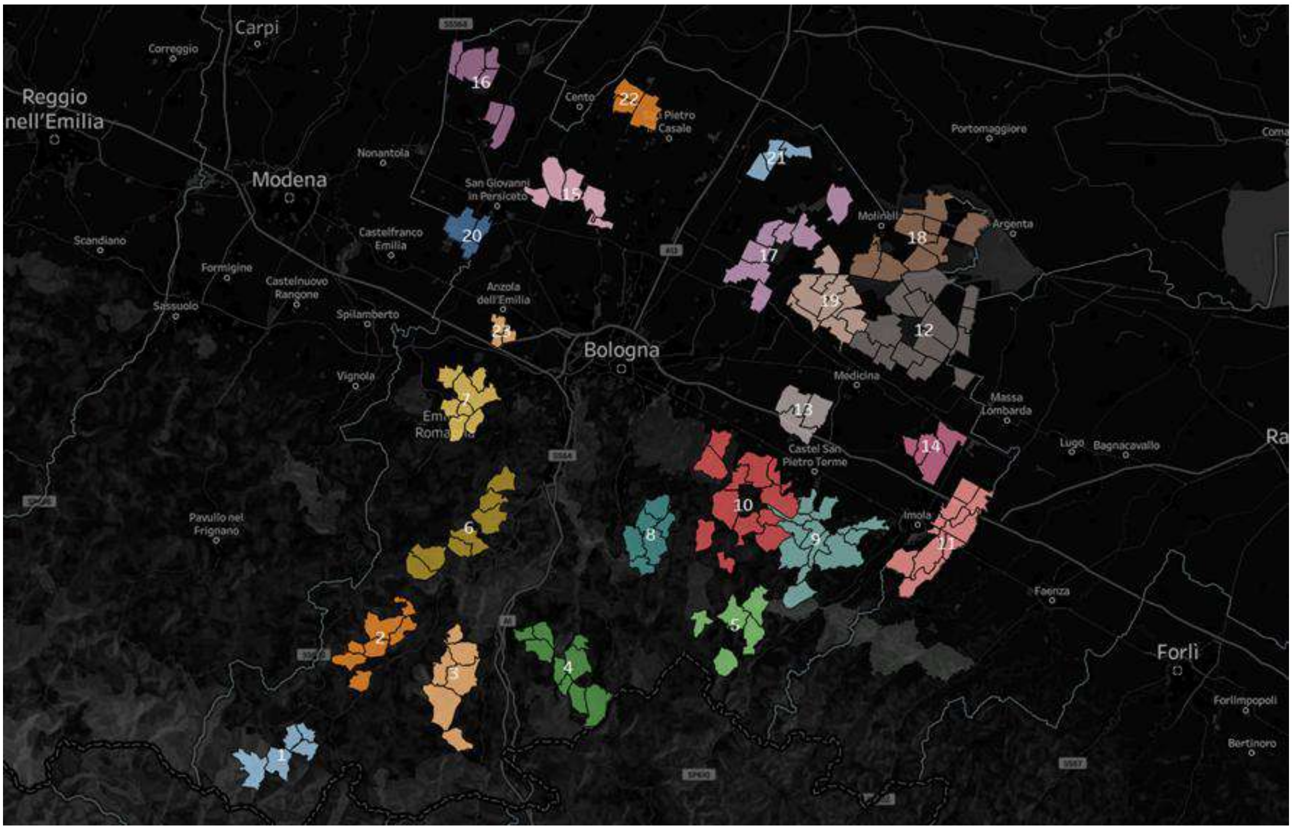

Figure3 Areas with low demand obtained by applying the methodology (Source: GO-Mobility analysis)

4. Hypotheses for operational models of DRT services based on demand characteristics

Once areas with low demand have been identified, the next step is to define **the** most suitable **DRT service model** for each local context. As specified several times in the various phases of the project, demand-responsive transport (DRT) services are not a single, standardized solution, but ***can be configured in different operating modes*, *depending on a variety of factors***:

- the settlement and morphological structure of the territory,
- the spatial and temporal distribution of mobility demand,
- the degree of integration with the planned TPM network,
- the management and contractual complexity compatible with the context.

The objective of this phase is therefore to adapt the service to local specificities in order to maximize operational effectiveness, ensure adequate coverage of mobility needs, and optimize economic and financial sustainability. To do this, a **classification logic** based **on the integrated analysis of estimated demand (quantitative and qualitative)** and **the suitability of the different DRT models to the configuration of the areas** has been adopted**.**

This document is part of a broader process developed within the DREAM_PACE project, which analyzed:

- the main organizational and contractual models of DRT;
- the characteristics of flexible services in terms of economic and financial sustainability;
- demand levels in the context of the Metropolitan City of Bologna.

The objective of this chapter and the following chapter §5 is therefore to integrate the application of the methodology for identifying areas with low demand with the evidence that emerged during the various phases of the project, arriving at a concrete proposal for differentiated operating models that are consistent with both territorial constraints and the requirements of effectiveness, equity, and sustainability.

4.1. Criteria for selecting the DRT model for each area

This section summarizes the **four DRT service operating models** considered in this document, illustrating their main functional characteristics and consistency with different territorial, settlement, and organizational scenarios. As is well known, **DRT configurations are not uniform solutions** but must be carefully selected on the basis of an integrated set of factors, including:

- **the geographical extent and territorial characteristics** of the area to be served: large areas with poor accessibility require greater operational flexibility, while compact areas or those with good road access are more suited to structured routes;
- **estimated demand** and **the prevailing direction of travel**: areas with mobility directed towards a single hub justify fixed route models, while the presence of widespread or polycentric demand points towards more dynamic solutions;
- the level of **integration with existing local public transport**, in particular with the TPM network provided for in the SUMP: in some areas, DRT can play a feeder role to the main lines, while in others it can act as a direct service to the centers of attraction. Integration also includes tariff, information, and contractual aspects.

In ascending order of flexibility, DRT service configurations are:

1. ***Basic route service with fixed stops***: predefined route with on-demand activation. This is suitable for contexts with demand directed towards a single axis and a linear mobility structure;
2. ***Basic route service with deviations and fixed stops***: the main route is guaranteed, but occasional deviations are allowed on request to serve secondary or less frequented areas. The model is

designed for areas with a larger center and smaller, scattered settlements, ensuring a good compromise between territorial coverage and operational regularity;

3. ***Free route service between a predefined set of points***: there is no fixed route: the service connects, on request, a defined set of pre-established stops. It offers high flexibility and is particularly suitable for areas with scattered settlements, where it is important to guarantee access to essential services from multiple points. However, it requires advanced booking systems and effective communication;
4. ***Free itinerary service between any set of points***: the highest level of flexibility, where the origin and destination are freely defined by the user within the area served. It is applicable in areas with fragmented demand, accessible and widespread road networks, and where a highly customized response to mobility needs is required. However, the unit cost is higher and operational management is more complex.

As mentioned above, the selection of the most suitable operating model for each area with low demand is based on a joint analysis of two key dimensions of mobility demand:

- **temporal variability**, i.e., the regularity or irregularity of trips throughout the day: from peaks at school or work times to a more distributed and less predictable demand;
- **spatial variability**, i.e., the distribution of mobility flows across the territory: from situations with demand concentrated along main routes to contexts characterized by widespread settlements and multiple polarization.

The intersection of these two axes allows us to construct a **logical grid of correspondence** between the demand profile and the DRT service model, as shown in Table 2 .

Temporal/spatial variability	Concentrated demand (e.g., linear axis, single hub)	Dispersed demand (spread-out settlements)
Regular demand (school/work hours)	**Model** 1-2 With fixed timetables	**Model** 3-4 With pre-established times
Variable **request** (irregular during the day)	**Model 2** - By appointment	**Model** 4 By reservation

Table 2 Correspondence between DRT service operating models and spatial and temporal characteristics of demand (Source: GO-Mobility calculations)

The grid is not a rigid classification, but an **interpretative map** useful for guiding operational choices, taking into account local characteristics and objectives of accessibility, sustainability, and ease of management. In particular:

- in the presence of **concentrated and regular demand**, simple and structured models (fixed routes) can be adopted;
- where demand is **spatially dispersed**, it is necessary to introduce a greater degree of flexibility, both in terms of routes and booking methods;
- in contexts with **distributed and variable demand**, the service must be able to adapt dynamically, with highly customized solutions (free itineraries).

This matrix is the link between the analysis of estimated demand (summarized in section §2) and the definition of the operating models proposed for the individual areas (section §4.2), through the territorial and functional characterization of the 23 areas with low demand (section §4.3).

4.2. Characterization of mobility demand: spatial and temporal structure

This section analyzes mobility demand in the 23 areas identified, with the aim of defining in a robust and concise manner the factors that influence the choice of DRT service operating models. In particular, two fundamental dimensions are explored in depth:

- the ***temporal structure of demand***, i.e., the distribution of trips throughout the average working day and the presence or absence of systematic patterns attributable to regular and recurring needs (work, school, services);
- the ***spatial structure of demand***, i.e., the territorial configuration of trips, the degree of concentration along main axes or dominant hubs, and the presence of scattered or polycentric settlements.

These dimensions are key to interpreting which operational model is most suitable in each context and have been constructed on the basis of the integration of mobility data, sub-municipal zoning, and analysis of travel relationships. The following sub-sections provide a separate reading of the two components:

- Paragraph §4.2.1 provides further details on how to analyze the temporal profiles of estimated demand.
- Paragraph §4.2.2 describes how to analyze the spatial characteristics of mobility relationships.

The intersection between these two dimensions will guide the assignment of operational models to areas with weak demand, as illustrated in the following paragraph §4.3 . It should be noted that, before proceeding with the temporal and spatial characterization of demand, a fundamental preliminary activity was carried out, consisting of calculating the total volume of demand generated and attracted for each of the 23 areas with weak demand identified. For each area, demand was divided according to two macro-types of territorial relationship:

- **movements to and from Bologna**, the main attraction center and hub of the metropolitan area;
- **movements to and from other municipalities other than Bologna**, which include both intra-municipal and interprovincial relations.

4.2.1. Temporal characterization

As mentioned above, the temporal distribution of trips is a determining factor in the design of DRT services, since the degree of concentration of demand throughout the day makes it possible to distinguish between contexts where it is preferable to plan fixed-time trips and situations where it is more efficient to adopt flexible, on-demand models. In general, if demand is **concentrated in specific time slots,** such as morning and afternoon peaks linked to school or work, it is advisable to plan fixed-time trips using higher-capacity vehicles. on the other hand, if journeys are **more spread out and irregular,** a reservation-based service is preferable, as this allows for the optimization of shifts and better calibration of supply, even with smaller vehicles.

To support this assessment, a specific analysis was carried out on each of the 23 areas with low demand, broken down according to the type of relationship (to/from Bologna and to/from other municipalities). The activities carried out were:

- analysis of **the hourly distribution** of demand generated and attracted by each area during an average weekday;
- **calculation of the hourly share** of the daily total, useful for identifying peak times;
- **identification, for each area/relationship combination**, of the time slot with the highest load:

  - in the morning (until 12 noon), the peak is almost always concentrated between 7:00 and 9:00 a.m.;
  - in the afternoon (after 12:00), the values are more distributed, but often concentrate around 1:00 p.m.

Finally, for each combination of low demand area/relationship type, the **sum of the demand shares concentrated** in the two main time slots (morning + afternoon) was calculated in order to measure the overall degree of time concentration. This information was translated into a simple operating rule for choosing the service model:

- if the concentrated share represents **at least 30%** of demand to/from Bologna and **at least 20%** of demand to/from other municipalities, a **fixed-time service** is recommended;
- otherwise, it is preferable to opt for a **reservation-based service**, which is better suited to managing fragmented and distributed flows.

It is important to emphasize that the thresholds identified (30% for connections with Bologna, 20% for others) are an operational reference criterion but **can be adjusted according to specific local needs, service objectives, or management constraints**. A change in these parameters may in fact lead to different design solutions, guiding the choice between more structured and more flexible models, in line with the territorial context and expected levels of demand.

