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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

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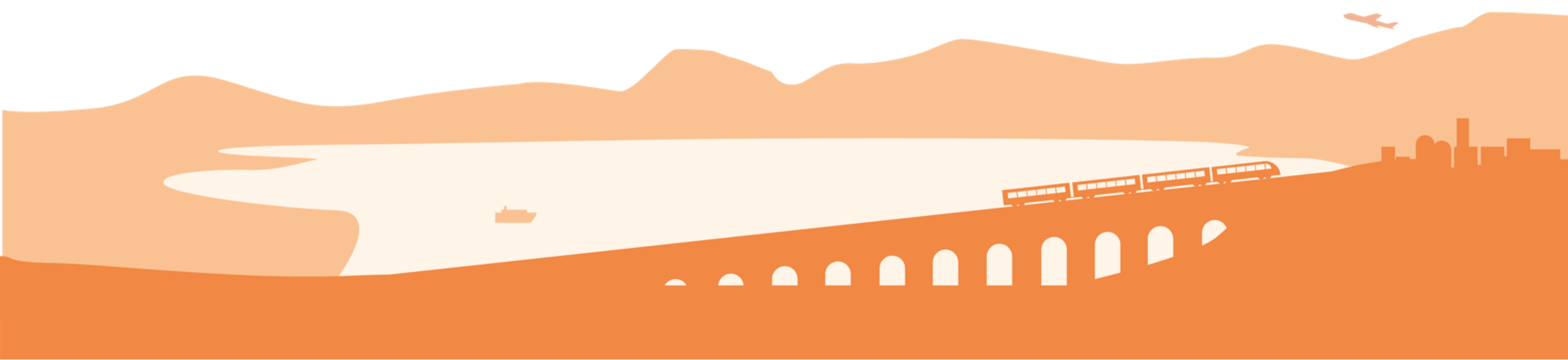

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Contents

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 week-day 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.

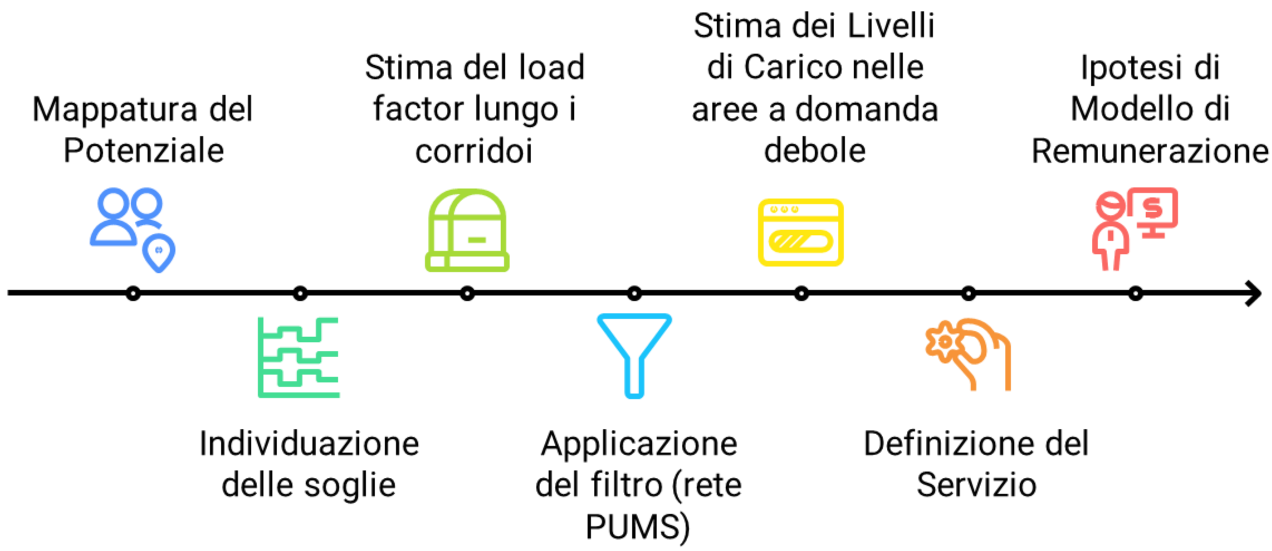

Figure 1 Graphical representation of the proposed methodology for calculating potential demand and defining service levels in areas with low demand (Source: GO-Mobility)

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.

