Interreg CENTRAL EUROPE

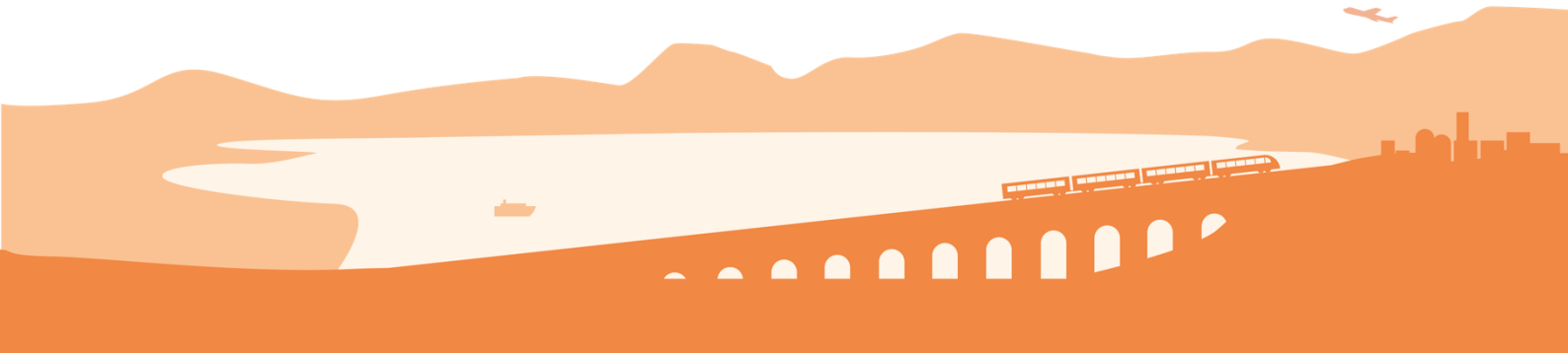
Co-funded by the European Union

DREAM_PACE

D2.1.1 Analysis report on DRT digital and operational innovations in CE Regions and engaged areas

Final Version

09 2023



Authors and log change of the document

Partner No.	Partner Acronym	Name of the author	Action	Version
6	DYVOLVE	Saša Bart Domagoj Majcan Dijana Mišerić Beganović Božo Cicvarić Gordan Topolovec	1st version of the document	1
4	Mobilissimus	Nikolett Csörgő	Review of the document	2
2	Redmint	Gabriele Grea	Review of the document	3
6	DYVOLVE	Saša Bart Domagoj Majcan Dijana Mišerić Beganović Božo Cicvarić Gordan Topolovec	Revised version	Proposed final
1	SRM	Chiara Lepori Marco Amadori	Edited approved version for official release	Final

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1. Executive summary

The territory of Central Europe is characterised by uneven transport connections and mobility opportunities, across and within regions, between urbanised contexts, and rural and peripheral areas.

The project's common challenge is to improve accessibility and connectivity in CE peripheral and rural areas through better integration of public transport networks with Demand Responsive Transport (DRT) services, building on joint development and implementation of governance, planning, digital and operational innovations.

DREAM_PACE will develop innovative DRT concepts complementing regional mobility networks.

The project will improve DRT planning and delivery capacities of public authorities and operators.

A new generation of DRT services will become functional and integral part of regional mobility networks, enhancing accessibility for citizens, territorial cohesion, and social inclusion. Integration is the key to the DREAM_PACE innovative approach, as DRT services are mostly developed as stand-alone solutions to specific needs, the potential of scalable strategies and solutions is widely underestimated.

Project Partners (thereafter PP) will jointly develop a strategy for DRT in Sustainable Urban Mobility Plans to be adopted at EU level, co-design, test and implement innovative DRT solutions enhancing mobility networks. Strategies and solutions will foster a better integration of DRT and public transport (Bologna, Pavia, Budapest areas), support a higher coordination among existing DT initiatives (Osttirol, Baden-Württemberg) and experiment new integrated approaches for DRT "green fields" (Split-Dalmatia County).

DREAM_PACE will exploit the potential of integrated planning and digital and operational innovations for a common strategy and develop innovative DRT modular solutions. The project implementation builds on transnational cooperation to guarantee an adequate responsiveness and adaptability of project results to specific characteristics of mobility ecosystems across CE rural and peripheral areas.