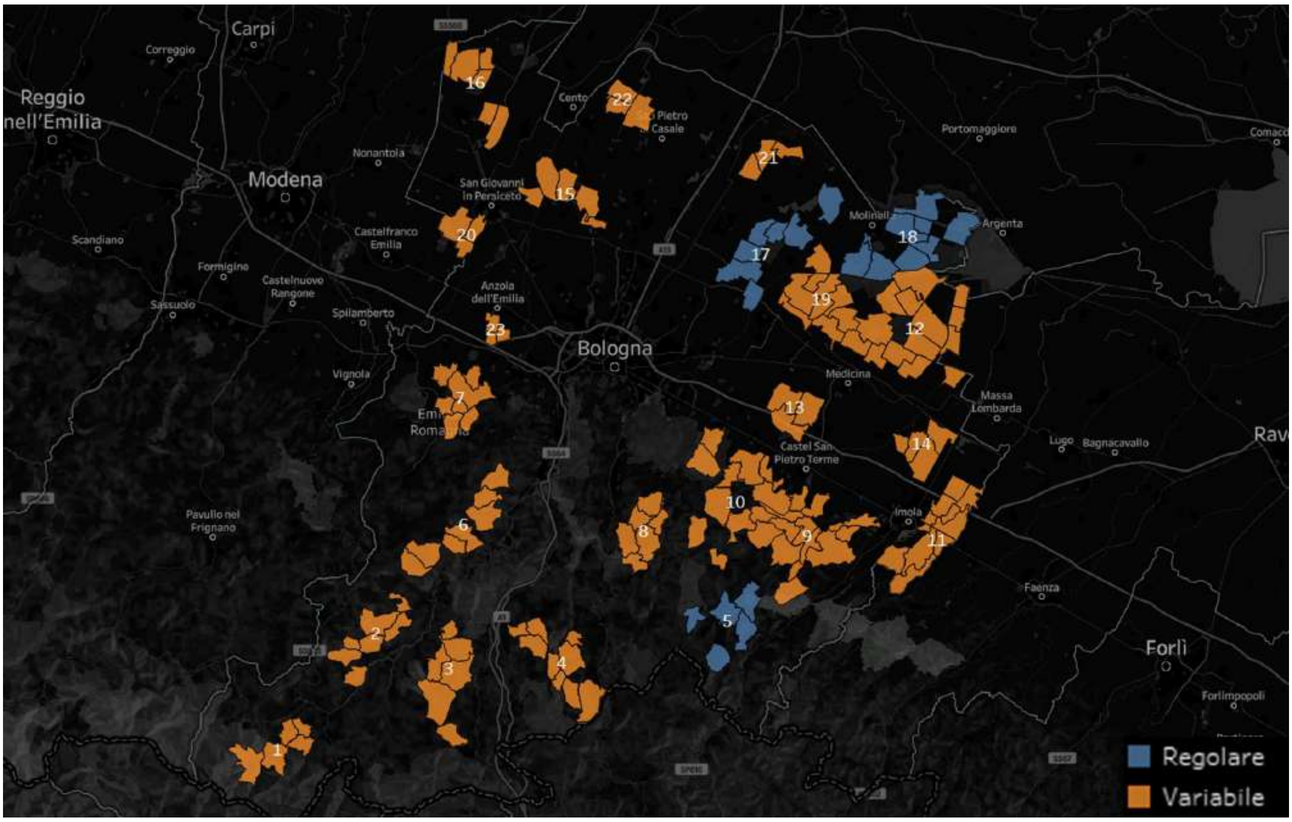

Figure4Temporal characterization of potential demand in areas identified as having weak demand (Source: GO-Mobility analysis)

4.2.2. Spatial characterization

Alongside the temporal dimension, the **spatial** structure **of demand** is also a key factor in choosing the most suitable operating model in areas with weak demand. In particular, the distribution of trips across the territory can vary from highly polarized scenarios (with a well-defined main attraction center or h) to more widespread and fragmented contexts. As mentioned above, if demand is **concentrated in a limited geographical area,** it is preferable to structure the service on **fixed routes,** capable of ensuring regularity and operational efficiency. Conversely, in the presence of a **more dispersed territorial distribution,** flexible configurations may be more effective, with **targeted deviations** or **free routes,** capable of reaching a scattered and less predictable demand.

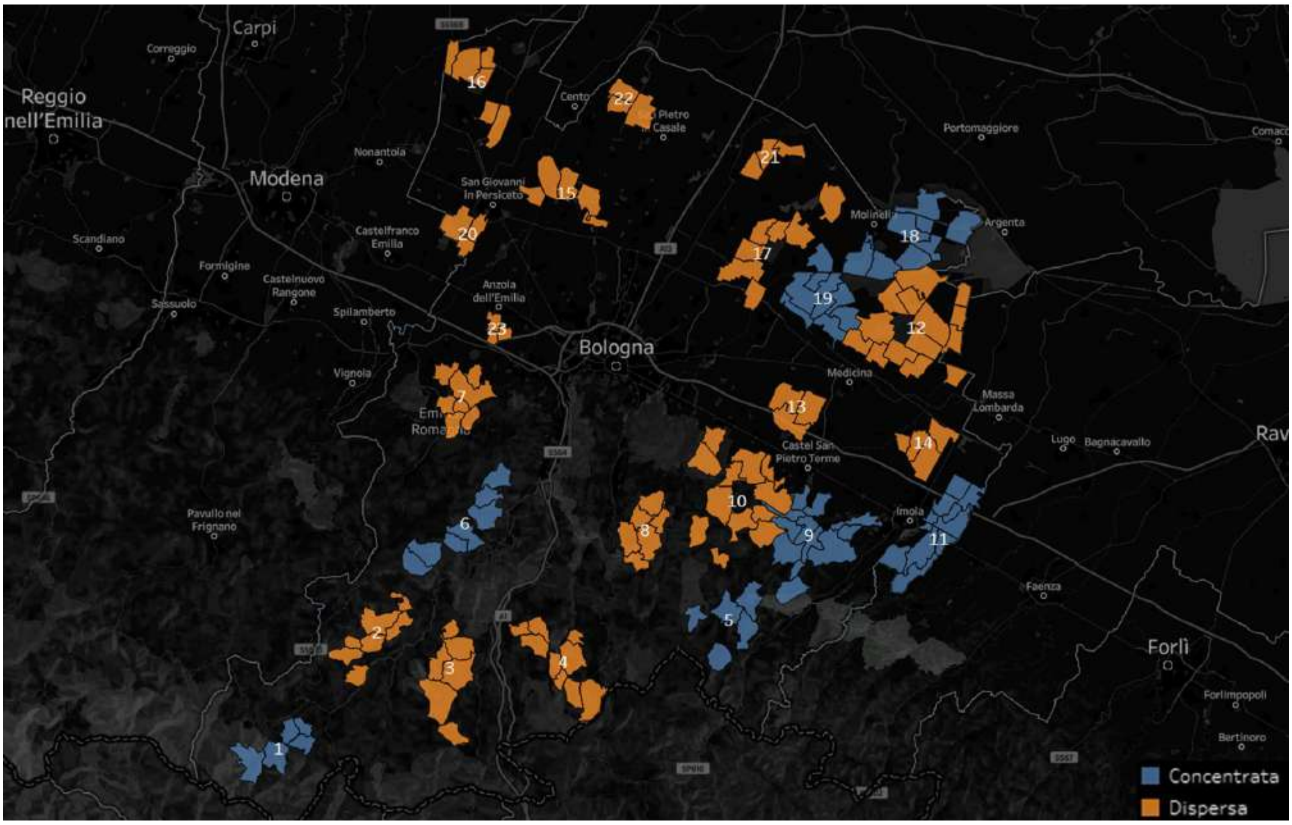

Figure5Spatial characterization of potential demand in areas identified as having weak demand (Source: GO-Mobility analysis)

To assess the degree of territorial concentration, a detailed analysis was carried out for each of the 23 areas with weak demand, according to the following steps:

- for each elementary zone (sub-municipal), the **share of demand** generated/attracted was calculated in relation to the total for the entire area;
- for each area, the **zone with the highest potential** was identified, i.e., the zone with the highest concentration of trips;
- the **share of surface area** occupied by each zone was then calculated in relation to the total area of low demand;
- finally, for each area, the **ratio between the share of demand and the share of surface area** was estimated: a summary indicator of the relative density of demand.

This ratio was used as an objective criterion to distinguish between highly polarized contexts and areas with widespread demand:

- **if the ratio exceeds the threshold value of 5**, the adoption of **a fixed route model** is recommended, as a significant part of the demand is located in a small portion of the territory;
- **otherwise**, it is possible to adopt **models with deviations** or **free routes**, capable of flexibly covering a more distributed demand.

Again, the threshold identified is a technical reference point, but it can be **adjusted according to the characteristics of the territory**, the availability of infrastructure, and strategies for integration with existing public transport.

4.3. Assignment of DRT service operating models to the 23 areas with low demand identified by th

Once the analysis of the spatial and temporal characteristics of demand in the 23 areas with low demand had been completed, it was possible to assign the **DRT service model most consistent** with the specific characteristics of each context.

Each combination was associated with a **DRT operating model** described in paragraph 4.1, with an indication of **the hourly management mode** (fixed timetables or flexible booking), in line with the information provided inTable 2 . The results of the analysis are summarized in the following table, which shows the following for each area:

- **the numerical ID** (in line with the reference map);
- the **demand profile**, divided into temporal and spatial components;
- the **proposed DRT operating model**;
- and the related **hourly management**.

AREA ID	TREND TIME	SPATIAL SPATIAL	MODEL DRT MANAGEMENT	MANAGEMENT SCHEDULES
1	Variable	Concentrated	Model 2	By appointment
2	Variable	Dispersed	Model 4	By appointment
3	Variable	Scattered	Model 4	By reservation
4	Variable	Scattered	Model 4	By appointment
5	Regular	Concentrated	Model 1-2	Pre-set
6	Variable	Concentrated	Model 2	Upon reservation
7	Variable	Missing	Model 4	By appointment
8	Variable	Scattered	Model 4	By appointment
9	Variable	Concentrated	Model 2	By appointment
10	Variable	Dispersed	Model 4	By appointment
11	Variable	Concentrated	Model 2	By appointment
12	Variable	Dispersed	Model 4	By reservation
13	Variable	Scattered	Model 4	By reservation
14	Variable	Scattered	Model 4	By appointment
15	Variable	Scattered	Model 4	By appointment
16	Variable	Scattered	Model 4	By appointment
17	Regular	Scattered	Model 3-4	Pre-established
18	Regular	Concentrated	Model 1-2	Preset

19	Variable	Concentrated	Model 2	Upon reservation
20	Variable	Dispersed	Model 4	By appointment
21	Variable	Scattered	Model 4	By appointment
22	Variable	Scattered	Model 4	By appointment
23	Variable	Scattered	Model 4	By reservation

Table1Hypothesis of operational models for DRT services in areas with low demand based on the temporal and spatial characteristics of demand (Source: GO-Mobility analysis)

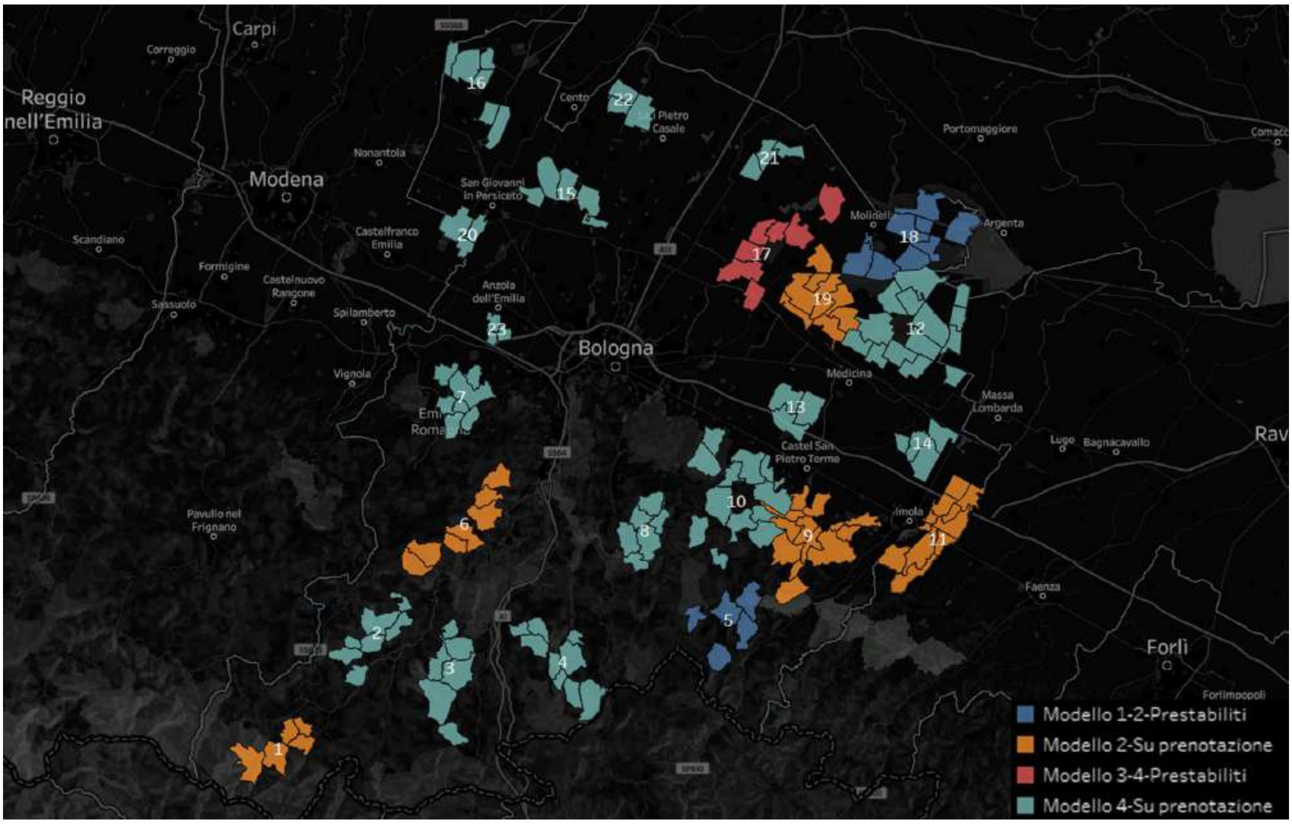

Figure6Hypotheses for operational models of DRT services in areas with low demand based on the temporal and spatial characteristics of demand (Source: GO-Mobility analysis)

4.4. General

Once the types of demand have been cross-referenced with the territorial contexts, consistent patterns emerge between the structure of demand and the operating model described below.

The Apennine areas (ID 2, ID 3, ID 4) tend to show spatially and temporally varied demand: for these, flexible type 4 models have been chosen, which offer maximum customization and the ability to cover scattered territories with distributed movements. At the same time, **less isolated hilly areas** (ID 6, ID 9) and **the eastern Imola area** (ID 11) show a certain territorial concentration combined with demand that is not exclusively regular: therefore, Model 2 (route with deviations) was found to be the most appropriate choice here, balancing coverage and operational regularity.