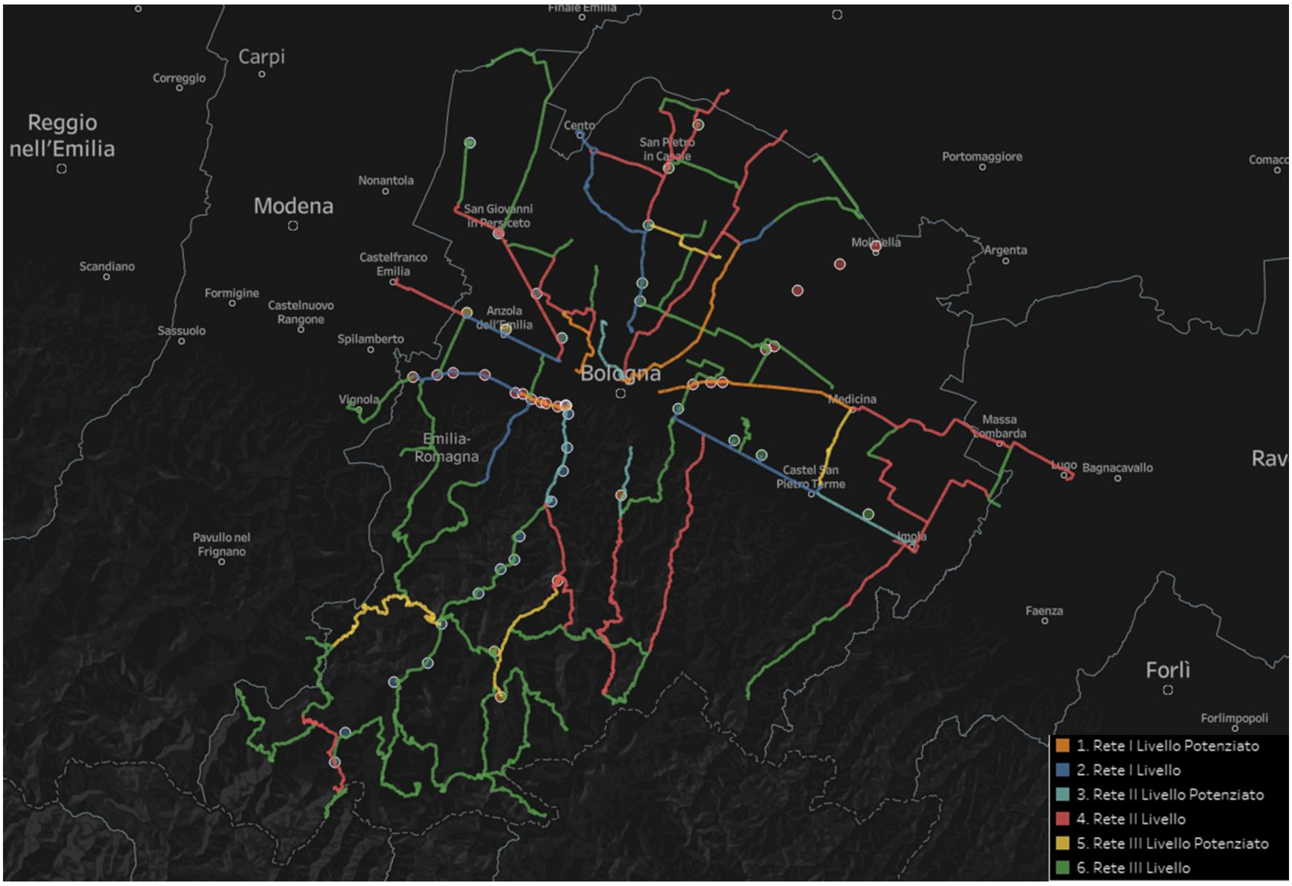

Figure 2 Classification of the suburban bus network into levels I, II, and III (Source: GO-Mobility analysis of SUMP data for the metropolitan city of Bologna)

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.

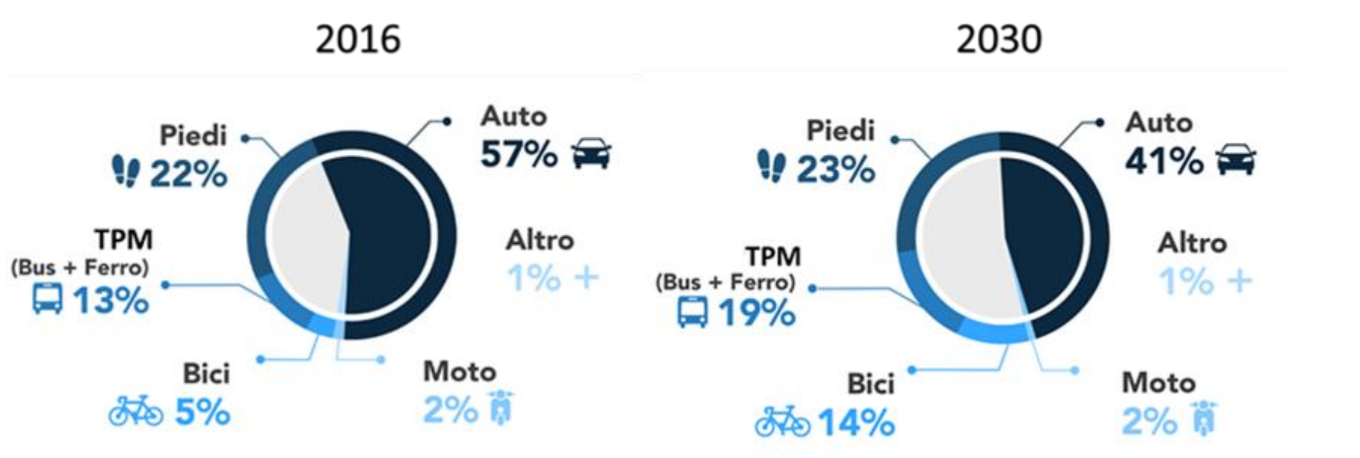

Figure 3 Comparison of modal split between 2016 and the metropolitan targets of the SUMP-2030 scenario (Source: SUMP of the Metropolitan City of Bologna)

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 methodology 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/km²,** 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.