In a **flatter context with polarization towards established centers and regular timetables**, such as the area between Molinella and the border with the province of Ferrara (ID 18), a Model 1-2 configuration with fixed timetables was proposed, thanks to the spatial concentration of demand and the presence of defined hubs.

The **areas in the eastern plains** on the border with the province of Ravenna (ID 12, ID 14) and **in the northwestern plains**, near San Giovanni in Persiceto, have geographically dispersed demand and low territorial concentration: for these, Model 4 was widely used. Similarly, the areas of northern Valsamoggia, between Altedo, Baricella, and Malalbergo and between Galliera and San Pietro in Casale (ID 20 to 22) are characterized by scattered settlements and no strong centers of gravity or prevailing times: here too, Model 4 was considered the most suitable.

The only exception to a totally flexible configuration is area 17 (**northeast quadrant**), where, despite the persistence of spatially dispersed demand, the relative regularity leads to considering Model 3 or 4, maintaining a margin for planned structure with pre-established points.

5. Hypothesis for a remuneration model for DRT services based on demand characteristics

This chapter addresses the issue of remuneration for DRT services in light of the demand characteristics that emerged in the analysis, with the aim of constructing a coherent framework between the operating model and the contractual arrangements. The proposed approach is based on three fundamental assumptions:

- **the assumptions of DRT service operating models**, introduced in the previous section §4.3 , which vary from structured configurations with fixed routes to completely flexible schemes, generate different cost structures, degrees of uncertainty, and control requirements;
- **the intensity of demand**, assessed in terms of potential mobility volumes, directly affects vehicle saturation and economic efficiency in management;
- **the choice of remuneration model** has a direct impact on economic sustainability, incentives for the operator, and the level of oversight required by the public administration.

The rest of this chapter briefly analyzes the main cost factors in DRT services (detailed and explored in depth in *Document C - Study on DRT costs and the possibility of including them in the Service Contract, with reference to Ministerial Decree 157 of March 28, 2018, Standard costs)*, the possible alternative remuneration models to the standard cost method, and a logical grid for assigning each remuneration model to the 23 areas with low demand, depending on the configuration of the service and the level of demand observed.

5.1. Criteria for selecting the DRT service remuneration model based on demand levels and the operating model

This section outlines the rationale for choosing the most appropriate remuneration model for DRT services in each area with low demand. It begins with a review of the main operating cost factors, summarizes alternative remuneration models to the standard method, and illustrates possible criteria for allocating remuneration according to the operational types of service.

5.1.1. Review of operating cost elements in DRT services

As detailed in Document C, DRT services have a complex operating cost structure, strongly influenced by both the operating model adopted and the geographical configuration in which the service is provided. In general, costs can be divided into two main categories: ***fixed costs*** and ***variable costs***, to which are added some semi-fixed components linked to the expected level of demand and the technology used.

Fixed costs

Fixed costs are independent of the actual number of trips activated and belong to five macro-families:

- ***Analysis and study***: these are costs associated with higher-level surveys and assessments and are generally absorbed by existing dedicated structures;
- ***Permanent staff***: drivers and operators at the operations center, who are needed to ensure service availability even during periods of low demand or to cover extended hours;
- ***Fleet and maintenance***: costs related to the purchase or leasing of vehicles, as well as scheduled maintenance, insurance, and parking;

- ***Enabling technologies***: digital infrastructure for service management (e.g., booking platform, app, operational interface), which involves an initial cost and license/management fees even in the absence of high volumes;
- ***General expenses***: administrative, coordination, insurance, and logistics costs.

Variable costs

Variable costs increase as operational activity increases and include three macro categories:

- ***Operation and consumption***: direct expenses for fuel, vehicle consumption, maintenance related to use and environmental impact, but also additional costs related to extraordinary trips, shifts or services activated only on request;
- ***Technology and information systems***: such as SMS notifications, real-time tracking, dedicated interfaces for users with specific needs;
- ***Inefficiency costs***: canceled trips, downtime between bookings, and empty mileage.

5.1.2. Cost trends based on demand levels and the DRT service model

The cost structure of DRT services is strongly influenced by two key factors: the **operating model adopted** (from the most structured to the most flexible) **and the level of demand in the area served**. The different operating models, classified according to the increasing flexibility of the network, have different degrees of management complexity, service saturation, and fixed and variable costs.

Model 1 (basic route service with fixed stops) guarantees the greatest stability in terms of unit costs, especially when demand is high and regular, and can benefit from the standard method provided for in Ministerial Decree 157/2018. However, when demand is low, operating costs are likely to exceed revenues, making the service inefficient.

Model 2 (service with limited deviations from a fixed route) increases the degree of territorial coverage and requires a variable component in the remuneration model. The impact of additional kilometers can be managed with adjustments, but in low-demand contexts, service productivity may decrease significantly.

Model 3 (free routes between fixed points) is well suited to average and distributed demand, optimizing routes on a dynamic basis. However, variability in demand can negatively affect vehicle saturation, especially during off-peak hours.

Model 4 (completely free routes) is the most flexible, but involves high management complexity and a heavy load on information systems, ICT platforms, and dispatching mechanisms. When applied in low-demand areas, it requires significant operational and technological oversight relative to the actual number of users served.

The followingTable 4 summarizes the behavior of operating costs as a function of the level of demand for each DRT operating model.

Demand	Model 1	Model 2	Model 3	Model 4
High	Stable and predictable	Higher for greater mileage	Average predictable operating costs	High costs due to technological complexity and dispatching
Average	Partially stable with variable share	High incidence of variable costs	Stable costs, with variability in demand	High fixed costs and unpredictable variability
Low	Overhead costs exceed revenues	High costs relative to productivity	High operating costs compared to demand	High ICT and operating costs for minimal demand

Table 4 Cost trends based on demand levels and DRT service model

In summary, therefore, each DRT service configuration involves a different balance between fixed and variable costs, which makes it necessary to define **a remuneration model that is appropriately calibrated** to the demand profile of each area.

5.1.3. Remuneration models for DRT services alternative to the standard cost method

The current 'kilometric' remuneration model, defined at regulatory level by Ministerial Decree 157/2018, does not provide a standard cost system applicable to demand-responsive transport (DRT) services, explicitly excluding them from the methods provided for traditional modes of transport. In the absence of a single national methodological framework, Document C (*Study on DRT costs and the possibility of their inclusion in the Service Contract, with reference to Ministerial Decree 157 of March 28, 2018 - Standard Costs*), alternative approaches were explored for determining the economic consideration that takes into account the inherent limitations of applying the kilometer model to DRT services.

One of the most significant references is Lombardy Regional Council Resolution No. X/4927/2016, which introduced the concept of '***equivalent mileage***'. This method allows the availability time and level of service guaranteed by the operator to be converted into a parameter that can be compared with traditional scheduled services. This approach takes into account:

- the hourly availability of the vehicle (OREus);
- the average commercial speed;
- correction coefficients (c1 and c2) that reflect the operational complexity and risk of the service.

According to this model, for example, models with greater flexibility (free routes between any points) are associated with a higher coefficient to recognize higher unit costs and lower predictability. Among the possible developments of the Lombardy model (Table 5), the following can be envisaged:

- the introduction of fixed components linked to service availability (territorial coverage, operational continuity, booking system);
- a variable component that takes into account the volume of activity (driving hours, activations, kilometers traveled, users transported);
- the adoption of incentive coefficients for the use of digital tools, operational efficiency, or the achievement of certain levels of demand.

This approach allows for greater adherence to the specific characteristics of DRTs compared to the traditional €/km model, which is inadequate for services subject to high operational variability. However, it should be noted that none of the models analyzed is without its drawbacks: there is always a trade-off between administrative simplicity, fair remuneration, and incentives for efficiency.

Remuneration model	Description	Items considered	Strengths	Critical issues
€/km traveled	Payment based on actual kilometers traveled	Kilometers traveled	Easy to calculate; linked to actual activity	Not suitable for flexible or low-demand services
€/hour of service	Remuneration based on vehicle and staff availability time	Driving hours or hours of availability	Rewards territorial coverage; easy to plan	Risk of inefficiencies if demand is highly variable
Equivalent mileage	Hours are converted into equivalent kilometers using coefficients (c1, c2)	Active hours * correction coefficients	Comparable with traditional services; adaptable	Requires fine calibration of coefficients

Fixed + variable mixed model	Guaranteed fixed part + variable part linked to volumes or performance	Fixed quota + km / users / trips	Balances economic stability and incentives for efficiency	More complex contracts to manage
Based on objectives (KPIs)	Remuneration linked to the achievement of qualitative or quantitative targets	Performance indicators (e.g., users)	Stimulates quality and innovation	Requires a structured monitoring system

Table 5 Comparative summary of remuneration models applicable to DRT services (Source: GO-Mobility analysis)

5.1.4. Possible remuneration models based on demand levels and DRT service model

The following tables summarize the considerations developed in the previous paragraphs, cross-referencing demand level (high, medium, low) and DRT operating model (1 to 4) to identify the most appropriate remuneration methods. Each cell shows the suggested model and a brief explanatory note clarifying the underlying logic. The considerations proposed take into account:

- the operating cost structure associated with each model depending on service usage and expected saturation;
- the possible configurations of alternative remuneration models to standard costs for DR services.

As can be seen, in ***high-demand*** contexts, it is possible to apply kilometer-based models or models with variable components linked to quality and productivity. At the same time, in the presence of ***average demand***, hybrid solutions emerge that balance a fixed component of coverage with incentive elements. Finally, for ***low levels of demand***, models based on service availability, independent of actual use, are preferred to ensure coverage and accessibility.

Model 1 - Basic route service with fixed stops:

Level of demand	Remuneration model	Notes
High	Classic mileage with bonus/penalty	The service structure is similar to that of a regular local public transport line, making the mileage criterion consistent with the service provided, while the high regularity allows for the introduction of quality adjustments.
Med	Peq + fixed daily rate	The partial fluctuation in demand requires a fixed component to guarantee supply, accompanied by a valuation in equivalent kilometers for the part actually performed.
Low	Mixed fixed/variable	The mixed fixed/variable model ensures service availability in low-demand contexts through a fixed service provision fee, accompanied by a variable component that recognizes the actual activation of trips, maintaining consistency with the PSOs.

Table2Assumed remuneration model for DRT services for type 1 operating model based on demand levels (Source: GO-Mobility analysis)

Model 2 - Basic route service with deviations and fixed stops:

Demand level	Remuneration model	Notes
High	Peq + correction for deviations	The Peq system ensures consistency with regular public transport and facilitates integration with existing systems; the corrective factor reflects the additional costs associated with flexibility.
Med	Fixed fee + €/km with minimum threshold	Economic balance is protected with a fixed base, while still remunerating the actual kilometers traveled, with minimum thresholds to avoid diseconomies.
Low	Fixed fee only on availability	The fixed component guarantees the sustainability of the minimum offer without generating distortions linked to low kilometer productivity.

Table3Assumed remuneration model for DRT services for the type 2 operating model based on demand levels (Source: GO-Mobility analysis)

Model 3 - Service with free itineraries between a predefined set of points:

Demand level	Remuneration model	Notes
High	Peq or hourly rate	Despite a structured organization, revenues remain at average levels, requiring a model that values continuous availability rather than productivity.
Medium	Fixed hourly rate independent of activation + qualitative KPIs	The fixed rate guarantees minimum availability without overestimating actual usage, with possible quality bonuses.
Low	Fixed hourly/daily rate	The only way to ensure sustainability in these contexts is remuneration based on availability, independent of actual demand.

Table4Assumed remuneration model for DRT services for type 3 operating model based on demand levels (Source: GO-Mobility analysis)

Model 4 - Service with free routes between any set of points:

Demand level	Remuneration model	Notes
High	€ per hour of availability + qualitative KPIs	Remuneration per hour of availability allows alignment with actual usage, while operational KPIs monitor service quality
Medium	€ per hour of availability + €/activation	The €/activation logic reflects the variability of the service and mitigates downtime costs.
Low	Fixed hourly rate independent of activation + quality KPIs	The fixed fee guarantees minimum availability without overestimating actual usage, with possible quality bonuses

Table5Assumed remuneration model for DRT services for the type 4 operating model based on demand levels (Source: GO-Mobility analysis)

This grid therefore allows contracting authorities to orient their choices towards models consistent with specific territorial and operational characteristics, representing a useful tool also during the tender phase or when updating contracts.

5.2. Characterization of demand levels

In order to consistently guide the choice of remuneration model for DRT services, it was essential to have a concise but robust classification of **the level of mobility demand** that each area with weak demand is potentially capable of generating. To this end, an operational methodology was adopted that **classifies** the daily generative potential of areas **from a qualitative/quantitative perspective**.

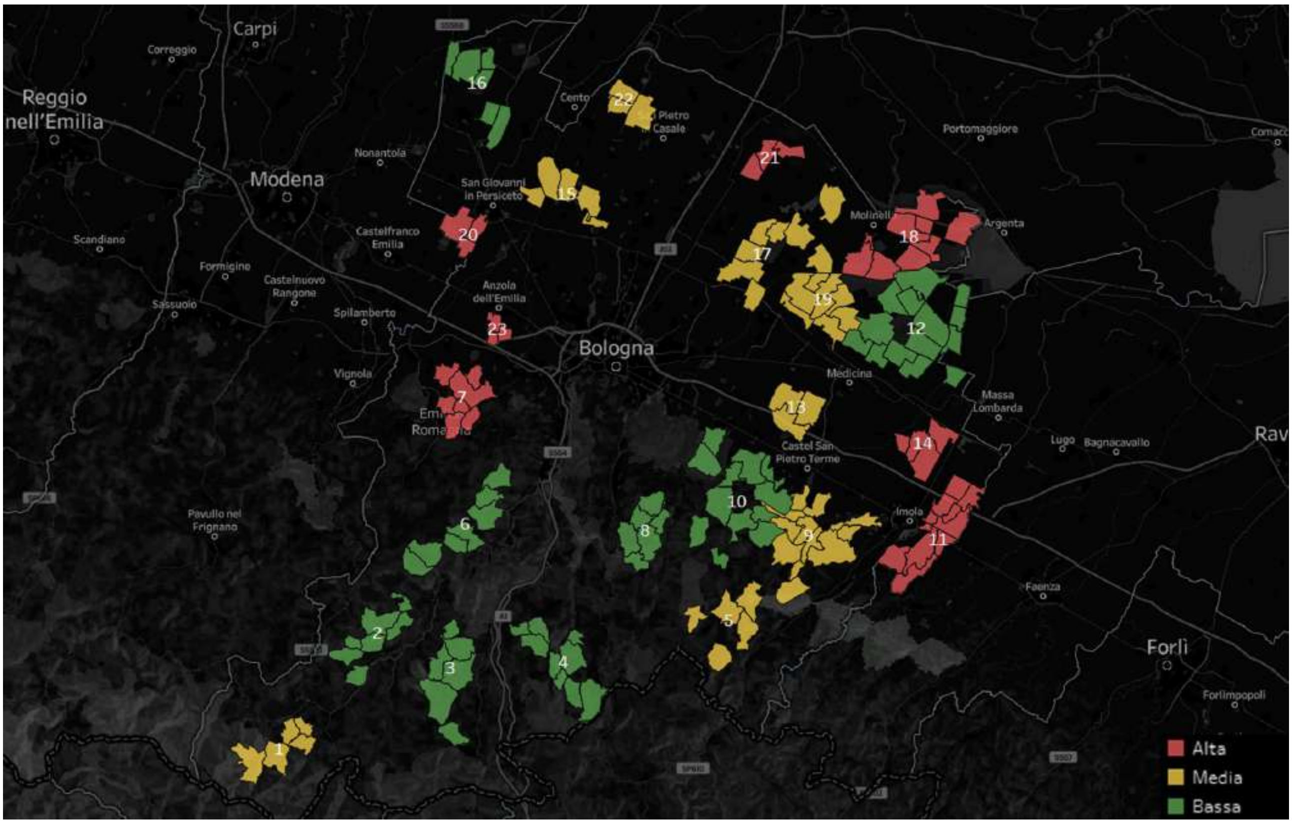

Figure7Characterization of potential demand levels in areas with low demand (Source: GO-Mobility analysis)

The process was divided into three main steps:

- **Association of generative potential at the zone level**: for each of the more than 1,000 sub-municipal zones into which the metropolitan area was divided, the number of daily trips generated was calculated, with a specific focus on the zones included within the 23 areas with weak demand;
- **Calculation of the average per area**: for each area, an average value of normalized generative potential per surface area (in trips per km^2) was estimated in order to ensure comparability between territories that differ in size and population density;
- **Classification into demand bands**: based on the average value obtained, each area was assigned to one of the following three classes:

  - **High Demand**: over 30 trips/km^2;
  - **Medium demand:** between 15 and 30 trips/km^2;
  - **Low demand:** less than 15 trips/km^2.

This classification provides an immediate indication of the **potential suitability** of each territorial context **for local public transport** and represents an **objective criterion** for consistently matching operating models and related remuneration mechanisms to the actual conditions of demand for services.

5.3. Assignment of DRT service remuneration models to the 23 areas with low demand

Based on the operating model identified for each area and the estimated level of potential demand, a specific remuneration model has been proposed for each '*low* demand' territorial context, consistent with the operational characteristics and dynamics highlighted in the previous paragraphs. The followingTable 10 summarizes the results of this process, highlighting for each area:

- the numerical identifier,
- the selected operating model,
- the estimated level of demand (high, medium, low),
- and the most suitable remuneration model, possibly proposed as an alternative.

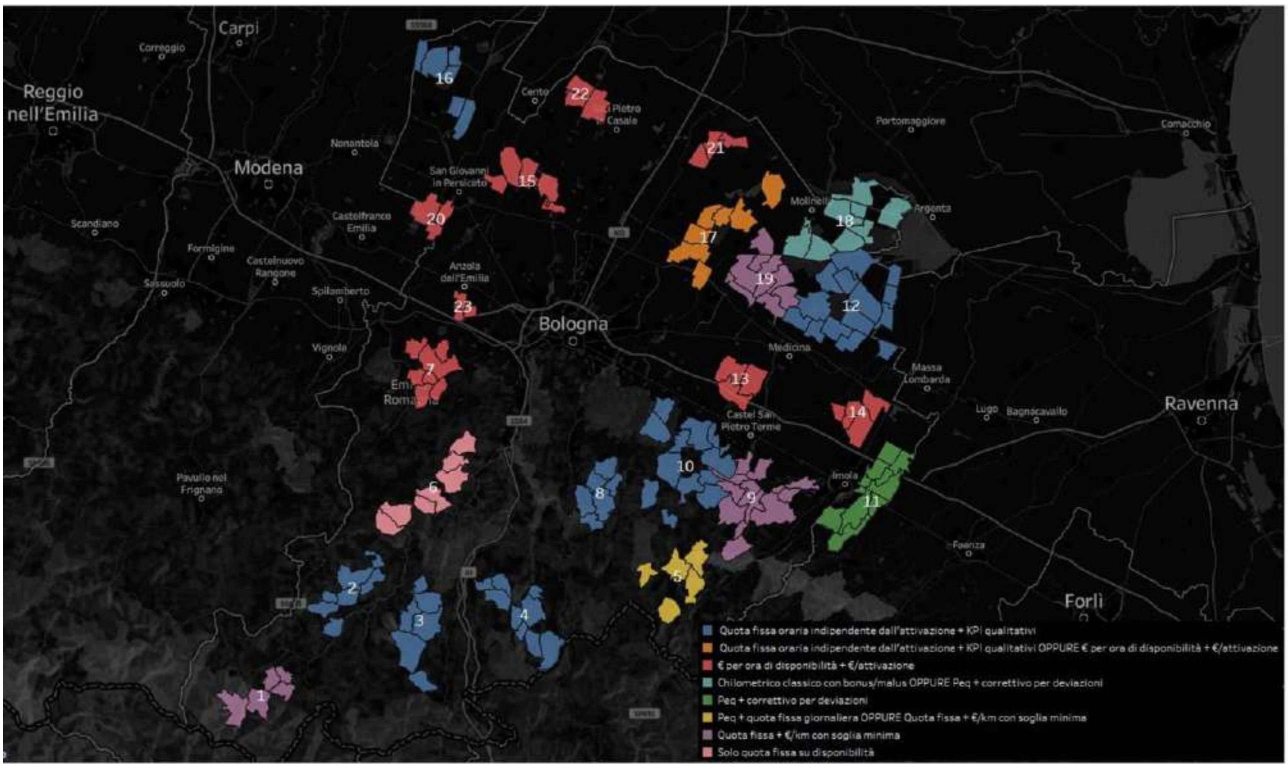

Figure8Assignment of DRT service remuneration models to the 23 areas with low demand (Source: GO-Mobility analysis)

AREA ID	OPERATING MODEL	DEMAND LEVEL	DRT REMUNERATION MODEL
1	Model 2-By reservation	Average	Fixed fee + €/km with minimum threshold
2	Model 4-Upon reservation	Low	Fixed hourly rate independent of activation + qualitative KPIs
3	Model 4-Upon reservation	Low	Fixed hourly rate independent of activation + qualitative KPIs

4	Model 4-Upon reservation	Low	Fixed hourly rate independent of activation + qualitative KPIs
5	Model 1-2-Pre-established	Med	Pe**q** + fixed daily rate OR Fixed rate + €/km with minimum threshold
6	Model 2-Upon reservation	Low	Fixed rate only, subject to availability
7	Model 4-Upon reservation	High	€ per hour of availability + €/activation
8	Model 4-Upon reservation	Low	Fixed hourly rate independent of activation + qualitative KPIs
9	Model 2 - Upon reservation	Average	Fixed rate + €/km with minimum threshold
10	Model 4-Upon reservation	Low	Fixed hourly rate independent of activation + qualitative KPIs
11	Model 2 - Upon reservation	High	Peq + corrective for deviations
12	Model 4-On request	Low	Fixed hourly rate independent of activation + qualitative KPIs
13	Model 4-Upon reservation	Med	€ per hour of availability + €/activation
14	Model 4-Upon reservation	High	€ per hour of availability + €/activation
15	Model 4-Upon reservation	Medium	€ per hour of availability + €/activation
16	Model 4-Upon reservation	Low	Fixed hourly rate independent of activation + qualitative KPIs
17	Model 3-4-Pre-established	Med	Fixed hourly rate independent of activation + qualitative KPIs **OR** € per hour of availability + €/activation
18	Model 1-2-Pre-established	High	Classic mileage with bonus/penalty OR Peq + correction for deviations
19	Model 2-Upon reservation	Average	Fixed fee + €/km with minimum threshold
20	Model 4-Upon reservation	High	€ per hour of availability + €/activation
2	Model 4-Upon reservation	High	€ per hour of availability + €/activation
22	Model 4-Upon reservation	Med	€ per hour of availability + €/activation
23	Model 4-Upon reservation	High	€ per hour of availability + €/activation

Table 10 Assignment of DRT service remuneration models to 23 areas with low demand (Source: GO-Mobility analysis)

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DREAM_PACE

From Traditional Routes to Flexible Networks: A Strategic Approach to Demand Responsive Transport Development

Final Version

09/2025

Authors and change log of the document

Partner No.	Partner Acronym	Name of the author	Action	Version
5	BKK	Péter Chifiriuc, Viktória Hideg	Draft	1
2	Redmint	Gabriele Grea, Anja Seyfert	Reviewed version	2

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1. Introduction

Urban mobility systems are undergoing significant transformation in response to changing passenger needs, technological innovations, and sustainability goals. Traditional fixed-route services, while effective in high-demand corridors, often fail to provide efficient and attractive solutions in areas with dispersed travel patterns, low demand, or evolving urban structures. Demand Responsive Transport (DRT) offers an adaptive alternative, bridging the gap between conventional public transport and individual mobility.

Furthermore, its flexibility requires a rethinking of operational standards, especially in the design and placement of boarding and alighting points, as well as in the legal framework that governs them.

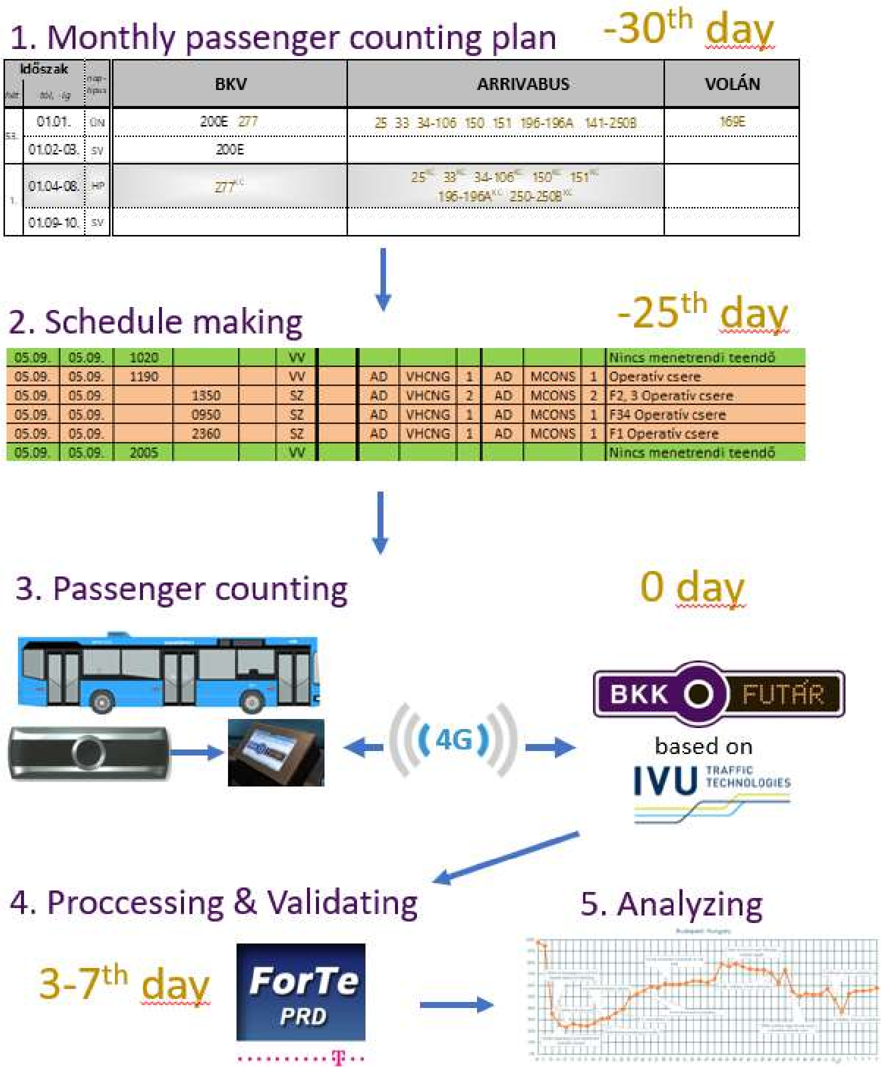
In Budapest, the introduction of DRT has highlighted the need for dedicated rules that differ from those applied to conventional bus services. Simplified stop infrastructure, flexible placement near intersections, and real-time passenger information tools all form part of a new approach that ensures accessibility, safety, and efficiency without the need for costly physical infrastructure. To enable these services, regulatory adjustments were made in cooperation between the BKK Centre for Budapest Transport and the Ministry of Construction and Transport, culminating in the inclusion of specific provisions in BKK's Service Regulations.