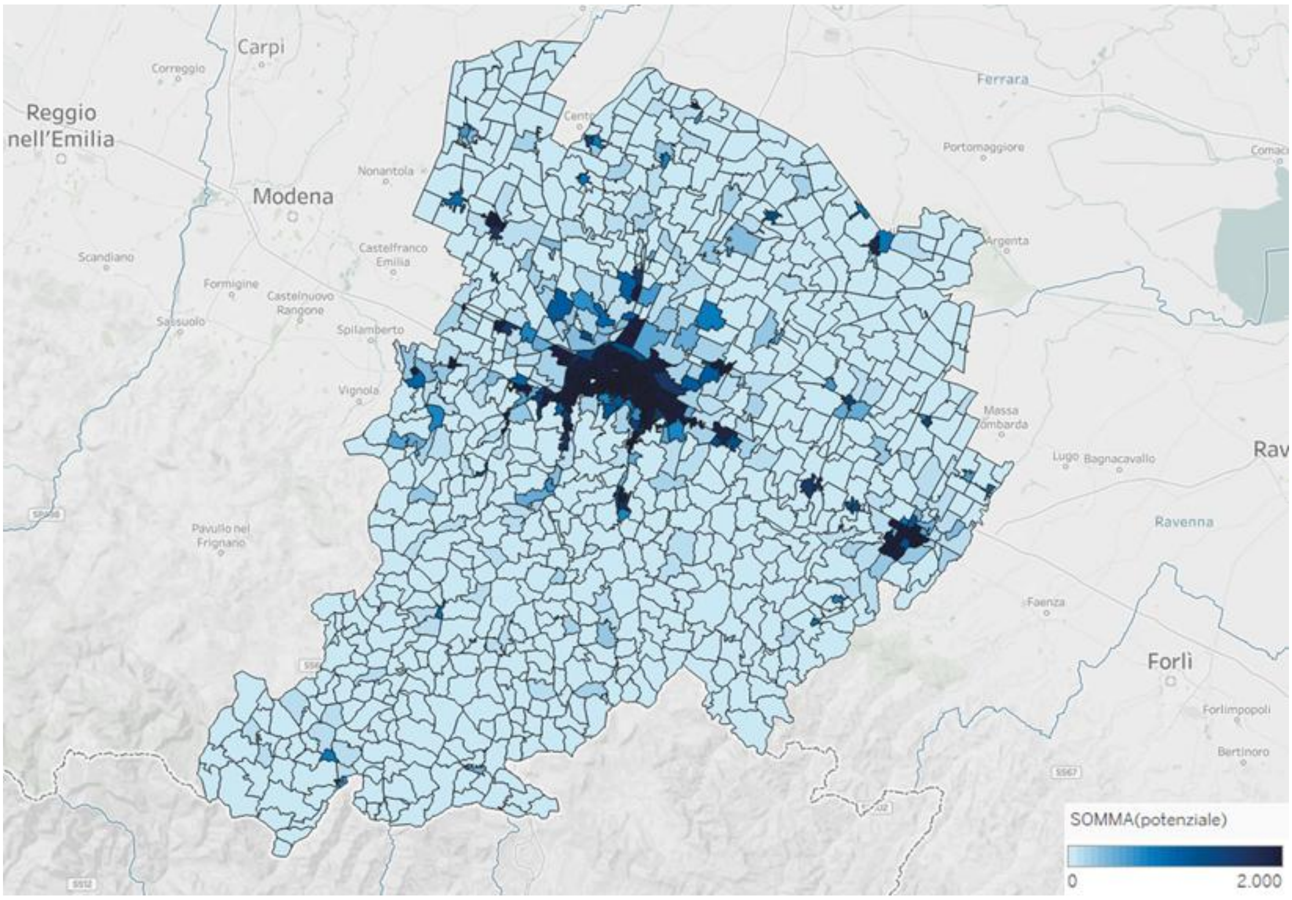

Figure1 Mapping of generative potential based on potential demand data from target SUMP (Source: GO-Mobility processing)

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.

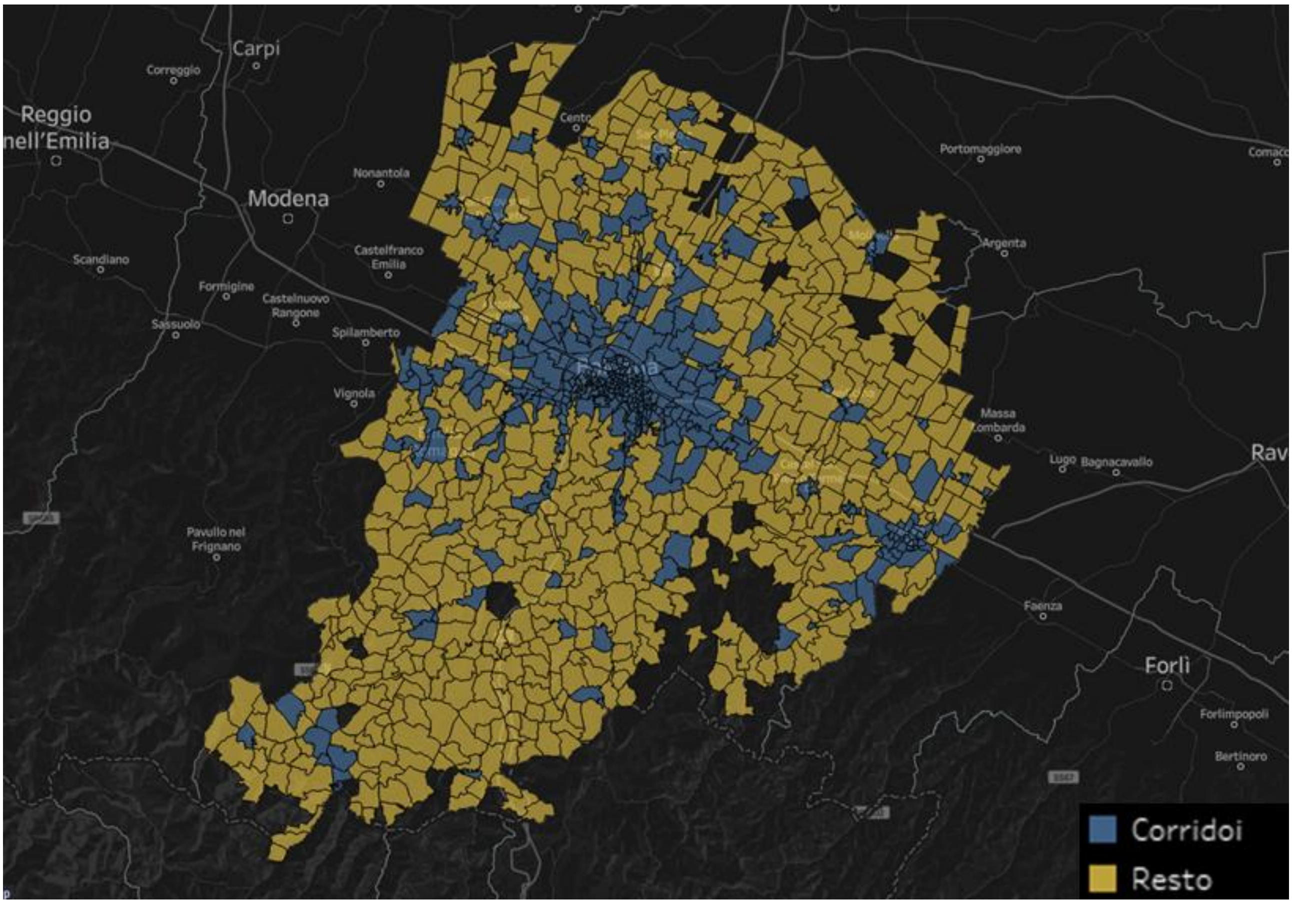

Figure 5 Subdivision of the territory according to classification thresholds for potential travel density in absolute terms (Source: GO-Mobility analysis)

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/km² 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/km² 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.