This document outlines the strategic approaches applied in Budapest to integrate flexible DRT solutions into the public transport system. It covers three key directions: the transformation of traditional fixed routes into demand-responsive services, the introduction of entirely new DRT lines in underserved neighbourhoods, and the enhancement of existing DRT services into more flexible and technologically supported solutions. The objective is to demonstrate how DRT can contribute to more efficient, sustainable, and passenger-oriented urban mobility, while aligning with long-term transport development strategies.

Chapter 7 provides an overview of how DRT and flexible-route DRT boarding points should be designed, located, and regulated, combining legal, operational, and passenger-oriented considerations into a coherent framework.

2. Data collection

In public transport, demand is strongly influenced by supply, particularly in urban areas. A frequent service, for example one with a higher level of service, generates more demand than a less frequent service. In urban areas, demand is ad-hoc and the travel chains are not quite preplanned. Digitalisation has made it possible to collect data completely, so we are able to determine exact demand. This fundamentally changed transport network and capacity planning and facilitate the widespread deployment of flexible systems. In Budapest the passenger number data comes from IRMA/DILAX passenger counters (infrared motion analyser). 60% of our buses, almost 100% of our trolleybuses are equipped with IRMA. With this method, detailed dataset can be collected, thus the constantly changing passenger demand is determined. This system can be used for annual traffic inspection on every bus line, trolleybus line and on some tram line. On these lines the cross-sectional passenger number, boarding and disembarking passenger numbers, vehicle utilisation are known through the whole line, every stop, full operation time.



1. Figure: Passenger counting process

For successful passenger counting monthly passenger counting plan and schedules are needed approximately a month before. During this time the operators are making everything ready, allocating vehicles suitable for passenger counting and giving all the information to the drivers. During passenger counting period, the passenger counting function is verified and inspected to filter the errors. The infrared passenger data is transmitted through fourth generation wireless mobile telecommunication technology to our system. After 3 days the raw data can be is validated semi-automatically in ForTe software, where all the static dataset of Budapest transport is stored. The validated passenger data can be used for analysing purposes.

3. Transforming traditional lines into DRT

Based on these data and analysis, new DRT service can be introduced on regular lines. In order to make an efficient, useful and convenient the DRT, low passenger number (0-5) is needed on a section or during specific operation time on the line. The goals are reducing noise pollution and eliminating unnecessary vehicle performances.

Spatial (section) differences:

- DRT in the full length of the line
- DRT in a particular section of the line

Time of operation (interval):

- in full operation
- outside of peak hours
- at the weekends
- at the weekends during early and night hours etc.

Spatial and operation combined:

- e.g. late night outer sections of particular lines.

On these complementary DRT services fix departure times are given and the routes are not flexible on the 'on demand section' (usually no infrastructure for turning).

To indicate a request a journey there are 4 options:

1. in person (in the terminal station or on the bus if the only the outer service of the line is operated in a demand-responsive way)
2. via phone
3. on Telebusz.bkk.hu website
4. through BudapestGO application on Telebusz.bkk.hu website

During the operation the dispatcher always records in the system which route the current departure was on through the whole day. This is an important requirement for financial and accounting aspects, also provides precise data about all journey requests to make adjustments in the future. All DRT lines in Budapest are operated by our internal operator (BKV – Budapest Transport Company also fully owned by Municipality of Budapest like BKK), because external operator contract does not allow such flexibility.

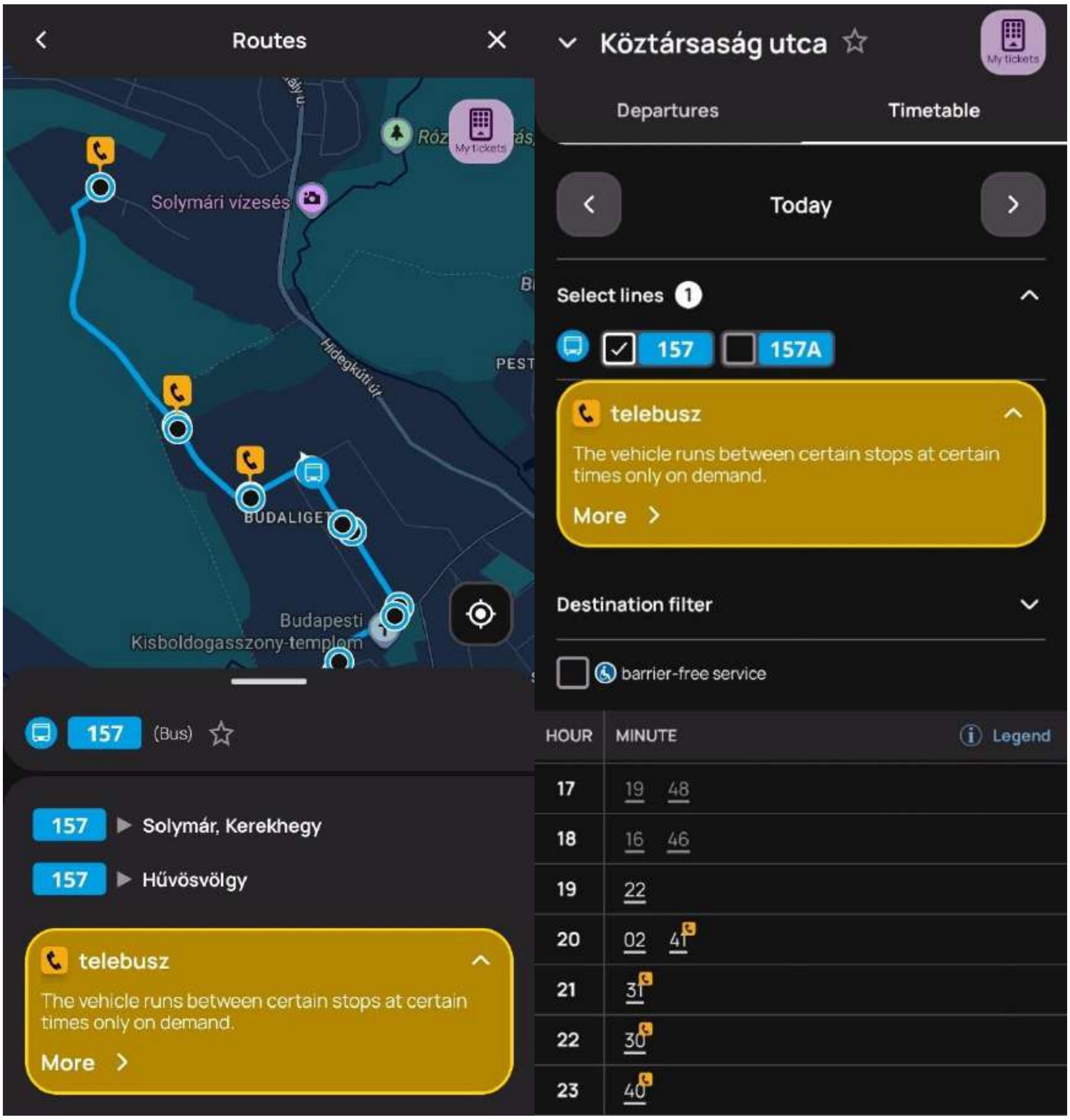
On DRT lines It is mandatory for the driver to have an extra smartphone to get the notifications for the demand, the current OBU (on board unit) does not have this function.

4. Introduction of an existing DRT line served by regular-sized buses: bus line 157

Bus line 157 has an on-demand service on the outer section (dashed line on the map) on weekday-nights and on the weekend. This outer section located in a protected forest, so the relevance of maintaining calmness is relevant. The diagram above shows that weekday nights the average passenger number between 2-3 people, if the bus was operating on the outer section based on demand. Only a little bit more than half of the departures has been completed during this period.

4.1. Passenger information and communication

All information is given via BudapestGO application, BKK.hu website and on the spot in the bus stops. (English language is also available).



2. Figure: BudapestGO application

3. Figure: Website and bus stop information I.

157 157A

▶ Budaliget, Géza fejedelem útja ▶ Solymár, Kerekhegy

	Hűvösvölgy
1'	Bátori László utca
2'	Bükkfa utca
3'	Széchenyi utca
4'	Turul utca
5'	Ábránd utca
6'	Arany János utca
7'	Szirom utca
8'	Kerekhegyi utca
9'	Máriaremetei kegytemplom
10'	Köztársaság utca
11'	Honfoglalás utca
12'	**Budaliget, Géza f. útja** 157A
13'	Muflon utca
15'	**Solymár, Kerekhegy** 157

Tanítási időszakban hétfőtől csütörtökig *Mon–Thu during school terms*	**Tanítási időszakban pénteken** *Fridays during school terms*	**Tanítási szünetben munkanapokon** *Workdays during school holidays*
04: 59A	04: 59A	04: 59A
05: 11, 31A, 51A	05: 11, 31A, 51A	05: 11, 31A, 51A
06: 05, 15A, 25, 35A, 45, 55A	06: 05, 15A, 25, 35A, 45, 55A	06: 05, 20A, 32, 47A, 57
07: 05, 15A, 25, 37A, 52	07: 05, 15A, 25, 37A, 52	07: 12A, 27, 40A, 52
08: 07A, 22, 42A	08: 07A, 22, 42A	08: 07A, 22, 42A
09: 02A, 22, 42A	09: 02A, 22, 42A	09: 02A, 22, 42A
10: 02A, 22, 42A	10: 02A, 22, 42A	10: 02A, 22, 42A
11: 02A, 22, 42A	11: 02A, 22, 42A	11: 02A, 22, 42A
12: 02A, 22, 42A	12: 02A, 22, 42A	12: 02A, 22, 42A
13: 02A, 22, 42A, 52A	13: 02A, 22, 42A, 52A	13: 02A, 22, 37A, 52A
14: 07, 22A, 37, 52A	14: 07, 20A, 32, 44A, 56	14: 07, 22A, 37, 52A
15: 07, 20A, 32, 44A, 56	15: 08A, 20, 32A, 44, 56A	15: 07, 20A, 35, 50A
16: 08A, 20, 32A, 44, 56A	16: 08, 20A, 35, 50A	16: 05, 20A, 35, 50A
17: 08, 20A, 35, 50A	17: 05, 20A, 35, 50A	17: 05, 20A, 35, 50A
18: 05, 20A, 35, 52A	18: 05, 20A, 35, 52A	18: 05, 20A, 35, 52A
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20: 12A, 32*, 52A	20: 12A, 32*, 52A	20: 12A, 32*, 52A
21: 22*, 51A	21: 22*, 51A	21: 22*, 51A
22: 21*, 51A	22: 21*, 51A	22: 21*, 51A
23: 31*	23: 31*	23: 31*

Szombaton *Saturdays*	**Munkaszüneti napokon** *Sundays and public holidays*	**December 27–31. között munkanapokon** *Workdays between 27–31 Dec*
04: 59A	04: 59A	04: 59A
05: 21*	05: 21*	05: 11, 31A, 51A
06: 01A, 21*, 51A	06: 01A, 21*, 51A	06: 05, 20A, 32, 49A, 59
07: 22*, 52A	07: 21*, 51A	07: 14A, 29, 42A, 54
08: 22*, 52A	08: 21*, 51A	08: 09A, 24, 44A
09: 22*, 52A	09: 24*, 54A	09: 02A, 22, 42A
10: 22*, 52A	10: 24*, 54A	10: 02A, 22, 42A
11: 22*, 52A	11: 24*, 54A	11: 02A, 22, 42A
12: 22*, 52A	12: 24*, 54A	12: 02A, 22, 42A
13: 22*, 52A	13: 24*, 54A	13: 02A, 22, 37A, 52A
14: 22*, 52A	14: 24*, 54A	14: 07, 22A, 37, 52A
15: 24*, 54A	15: 24*, 54A	15: 07, 20A, 35, 50A
16: 24*, 54A	16: 24*, 54A	16: 05, 20A, 35, 50A
17: 24*, 54A	17: 24*, 54A	17: 05, 20A, 35, 50A
18: 24*, 54A	18: 24*, 54A	18: 05, 20A, 35, 52A
19: 24*, 54A	19: 24*, 54A	19: 12, 32A, 52
20: 24*, 54A	20: 24*, 54A	20: 12A, 32*, 52A
21: 24*, 51A	21: 24*, 51A	21: 22*, 51A
22: 21*, 51A	22: 21*, 51A	22: 21*, 51A
23: 31*	23: 31*	23: 31*

A: 157A busz, Budaliget, Géza fejedelem útjáig
bus 157A to Budaliget, Géza fejedelem útja

A *-gal jelölt időpontokban Budaliget, Géza fejedelem útja–Solymár, Kerekhegy szakaszon csak igény esetén közlekedik: telebusz.bkk.hu, nyitvatartási időben +36 1 3 255 255 (#3).
*At the times marked with an * the bus runs as on-demand service on the route section Budaliget, Géza fejedelem útja–Solymár, Kerekhegy, please request in advance: telebusz.bkk.hu, or while our lines are open +36 1 3 255 255 (#3).*

Minden jármű akadálymentes.
All vehicles are accessible.