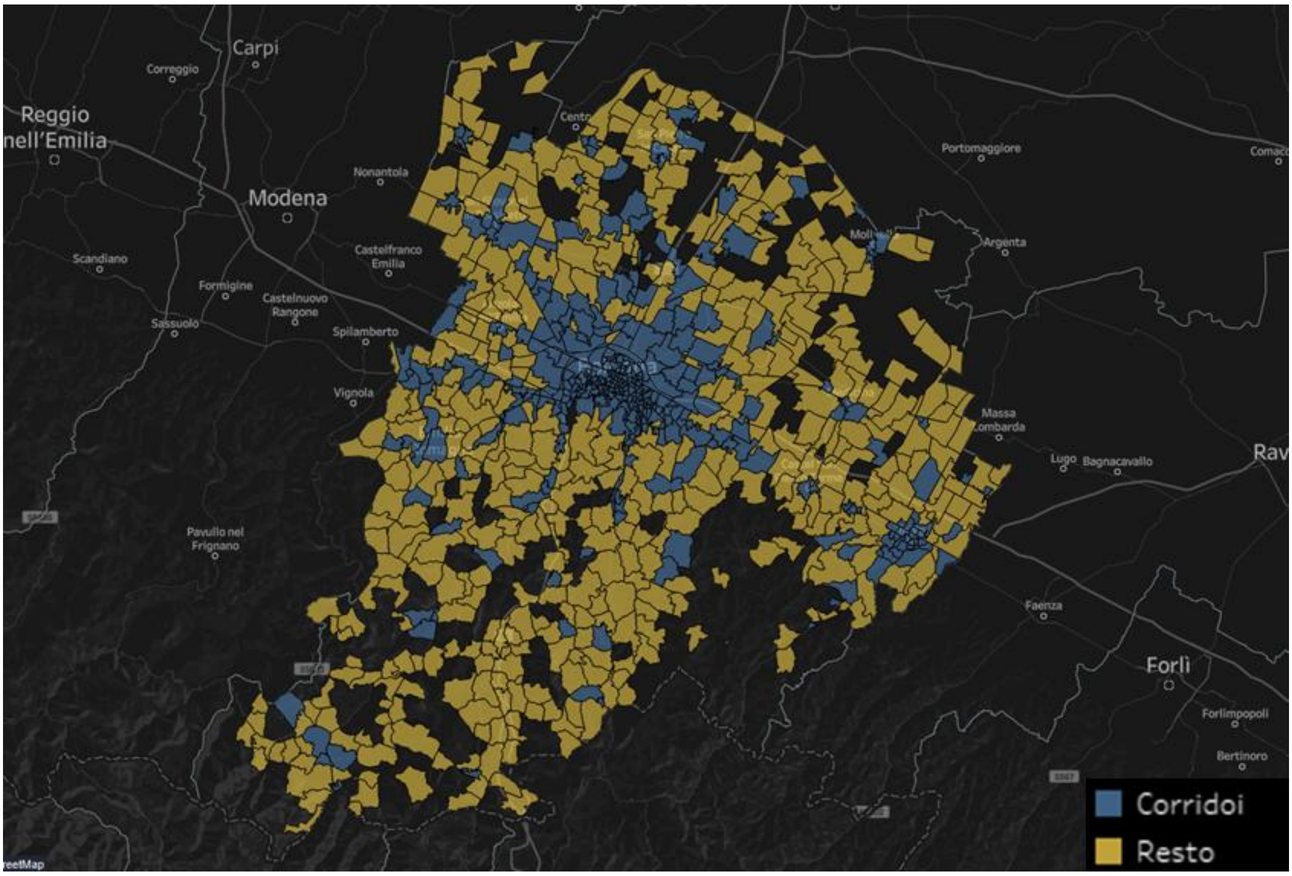

Figure2Division of the territory according to classification thresholds for potential travel density in terms of time (Source: GO-Mobility analysis)

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.

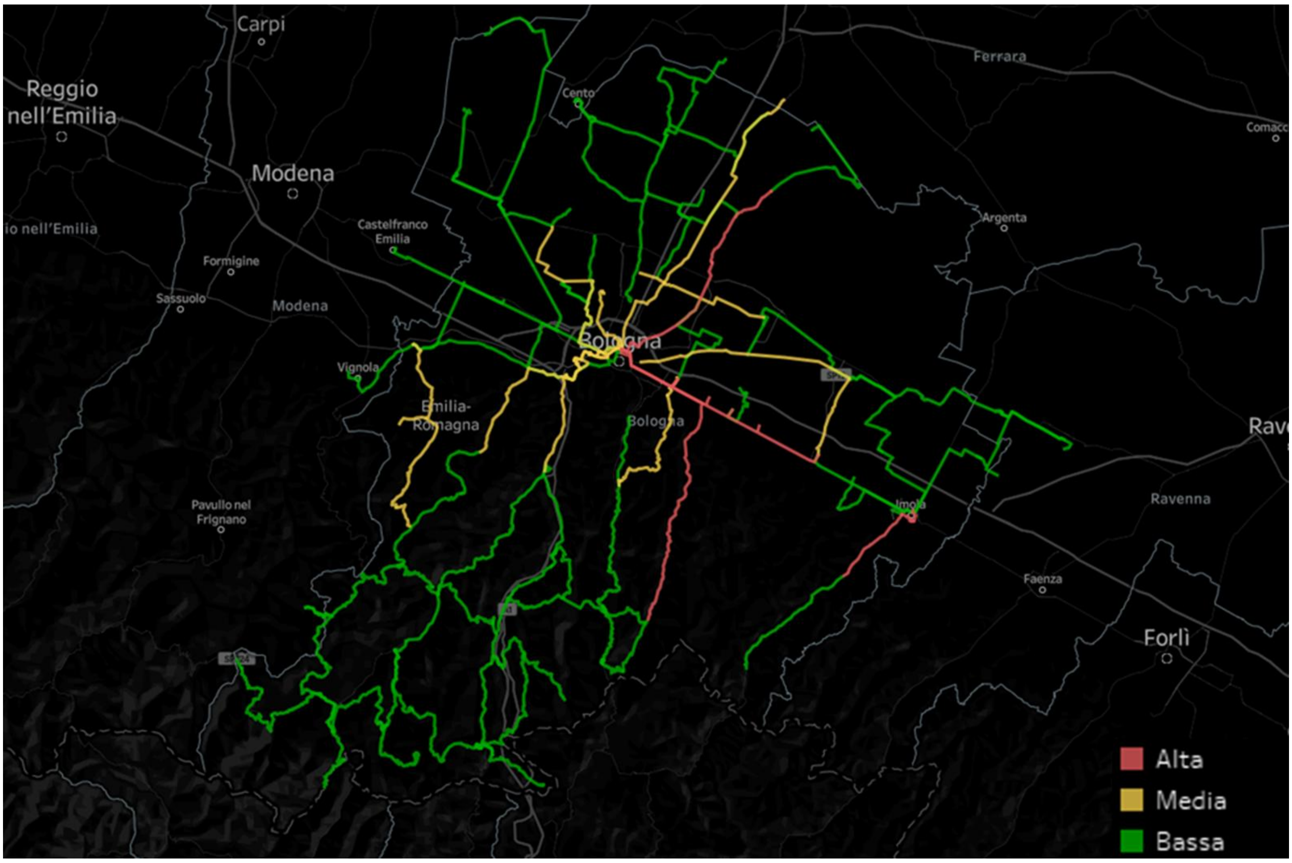

Figure 7 Estimated load factor of the SUMP-planned suburban bus network (levels I, II, and III) following application of the methodology (Source: GO-Mobility analysis of SUMP data for the Metropolitan City of Bologna)

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.