BUDAPEST BKK
bkk.hu +36 1 3 255 255
BKK Utastájékoztatás

Felszállás az első ajtón / *Front-door boarding only*

Érvényesség kezdete (visszavonásig) / *Valid from (y/m/d) until further notice:* 2024.02.01.
Az adatok tájékoztató jellegűek. / *Data provided for information purposes only.*

007977

4. Figure: Website and bus stop information II.

5. Figure: Passenger traffic and demand percentage of bus line 157 on weekdays – on the outer section

Departure times marked in blue are demand-responsive ones

The empty purple columns are showing the average demand percentage (fix departures are 100%)

The magenta columns are showing the average passenger number on each departure

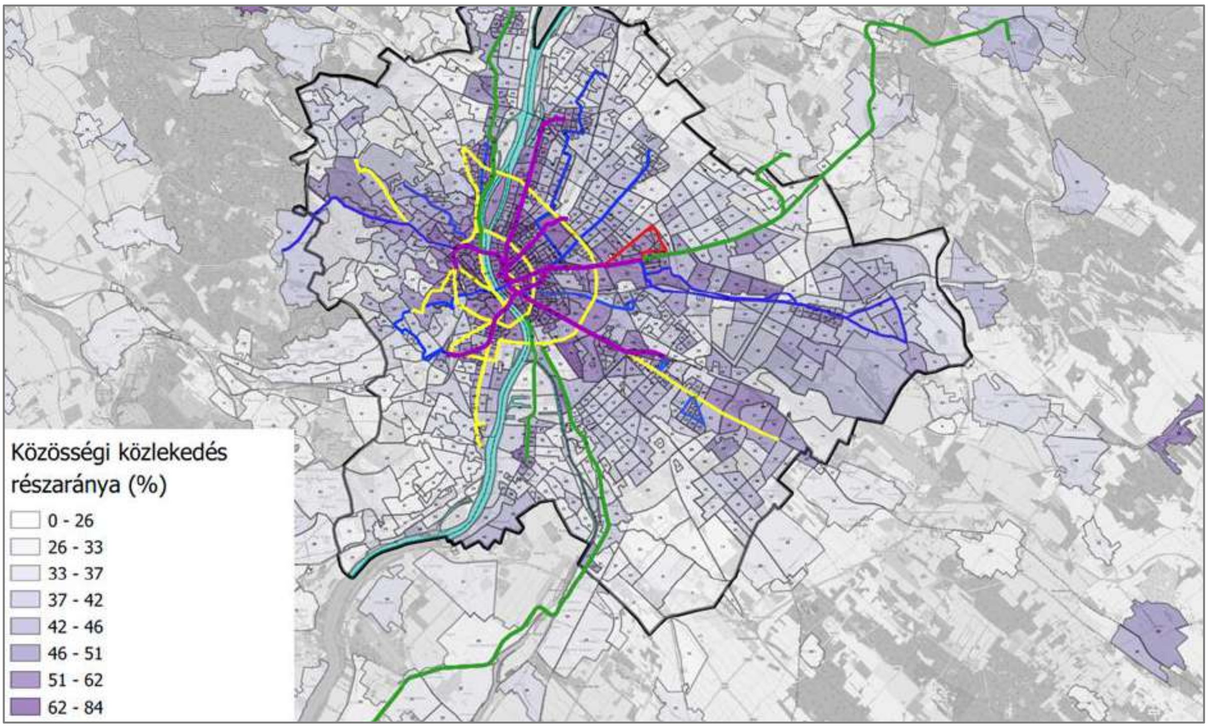
5. Developing new DRT lines

Changing, developing and introducing new public transport network is a long and complex process. In this section focuses are on the introduction of new service.

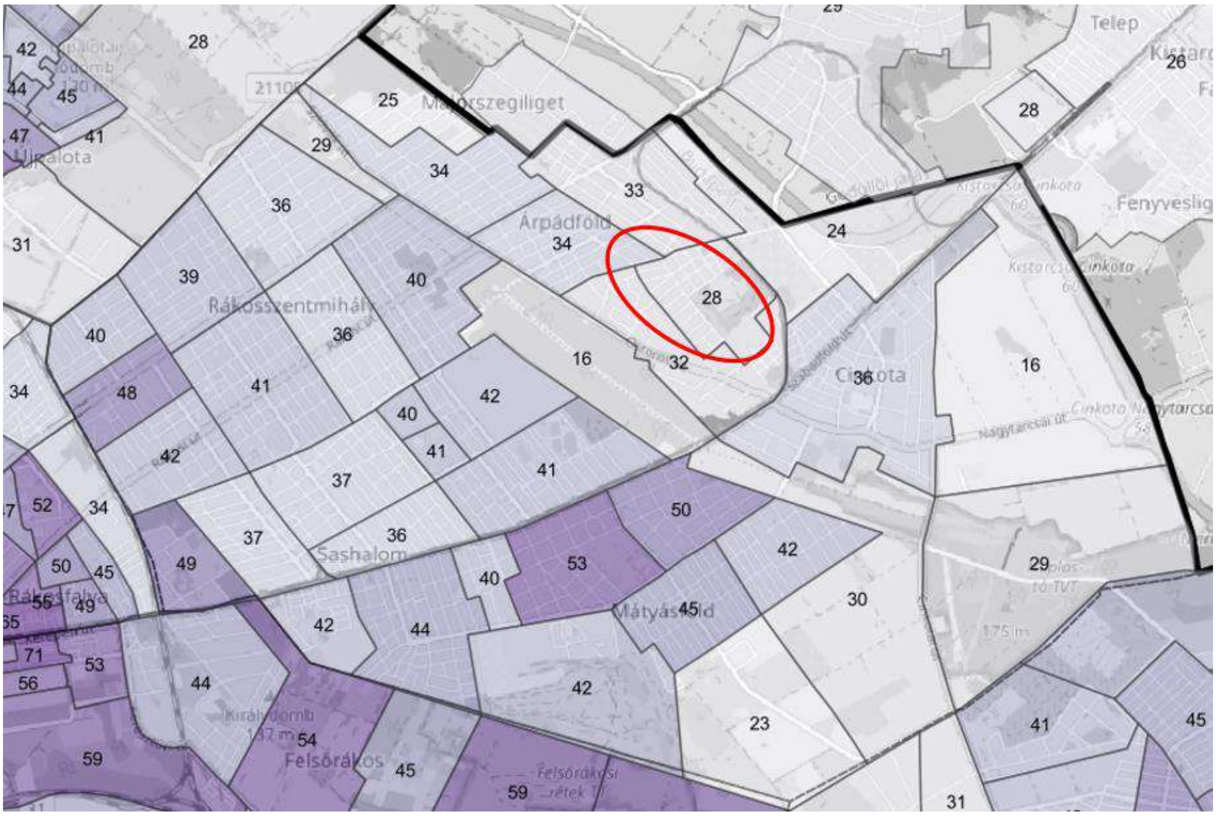
The Budapest Mobility Plan precisely states the direction of the public transport development. It is necessary and possible to expand and refine the bus network. The public transport network in Budapest is generally of good quality, but there are a significant number of neighbourhoods in the capital (e.g. suburbs or even new residential areas) where there is no competitive public transport service. In these areas, restructuring of existing capacity or new capacity by creating new bus lines, a measurable change can be achieved. In terms of the network, urban transport development in the past three decades has not been flexible enough to follow urban developments, and real estate developments have not taken into account network accessibility aspects and changes outside the transport system in general. Private car use is high and access to the city from outlying areas by public transport is generally more difficult. In the case of the public transport network, this means improvements to reinforce its integrity: connecting isolated parts of the network, while improving operational efficiency and the cityscape.

When designing the public transport network, the aim is to reduce the number of transfers per trip. But transfers and mode changes cannot be eliminated completely, so Budapest is striving to create simple, fast, transparent, passenger-friendly intermodal hubs that provide convenient customer movement. In designing transfer hubs, Budapest takes into account passenger flow characteristics, reducing the number of transfers per passenger, increasing the number of connecting transfers points along with the comfort level of transfers, reducing walking distances and differences in height level.

For complex network planning BKK has the opportunity to use its macroscopic transport planning and simulation software, called EFM ("Egységes Forgalmi Modell = Unified Traffic Model" based on PTV Visum). This software has several inputs: public transport GTFS, public transport passenger numbers, surveys (e.g. household surveys), road traffic data, regional statistics data, Hungarian Central Statistical Office data, infrastructure. Based on this dataset detailed analytics are available.



6. Figure: Public transport modal split in Budapest (White: low, dark purple: high)



7. Figure: Public transport modal split in Csobaj-bánya (DREAM_PACE pilot)

8. Figure: Public transport stops accessibility within 250 metres

In the particular area of the district XVI., called „Csobaj-bánya", new housing areas have been established in the previous years. The public transport coverage is poor, bus stops are hardly accessible, this is why public transport modal split is the lowest in this area of district XVI. and the car dependency is really high.

It is considered good accessibility if public transport reachable within 5-minute-walk (200-400 meters), but it also depends on terrain, people's physical condition, size of the luggage etc.

9. Figure: Csobaj-bánya is on a little hill

This area is underserved by public transport and due to the green residential area, the narrow streets with high occupancy parking and complex city structure, regular-sized buses are not suitable for the operation.

10. Figure: Csobaj-bánya street parking and the new DRT line

Considering the complex situation here a new demand-reponsively operated bus line was introduced in the area with flexible route options and boarding points, connecting the neighbourhood with the local suburban railway station of Cinkota.

Those who travelling by private cars they often oppose bus transportation, considering as dirty, noisy, pollutant, dangerous for children and destroys the good condition of the roads. In this situation a demand-reponsively operated bus can positively influence the opinions and people are accepting faster the new service this way.

6. Transforming existing DRT lines into flexible DRT lines

Transforming an existing line is not that complex like introducing a new one. To make a line spatially flexible, the following are needed:

- Analysing passenger numbers, too high demand is not suitable for flexible DRT
- Designating new boarding points and turning points,
- A flexible DRT software like in DREAM_PACE project,
- New hardware on board:
    - changing, making smarter the current OBU and its system on the vehicles or
    - buying more portable smart OBU like in DREAM_PACE project,
- Training more bus drivers to use this flexible system,
- Financial, accounting and SLA (service level agreement) clarification in accordance with operator contracts (currently we are using a temporary method* during the DREAM_PACE project, it is also possible that this solution can be permanent in the future).

(*every departure marked as "cancelled" because we can't assign kilometres to it, and on the end of the day summary document is uploaded containing total daily kilometres.)

7. Designing, locating and regulating stops for demand responsive and flexible DRT services

This section provides an overview of how DRT and flexible-route DRT boarding points should be designed, located, and regulated, combining legal, operational, and passenger-oriented considerations into a coherent framework.

7.1. Regulatory framework

According to Hungarian legislation (Act XLI of 2012 on Passenger Transport), demand-responsive transport is defined as a licensed public service operated under a Service Contract or a route licence, supported by information technology, and functioning on a variable route, a variable timetable, or both. The BKK Telebus service in Budapest is one such demand-responsive system, legally recognised under this framework, and operated with IT-based request and scheduling mechanisms.

To enable these services, a specific regulatory environment had to be established. The BKK Centre for Budapest Transport, in coordination with the Ministry of Construction and Transport, developed rules and incorporated them into BKK's official Service Regulations. These provisions define the design and operation of DRT stops, ensuring safety, accessibility, and compliance with traffic regulations.

7.2. Boarding points design principles

Unlike traditional public transport stops, DRT boarding and alighting points do not require built infrastructure such as shelters or designated bus bays. Instead, they are identified by simplified "Telebus" signs, which do not qualify as standard traffic signs under the Hungarian Road Traffic Code (KRESZ). To distinguish them from traditional stops, we call them boarding and alighting points. These simplified signs indicate the location where passengers may board or alight on demand.

For flexible-route DRT, the same type of simplified stops is applied, but with added considerations due to the variability of vehicle approach directions. Because vehicles may arrive from multiple directions, stops are preferably located near intersections.

7.2.1. Boarding points placement guidelines

- **Intersection-based placement**: Stops should be designated near intersections, allowing vehicles to approach from multiple directions.
- **Avoid clustering of signs:** To prevent passenger confusion and urban clutter, only one stop sign should be placed at each intersection. Installing multiple signs at the same junction is discouraged, as it complicates wayfinding.
- **Passenger awareness:** Information materials (sign plates, system guides, digital platforms) must clearly state that the stop sign does not necessarily mark the exact boarding location, as vehicles may stop at different points around the intersection depending on the approach direction.
- **Safety considerations:** Passengers must be advised to cross the street carefully, as vehicles can arrive from more than one direction. This design is particularly suited for low-traffic residential streets, where safe crossing is feasible.