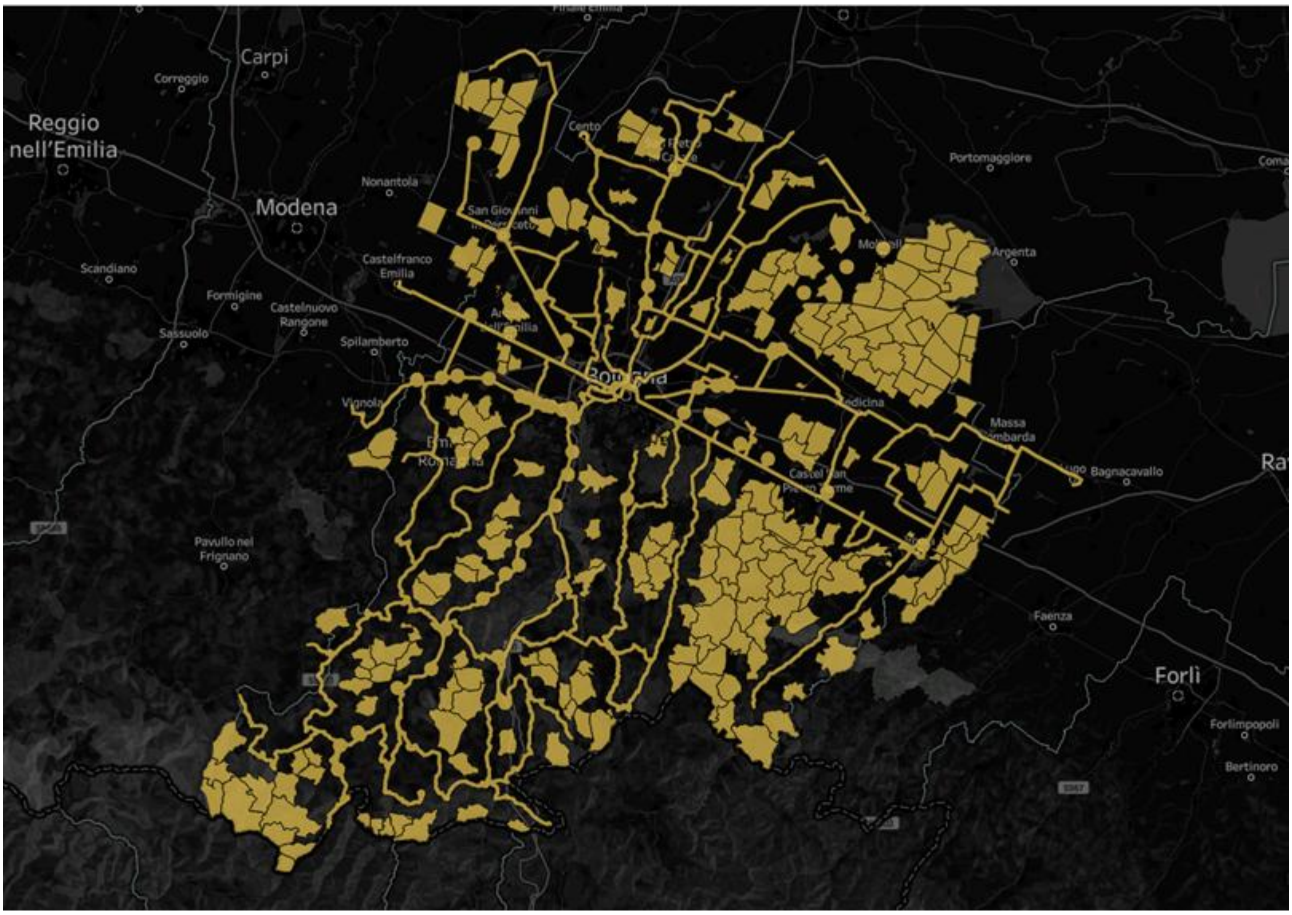

Figure 8 Areas excluded from the TPM network service provided for in the SUMP (Source: GO-Mobility analysis of SUMP data from the Metropolitan City of Bologna)

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.

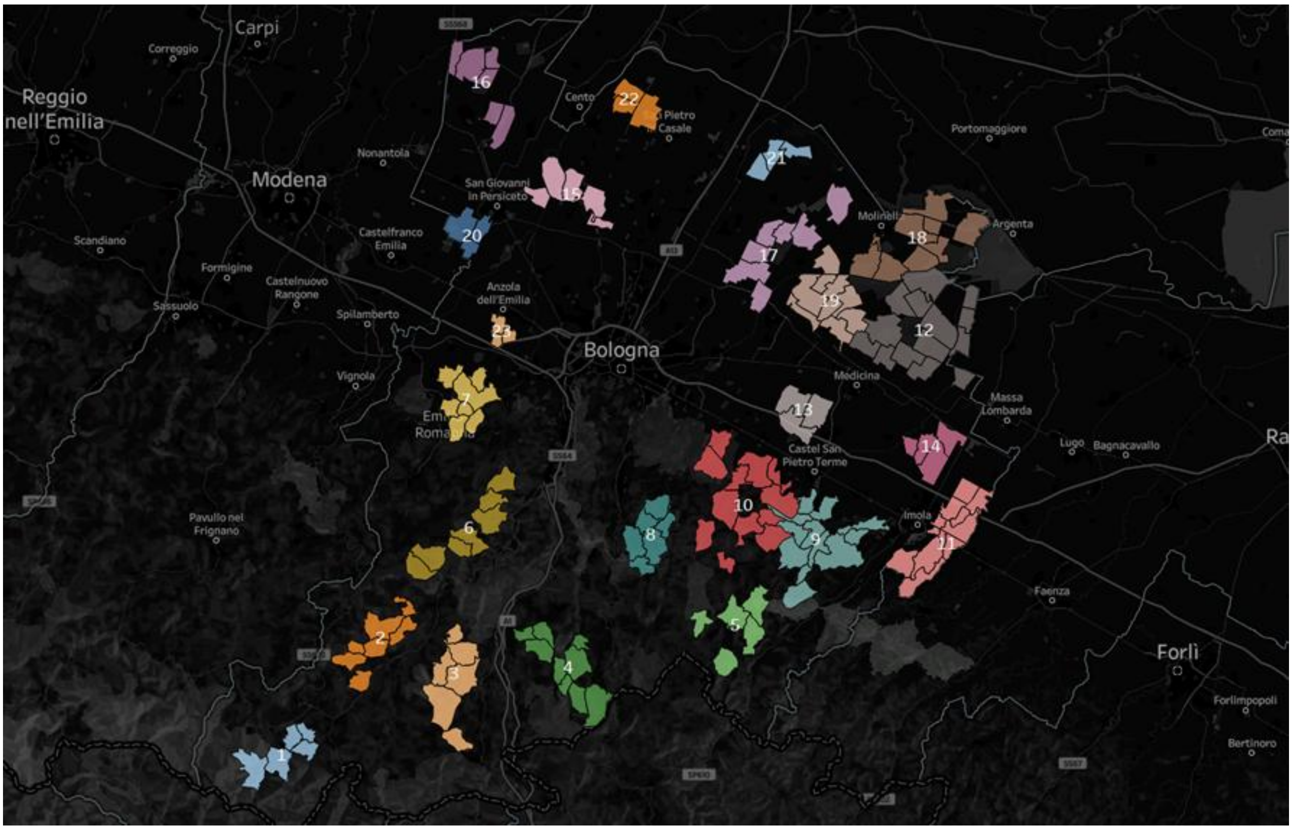

Figure3 Areas with low demand obtained by applying the methodology (Source: GO-Mobility analysis)

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.

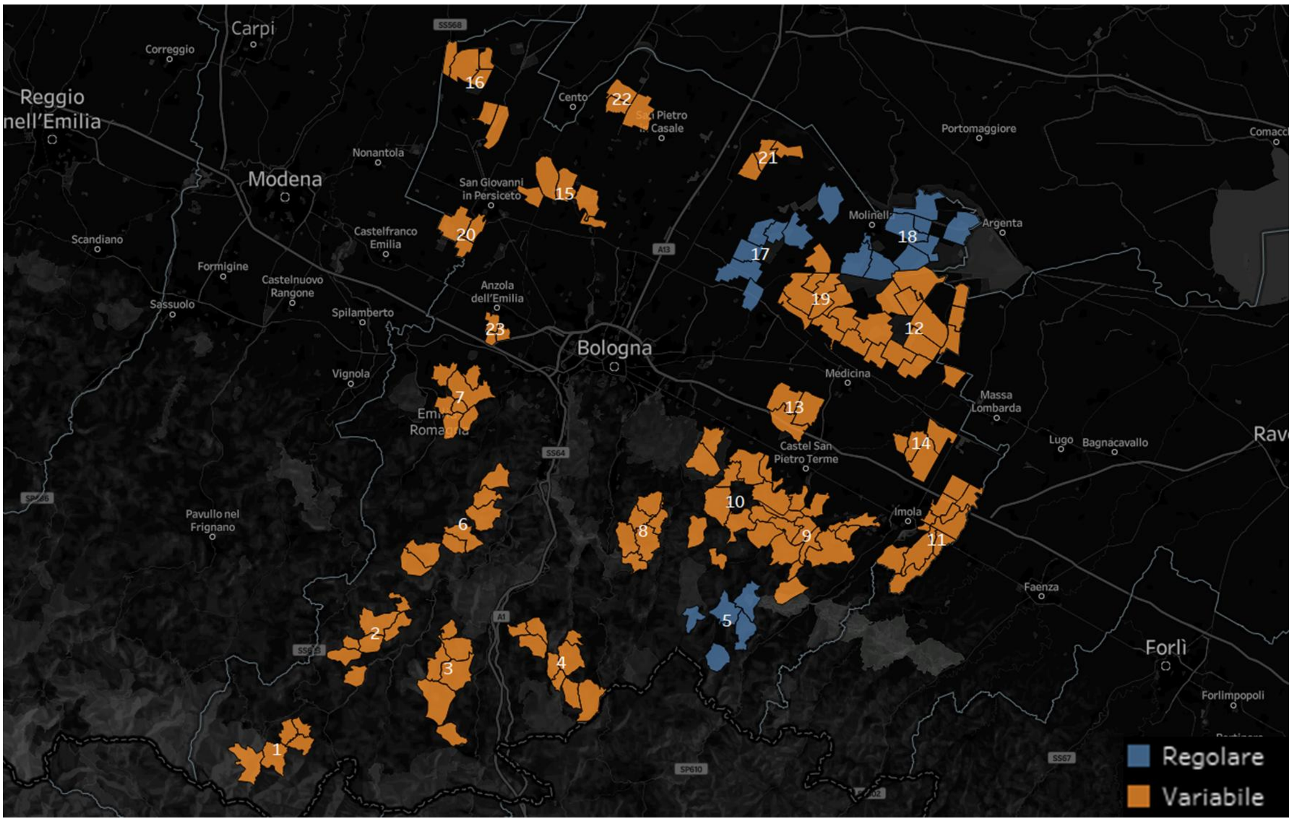

Figure4Temporal characterization of potential demand in areas identified as having weak demand (Source: GO-Mobility analysis)

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.