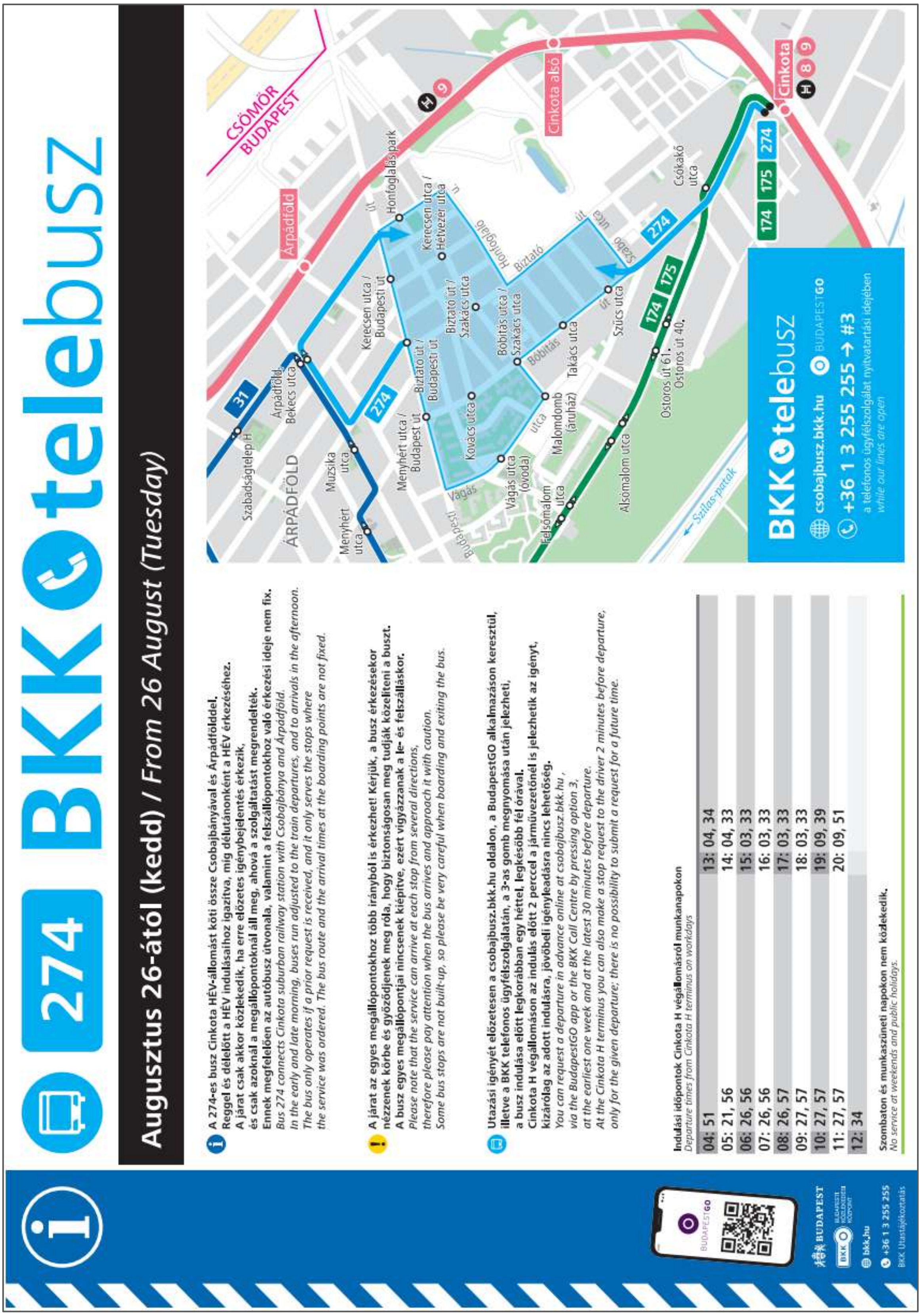
- **Digital support:** Real-time vehicle tracking via the BudapestGO application mitigates uncertainty, allowing passengers to follow the vehicle's exact approach and arrival time.

11. Figure: Sign indicating the boarding and alighting point of the new DRT line

12. Figure: Passenger information at the DRT boarding points

7.2.2. Accessibility requirements

All stops and vehicles used in DRT services must ensure accessibility for passengers with reduced mobility. Vehicles must be equipped with deployable ramps, designed to avoid excessive steepness, so that boarding with wheelchairs or strollers is possible. This ensures that flexible and demand-driven services are inclusive and meet universal design standards.



13. Figure: Website and bus stop information of the new DRT line

7.2.3. Regulatory definition of DRT boarding and alighting points

As stated in the BKK Service Regulations (developed in agreement with the Ministry of Construction and Transport):

"Boarding and alighting points are locations marked by signs that are not recognised as KRESZ traffic signs, where BKK vehicles may stop within the framework of demand-responsive services. Unlike traditional bus stops, boarding and alighting may take place directly from the roadway. The route of the service within the operating area includes only those points where a concrete, pre-announced travel request has been made. These points are located at road junctions, with vehicles stopping before the junction, in the direction of arrival."

The BKK Service Regulations are available on the BKK website: https://bkk.hu/downloads/31691/

8. Conclusion

The transition towards flexible and demand-responsive services represents an important step in reshaping public transport to meet 21st-century challenges. The case studies and experiences presented in this document highlight three complementary pathways: adapting traditional low-demand routes into DRT services, developing new flexible lines in growing residential areas, and upgrading existing DRT lines with enhanced flexibility and digital support.

Together, these approaches illustrate how demand-responsive transport can increase efficiency, reduce unnecessary vehicle kilometres, and improve accessibility in areas where traditional public transport solutions are insufficient. Beyond operational efficiency, DRT services also address broader strategic objectives such as reducing car dependency, lowering environmental impacts, and improving the perceived quality of public mobility.

The lessons learned point towards the importance of combining data-driven planning, flexible service design, and modern digital tools to achieve a balanced, sustainable, and customer-friendly mobility system. Demand Responsive Transport is not only a supplementary service but also a strategic enabler for the future of integrated and resilient urban transport networks.

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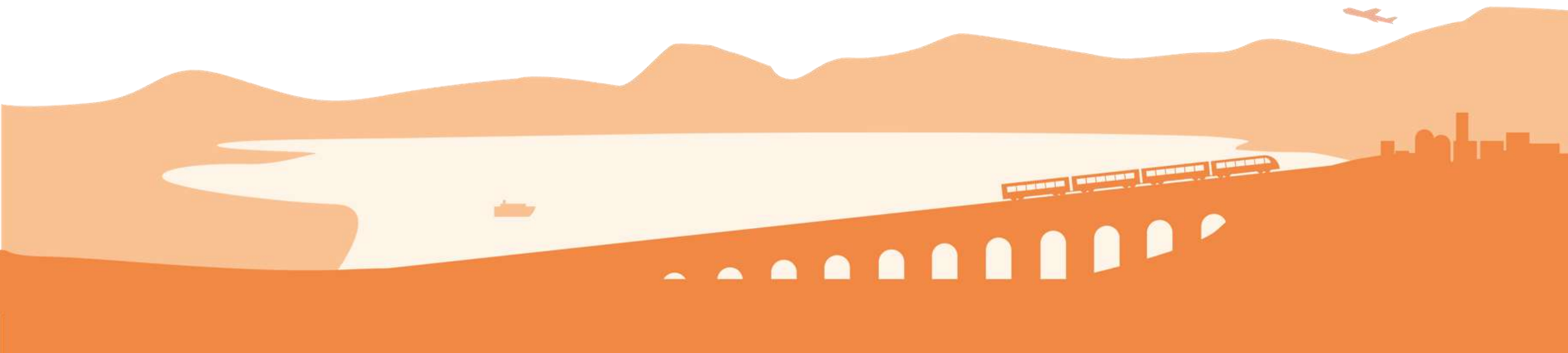
DREAM_PACE

DRT dedicated tendering procedure (greenfield)

Area Split Dalmatia

Final Version
09/2025



GUIDELINES FOR TENDER DOCUMENTATION AND THE TENDER PROCEDURE

Partner No.	Partner Acronym	Name of the author	Action	Version
6	Dyvolve	Saša Bart, Dijana Mišerić Beganović	Input for D.1.2.3.	1
2	Redmint	Gabriele Grea, Anja Seyfert	Reviewed version	2

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1. Summary

The chapters below represent the structure of the tender documentation. Each chapter provides a detailed description of what needs to be included when preparing the tender documentation. It is important to reference the applicable legal regulations in each chapter.

The tender documentation outlines the requirements and guidelines for procuring a Demand-Responsive Transport (DRT) service. It begins with an introduction defining the procurement scope, emphasizing whether the project is a pilot and detailing funding sources, service area, and bidder expectations, including vehicle categories, software needs, and human resources.

The DRT service section describes how the service will operate, its duration, funding, and organization. It highlights the service’s purpose, legal framework, and the obligations of both the contracting authority and service provider, including licensing and service quality. Key service features such as flexible timetables, stop policies, free-of-charge provisions, and legal compliance are detailed. The service area, operational standards, vehicle and communication requirements, and quality standards for cleanliness, heating/cooling, passenger information, and vehicle marking are specified.

Reporting and supervision processes are defined, including frequency, notification methods, and responsible entities.

The software section describes the required support system for the DRT service, consisting of three applications: back-office (for managing routes, passengers, and data), driver (for navigation and communication via tablets), and user (for ride booking and tracking). Functionalities and platform requirements (Android/iOS) are specified.

Vehicle equipment requirements focus on tablet devices to support communication, navigation, and interaction between drivers and the central system.

Selection criteria for the economic operator include valid licenses, proven experience, adequate human and technical resources, and compliance with technical specifications for vehicles and software. Proof of these criteria is required through various forms and documentation.

Contract duration options, such as a 1-month testing plus 11 months of service or continuous 12 months, are discussed.

Service availability standards establish response and resolution times based on problem severity, ensuring timely issue management to maintain service quality.

2. Introduction

In the introductory part of the tender documentation, it is necessary to describe the subject of procurement, i.e., the DRT service. If necessary, it should be emphasized whether this is a pilot project and what the sources of funding are. It is important to highlight the area in which the DRT service will be provided. This section should clearly state what is expected from the Bidder (which components are required in the applications and what documentation constitutes a complete application). The key components expected from the Bidder should be briefly summarized, such as the vehicle category, number of vehicles, whether software is needed, application solutions for users and drivers, and vehicle equipment. It should be emphasized that the Bidder is also expected to provide human resources (drivers, dispatchers, and other personnel who will operate the service). The introductory part must also define the terminology (contracting authority, bidder, and other definitions) that will be used in the rest of the tender documentation, in accordance with applicable national legislation.

3. DRT service

This section describes the method of providing the DRT service, its duration, funding, the area where the service will be provided, and its organization. It is necessary to emphasize the goal and purpose of implementing the DRT service, as well as to define DRT in accordance with national legal regulations and guidelines.
Focus should also be placed on the source(s) of funding/co-funding for the service (EU programs, national programs, regional and local sources, ticket sales, etc.). The duration of the service should be specified, including whether a testing period is required (e.g., the 1+11 model, where the first month is for testing and service adjustment, and the remaining 11 months are for full-service delivery). When describing the DRT service, it is important to highlight the rights and responsibilities of both the contracting authority and the service provider. For the service provider, it is necessary to outline the minimum requirements for application (e.g., valid passenger transport licenses and other documentation in accordance with national legislation).
The service provider must commit to offering the DRT service to meet the transport needs of residents in rural and sparsely populated areas where no public line transport is organized, in response to specific transport requests. It should also be clearly stated whether the DRT model is predefined (e.g., fixed or flexible timetables, fixed or flexible stops). It is important to describe and define possible scenarios, such as passengers waiting at a stop without having requested transport (the contracting authority must determine whether boarding the DRT vehicle is allowed without prior notice or only according to available vehicle capacity).

In cases where the service is free of charge for the end user, it is necessary to describe how users/passengers will receive confirmation of transport (depending on applicable national laws regarding travel tickets). In the case of free tickets, the service provider must commit not to charge end users for tickets, in accordance with the provisions of the Contracting Authority or the rules regarding co-financing from EU funds. It is necessary to list all legal acts and regulations related to the provision of DRT services in accordance with national legislation. In the descriptive part of the service, it is important to provide detailed information on the area where the DRT service will be provided, including:

- The DRT model (variable or flexible timetables and stops)
- DRT operating hours (weekends, holidays, nighttime hours)
- The administrative area in which the service will be provided
- The total route length
- The expected travel time (if the model allows for estimation, where at least one component is fixed)
- Daily mileage and fuel consumption estimates
- Number of driver shifts
- A map of the area and/or route where the service will be provided
- Transfer points to other DRT lines, if applicable
- Transfer points to other modes of transport, if applicable (regular bus, rail, and/or maritime lines)

- A table of stops for each line and in each direction (if a fixed-stop model is selected)

It is important to highlight and specify the quality standards of the DRT service that relate to:

- **Technical standards** (cleanliness, heating/cooling, passenger information and booking of DRT services via web and/or mobile applications)
- **Operational standards** (number and type of vehicles, regularity in service delivery, replacement vehicle in case of breakdown)
- **Communication standards within vehicles and with passengers** (a device in the provider's vehicle with a screen that can generate a route based on passenger requests, the ability to issue travel tickets outside the vehicle—via an app—and/or inside the vehicle, a web and/or mobile application for passengers, and responsiveness to feedback and complaints)

Quality standards are confirmed based on the submitted forms (annexes in the annex chapter). Each required standard must be described in detail. Guidelines for the standards include:

Technical quality standards and required criteria:

- **vehicle cleanliness includes:**
  - vehicles providing DRT services must be clean both inside and outside,
  - internal cleanliness of the vehicle means that the vehicle is swept, dirt is removed, and the vehicle is ventilated,
  - fabric-covered seats must be cleaned,
  - in case of significant internal and/or external contamination of the vehicle, cleaning must be carried out immediately after such contamination occurs, regardless of when the last cleaning was done,
  - external cleaning of the vehicle means that the vehicle is completely cleaned on the outside,
  - vehicles performing DRT services must be clean on the outside,
  - the DRT service provider is obliged to keep and maintain records of all performed cleanings.
- **heating and cooling of the vehicle:**
  - the DRT service provider must ensure that all heating and cooling devices are functioning properly and are set appropriately,
  - the DRT service provider is obliged to ensure that all vehicles are heated and cooled according to the weather conditions.
- **informing passengers via a mobile application**
  - a mobile application should be available to passengers,
  - the applications should include at least the following functionalities:
    - reservation, ordering, and cancellation of the DRTservice,
    - trip planning,
    - tracking the status and arrival time of the ordered vehicle via a map (automatic real-time status updates),
    - receiving status and general information from the dispatcher/system (through the app and push notifications),
    - payment support (support and management of credit cards),
    - support for integration with other systems (e.g., ticketing systems),
    - the application should support Android and iOS, mobile phones, and tablets (native applications for both platforms).
- **external marking of the vehicle**
  - the service provider, when performing the DRT service, must mark the vehicles with appropriate signs (indicating that the service is funded by an EU project), which will be prepared by the Client.