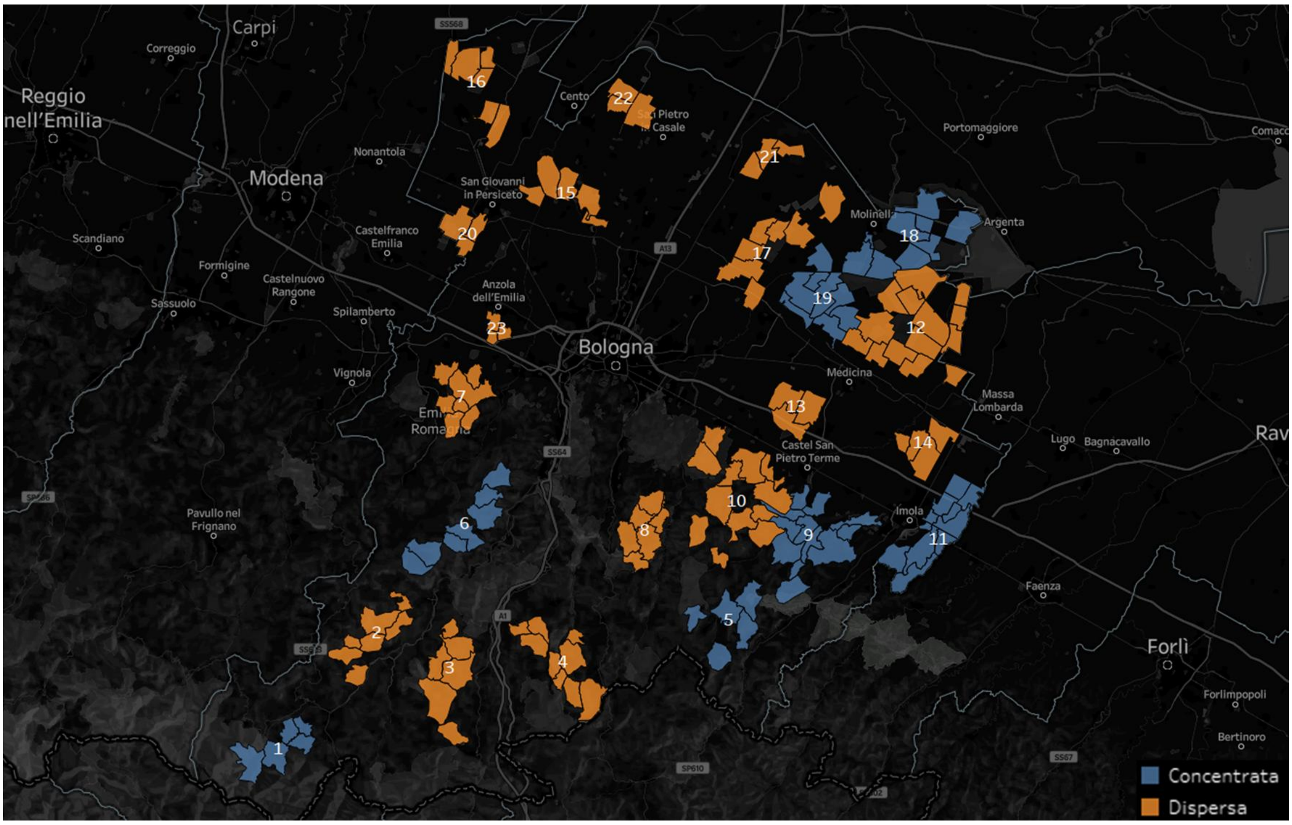

Figure5Spatial characterization of potential demand in areas identified as having weak demand (Source: GO-Mobility analysis)

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)

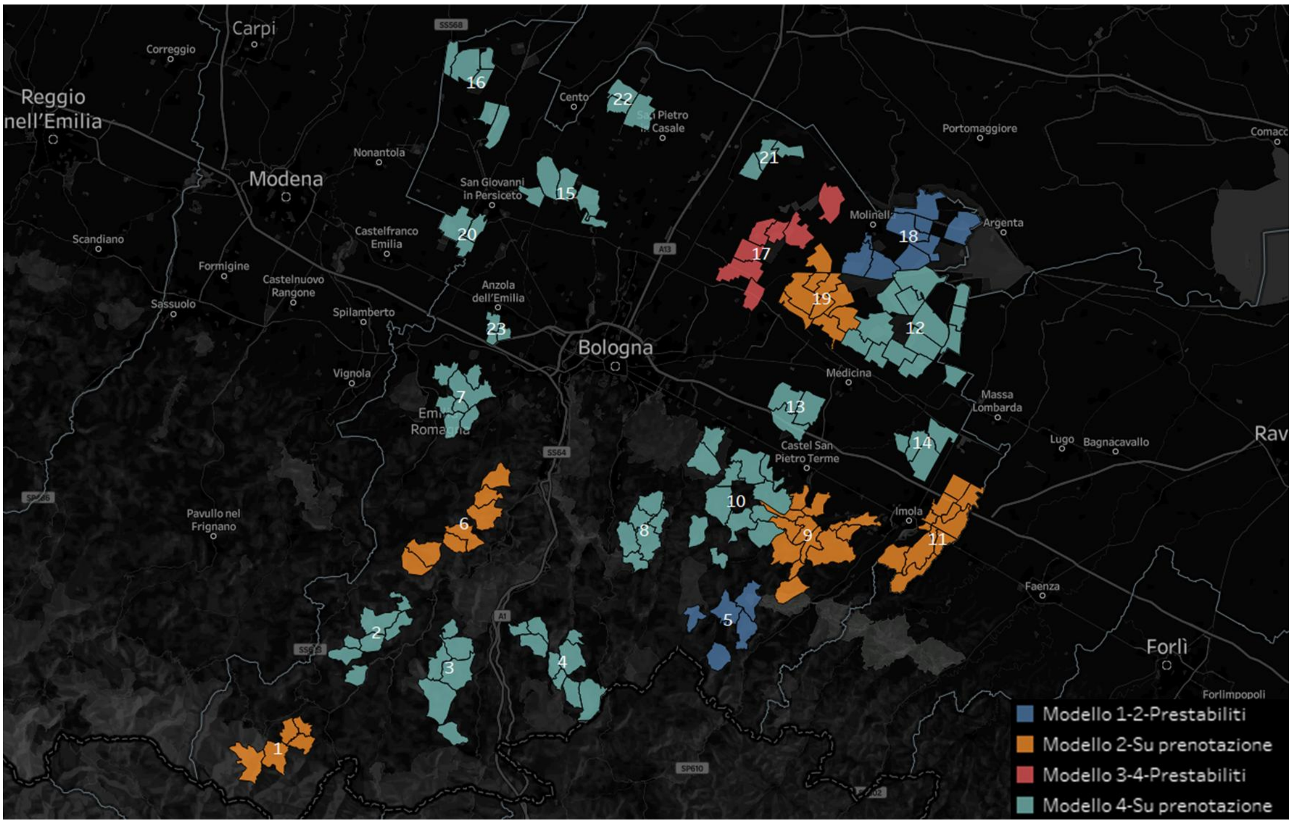

Figure6Hypotheses for operational models of DRT services in areas with low demand based on the temporal and spatial characteristics of demand (Source: GO-Mobility analysis)

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**.

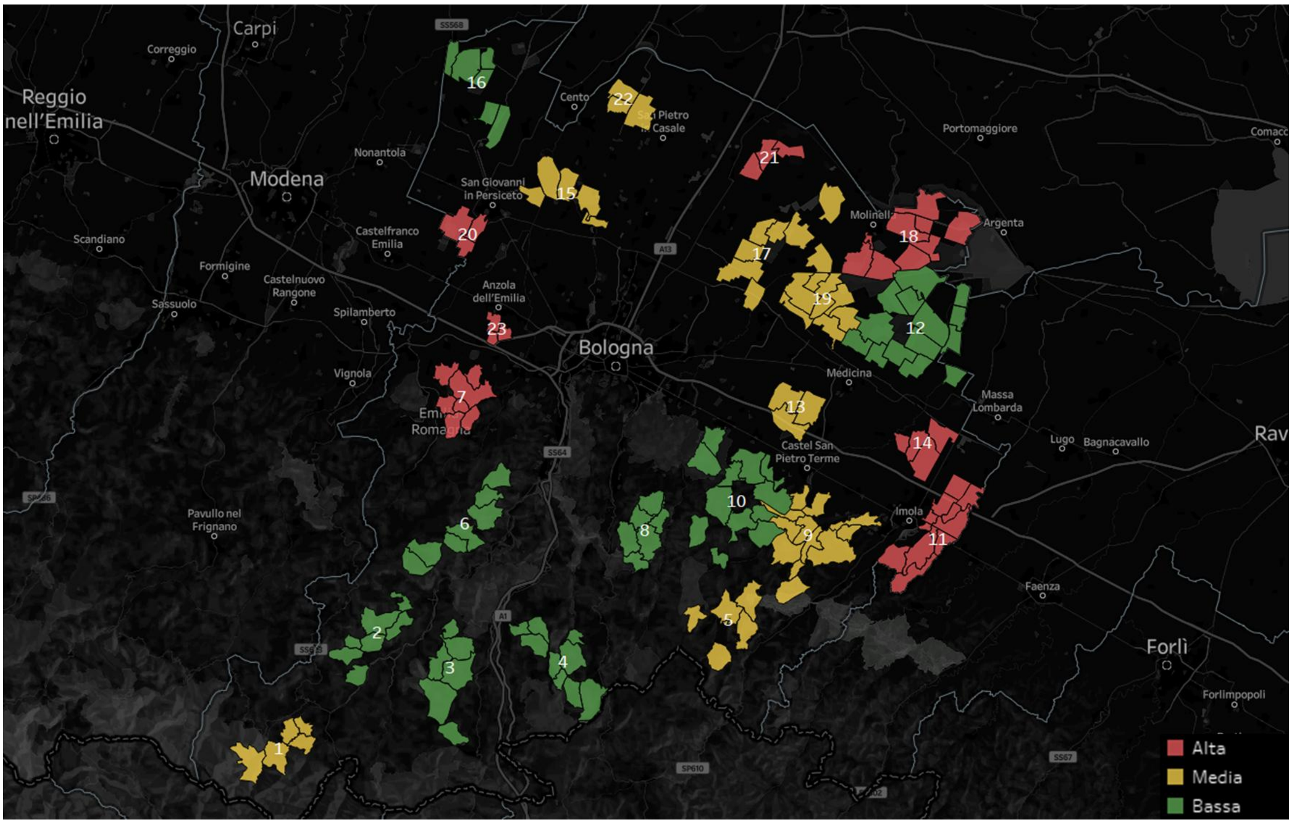

Figure7Characterization of potential demand levels in areas with low demand (Source: GO-Mobility analysis)

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.

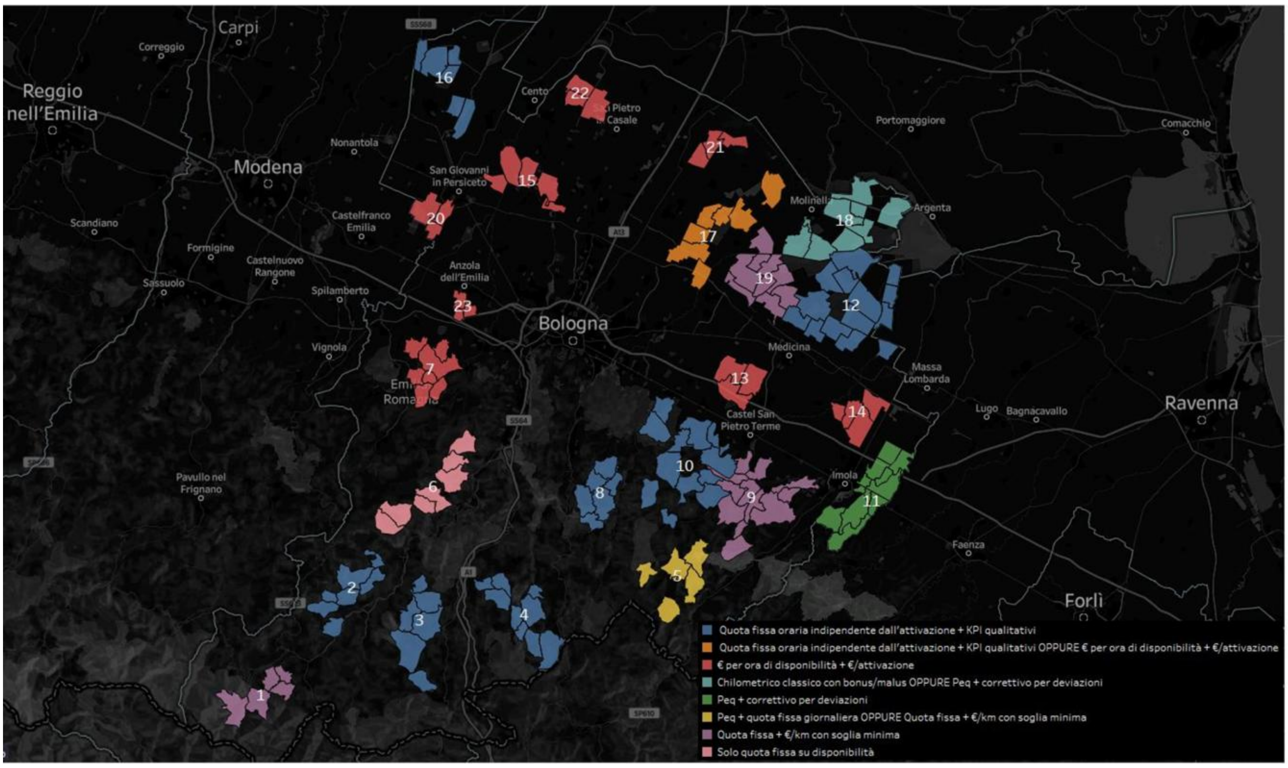

Figure8Assignment of DRT service remuneration models to the 23 areas with low demand (Source: GO-Mobility analysis)

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	Peq + 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)