Operational quality standards and required criteria are:

- Number of vehicles – The DRT service provider must deliver the planned public transport service in accordance with the obligations set out in the DRT Service chapter, either with the planned vehicles or with replacement vehicles in case of breakdowns or other operational difficulties.
- Type of vehicles – The DRT service provider is obliged to perform the services using the planned and approved types of vehicles according to the obligations in the DRT Service chapter.
- Regularity of transport – The DRT service provider commits to performing the contracted transport regularly and in accordance with the variable timetable.
- Adherence to the variable timetable – The DRT service provider commits to performing the contracted transport according to the variable timetable, which means that if there is demand and a variable timetable is generated, the service must be provided at the agreed time; otherwise, if there is no demand and no requests for DRT service are received, the provider is not obligated to run “empty rides.”
- Replacement vehicle – The DRT service provider commits that, in case the planned timetable is disrupted due to vehicle breakdown, accident, or other reasons, a replacement vehicle will be provided.

Communication standards with passengers and required criteria are:

- Informing passengers via website and/or mobile application,
- The DRT service provider is obliged to provide at least the following information: service operating hours, departure time and location, route lines, rules for using the DRT service, and the customer service phone number,
- The DRT service provider is obliged to inform passengers about planned changes in service provision via website and/or mobile application,
- The DRT service provider is obliged to respond to passenger suggestions and complaints within 14 days from the date of receipt,
- The DRT service provider is obliged to notify the Client of all received passenger suggestions and complaints within 14 days from the date of receipt, as well as inform about their response within 14 days from sending the reply to the suggestions and/or complaints.

Reporting

It is necessary to define the reporting method and how often supervision by the Client will be carried out. It is also necessary to define whether the supervision will be conducted with prior notice and/or unannounced, and whether it will be carried out exclusively by the Client or by a legal entity appointed by the Client (Form 4 in Annex).

4. SOFTWARE AS SUPPORT FOR THE DRT SERVICE

In the chapters related to software as support for the DRT service, it is necessary to define how the software should look and what it should include (a back-office application, a driver application, and a user application). In addition, it should be specified whether the vehicles need to be equipped with tablet devices (Android or iOS) on which the driver application will be installed.

4.1. Backoffice application

Through this application, the DRT service provider should have the ability to create new and optimize existing itineraries, as well as manage passenger pick-up and drop-off. In addition to service monitoring and management capabilities, various statistical data should also be available, such as information on vehicles, number of passengers, etc. The application must allow for user registration and management of registered users/passengers.

Functionalities that the Backoffice application should support - guidelines:

- real-time fleet monitoring,
- overview of vehicle data,
- creation and modification of itineraries,
- passenger pick-up and drop-off management,
- service-related statistical data,
- report generation based on available data,
- user management (user accounts, payment history, payment methods, etc.),
- driver management (creation of checklists),
- support for integration with other systems (e.g., ticketing systems),
- the client application should be accessible via standard web browsers on PC and Mac computers (cloud-based solution).

4.2. Driver application

In the chapter related to the driver application, the Client should emphasize the purpose of the application, which is the timely delivery of relevant information as well as general communication between the DRT vehicle network and the Backoffice system. The main focus of the application is real-time navigation functionality, which includes automatic routing and scheduling of pick-up and arrival times. Communication is carried out via tablet devices with which the vehicles used for providing the DRT service must be equipped.

It is also necessary to define the functionalities of the application. The guidelines are:

- communication between the driver and the central (Backoffice) system,
- turn-by-turn navigation with voice and visual instructions,
- automatic routing and time scheduling based on advanced algorithms for calculating the most efficient itineraries,
- display of traffic information,
- two-way text communication between one or more drivers and the dispatcher/system (via the app and push notifications),
- display of interactive checklists managed through the Backoffice application,
- interactive predefined interactions with drivers and dispatchers (e.g., confirmation of passenger boarding and/or drop-off),
- the application should support Android and iOS, both mobile and tablet devices (native applications for both platforms)

4.3. Application for the Service Users

In this chapter, the Client should emphasize in the documentation that this application is intended for the end users of the DRT service. The goal is to encourage users to utilize the service, which will provide them with additional mobility not supported by other modes of public transport due to infrastructural and/or organizational limitations.

Through the application, passengers should be able to order/reserve their ride and track the status and arrival time of the ordered vehicle.

The application must be connected to the Backoffice system, which should be the backbone of all transactions between the connected systems (Backoffice, Driver Application, and User Application).

Functionalities that the user application should support – guidelines:

- reservation, ordering, and cancellation of the DRT service,
- trip planning,
- tracking the status and arrival time of the ordered vehicle via a map (automatic real-time status updates),
- receiving status and general information from the dispatcher/system (through the app and push notifications),
- payment support (support and management of credit cards),
- support for integration with other systems (e.g., ticketing systems),
- the application should support Android and iOS, mobile phones and tablets (native applications for both platforms)

5. EQUIPMENT FOR VEHICLES (tablet devices for the driver application)

In the tender documentation, it should be emphasized that the vehicles used to provide the DRT service must be equipped with tablet devices, which will support communication with the central part of the information system (Backoffice), navigation, and other functions such as:

- communication between the driver and the central (Backoffice) system,
- turn-by-turn navigation with voice and visual instructions,
- automatic routing and time scheduling based on advanced algorithms for calculating the most efficient itineraries,
- display of traffic information,
- two-way text communication between one or more drivers and the dispatcher/system (via the app and push notifications),
- display of interactive checklists managed through the Backoffice application,
- interactive predefined interactions with drivers and dispatchers (e.g., confirmation of passenger boarding and/or drop-off),
- the tablet device must be based on the Android or iOS platform

6. Criteria for the Selection of the Economic Operator

In the tender documentation, it should be emphasized on the criteria according to which the DRT service provider will be selected. Below are guidelines that need to be adapted to the legal regulations of the country in which the tender is issued.

- **License authorizing the performance of public passenger transport activities**
  Proof method:
  A document proving this requirement is an extract from the license for each individual vehicle offered by the bidder for the execution of the passenger transport service (if the carrier has been issued a license for the provision of domestic road transport services).
- **The economic operator must demonstrate that it has the necessary human and technical resources, as well as the experience required to perform the public procurement contract at an appropriate level of quality,** especially by proving a sufficient level of experience, which shall be demonstrated through appropriate references from previously completed contracts.
  Proof method:
  A statement by the bidder that they have at their disposal the minimum required number of drivers, and that these drivers meet all professional qualification requirements, along with **Form 3**.
- **The economic operator must demonstrate that, in the year in which the public procurement procedure was initiated and during the three preceding years, it has been providing public passenger transport services**, and must prove that this has been done through one or more contracts related to passenger transport services.
  Proof method:
  A statement by the bidder confirming the provision of public passenger transport services for at least 3 years, through one or more contracts related to the provision of such services.

TECHNICAL CAPACITY REQUIREMENTS:

- The economic operator must demonstrate that it has an established information system with all three key components supporting the DRT service (Backoffice application, Driver application, User application).
- The economic operator must demonstrate that it has the minimum required number of vehicles available to provide the service subject to this public procurement procedure. All vehicles must comply with the applicable legal regulations of the country to which the tender documentation refers.

All vehicles must meet the following technical specifications:

1. Connected to the information system for managing the DRT service
2. Equipped with tablet devices as a platform for using the driver application
3. Air conditioning and heating of the passenger compartment – factory-installed or certified

Proof method:

Completed **Form 1 - Statement on the category and technical specifications of vehicles**, with attached copies of the registration documents for each vehicle, as well as a **statement on the age of the vehicles (Form 2)**.

CONTRACT DURATION

The duration of the contract must be defined, along with the applicable model (e.g., whether there is a testing period such as a **1 + 11** model, where the first month is dedicated to service testing, or a **12-month model** in which the DRT service is provided continuously for all 12 months).

SELECTION CRITERION

The tender documentation should also include the criteria for selecting the bidder. The selection criterion may be **the lowest offered price**. The offer must meet all the specified **minimum selection criteria**.

SERVICE AVAILABILITY

During the provision of the DRT service, the Provider must ensure service availability, i.e., resolve any issues affecting service delivery within defined timeframes, in accordance with the severity of the problem. Guidelines are presented in the table below.

Severity level	Problem description	Response time	Expected resolution time
1	Failures and malfunctions causing complete service unavailability. Example of a first-level problem: unavailability of the information system supporting the DRT service.	2 hours from the problem report	12 hours from the start of problem resolution
2	Failures and malfunctions causing partial service unavailability. Example of a second-level problem: vehicle malfunction.	1 hour from the problem report	24 hours from the start of problem resolution
3	Failures and malfunctions that reduce the quality of the service. Example of a third-level problem: certain functionalities of the user application are unavailable, e.g., real-time vehicle tracking is not working.	8 hours from the problem report	As soon as possible depending on the nature of the problem, but no later than 2 working days from the problem report
4	Difficulties that do not significantly affect system operation and do not slow down business processes (minor defects). Example of a fourth-level problem: issues with the vehicle's air conditioning function.	24 hours from the problem report	As soon as possible depending on the nature of the problem, but no later than 5 working days from the problem report

7. Conclusion

The tender documentation provides a detailed and structured guide to ensure that the procurement and delivery of the DRT service meet high standards of quality, efficiency, and legal compliance. By clearly defining technical, operational, and communication requirements, as well as the selection criteria for bidders, it aims to facilitate the selection of a competent service provider capable of delivering reliable and user-friendly transport solutions tailored to the specific needs of rural and underserved areas. This structured approach ensures transparency, accountability, and continuous service improvement throughout the contract duration.

8. Literature

Regulation (EU) No. 1370/2007 of the European Parlament and of the Council and the legal framework of the Republic of Croatia:

1) Regulation (EC) No. 1370/2007 of the European Parliament and of the Council of 23 October 2007 on public passenger transport services by rail and by road and repealing Council Regulations (EEC) No. 1191/69 and (EEC) No. 1107/70;
2) Road Transport Act (Official Gazette Nos. 41/18, 98/19, 30/21, 89/21, 114/22, 136/24);
3) Regulation on special conditions for vehicles used in public road transport and transport for own needs (Official Gazette Nos. 50/18, 56/19, 107/20, 147/21, 71/22).

9. Annex (forms)

FORM 1.

STATEMENT
ON THE CATEGORY AND TEHNICAL SPECIFICATIONS OF THE VEHICLE

CONTRACTING AUTHORITY:
REFERENCE NUMBER:
SUBJECT OF PROCUREMENT:

I, ____ from ________________________________,
(name and surname) (place)

ID card number/passport number: __________________________________, as the authorized person for this procedure

____
(name and registered office of the economic entity),

ID: _________________________, under material and criminal liability, I hereby declare that we have the following vehicles at our disposal:

Serial number	Vehicle registration number	Category of vehicles	Euro standard	The vehicle meets all technical specifications required under the chapters "Requirements for the Economic Operator" and "Technical Capacity Requirements" (yes/no)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

FORM 2.

STATEMENT
ON THE AGE OF THE VEHICLE

CONTRACTING AUTHORITY:
REFERENCE NUMBER:
SUBJECT OF PROCUREMENT:

I, ____ from _____________________________________,
(name and surname) (place)

ID card number/passport number: ______________________________________, as the authorized person for this procedure

____
(name and registered office of the economic entity)

ID: ____________________________, under material and criminal liability, I hereby declare that we have the following vehicles at our disposal:

Serial numb er	Vehicle registration number	Category of vehicles	Euro standard	The vehicle has all the technical characteristics required in the chapters "Conditions of the Economic Operator and Conditions of Technical Capability" (yes/no)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

Copies of the vehicle registration certificates for the vehicles listed in the table are attached to this statement.

FORM 3.

STATEMENT
ON THE AVAILABILITY OF HUMAN RESOURCES

CONTRACTING AUTHORITY:
RECORD NUMBER:
SUBJECT OF PROCUREMENT:

I, ____ from______________________________________,
(name and surname) (place)

ID card number/passport number: ______________________________________, as the authorized person for this procedure

____
(name and registered office of the economic entity),

ID: ____________________________, under material and criminal liability, I declare that we have the following bus drivers available who meet all the professional driver qualification requirements prescribed by the Law (specify the applicable law) (category "B" driving license, other necessary initial qualifications, and periodic training).

Serial number	Driver/s full name	Educational and professional qualifications	Driver's license with valid CODE 95 (driver's license number)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

FORM 4.

STATEMENT
ON ACCEPTANCE OF INSPECTION CONDUCTED BY THE PUBLIC CONTRACTING AUTHORITY

CONTRACTING AUTHORITY:
RECORD NUMBER:
SUBJECT OF PROCUREMENT:

I, ______________________________ from ___________________________________,
(name and surname) (place)

ID card number/passport number: _________________________________, as the authorized person for this procedure

____
(name and registered office of the economic entity),

ID: ______________________, under material and criminal liability, I declare that the bidder accepts the inspection conducted by the public contracting authority or, on its behalf, by the competent body of the service provider's country of establishment, which relates to the technical capacities of the service provider.