This report analyses the DRT digital and operational innovations in the CE Regions and in the areas engaged in the DREAM_PACE project. The purpose of the report is to assess the state of DRT in the countries of the CE Region's, focusing on the DREAM_PACE countries. An overview of the current situation is given through the analysis of the field of DRT. The aim of the report is the analysis and research of common frameworks in the field of digital and operational trends in the countries of the CE Region.

Chapter 2 provides highlights on the role of DRT services in low demand peripheral and rural areas and a common framework for the classification of DRT digital and operational models, focusing also on the technological components of a DRT system and on the digital frameworks enabling its functioning.

Chapter 3 presents the analysis of DRT in some Interreg Central Europe countries (Austria, Croatia, Germany, Hungary, Italy) plus France, which is the country of some of the DREAM_PACE Associated Partners. It investigates, the current state of DRT, the status of implementation and organisation, integration into the existing public transport system and the level of digitalization.

The conclusions of this analysis on DRT digital and operational features in CE Regions and in the DREAM_PACE engaged areas provides solutions to problems in DRT organization and digitalization that are similar in most of the analysed countries.

Finally, chapter 5 contains the references of the document.

2. DRT in CE Regions and engaged areas

2.1. The role of DRT services in low demand, peripheral and rural area

In areas with low population density or suburban regions, the challenges faced by traditional public transport become more pronounced. The limited demand for transportation services, long distances between destinations, and the lack of comprehensive transportation infrastructure make it difficult for traditional public transport systems to operate efficiently or to attract new passengers. As a result, residents in these areas often experience limited transportation options and may find it challenging to access essential services, employment opportunities, and recreational activities. It can lead to mobility poverty as well.

To address these transportation gaps, transport operators and local authorities have sought innovative solutions to provide effective and cost-efficient mobility services. Among various flexible mobility options like car sharing and bike sharing, Demand-Responsive Transport (DRT) through different sized buses has emerged as one of the most suitable and adaptable solutions for low population density areas or other areas with special mobility character (e.g., industrial areas).

Initially, the primary focus of DRT was on serving people with reduced mobility, such as elderly individuals or those with disabilities. However, recognizing the broader mobility needs of various passenger groups, DRT has evolved to cater to different target users based on the specific characteristics and demands of the area.

Demand-Responsive Transport fills a vital niche in the transportation landscape. It offers greater flexibility than traditional fixed-route public transport, enabling passengers to request transportation on demand. On the other hand, it is less personalised and more cost-effective than private car use, taxi services or taxi services that are integrated part of local public transport, making it a practical option for areas where taxi services may be economically impractical due to low demand.

The key characteristics of DRT service are the following: routes, stops and timetables are not fixed, partly fixed or time- and area-dependent, but adjusted to the user journey plans, and the service is oriented to fulfilling the user needs in a specific area.

Within the transport system of geographical area, DRT service can have different roles, for example:

- improving connection and accessibility to traditional public transport;
- operating in specific schedules or routes, or both, as a part of integrated public transport service;
- improving connection to the point of interest zones (hospitals, airports, business zones, campuses);
- substitute for traditional public transport service (e.g., disabled passengers, door2door service in low demand periods, offering safer and more attractive solutions during nights).

The DRT service can be successfully applied in urban and suburban areas. Moreover, this kind of service is usually the most sustainable solution for rural areas, areas with a low number of inhabitants or lower population density. Sometimes, public and private companies with more employees have organised transport for their employees in the form of DRT service, for example, if an employee in a certain area chooses to use their personal vehicle or, for some reason, doesn't come to work that day, that employee will not request DRT service, which will result in shorter travel time.

2.2. A common framework for the classification of DRT digital and operational models

2.2.1. Types of different operational DRT services (including infrastructure, fleet/vehicles etc.)

Traditional public transport operates within fixed routes, stops, and timetables while flexible DRT service usually doesn't use the same route, stops or even timetable. These characteristics make the DRT service more adequate in answering users' mobility needs, not only in the areas with low demand but also during the periods with low demand, for example, during weekends, holidays, at night, or during off-peak hours.

There are two different schedule organizations:

1) Fixed schedule;
2) Flexible schedule.

There are four main operational concepts of DRT service, which are described and graphically shown below:

1) route deviation with fixed stops (including route extension);
2) point deviation with fixed stops;
3) destination Demand-Responsive Transport;
4) pure Demand-Responsive Transport.

Route deviation with fixed stops

In this operational concept, the vehicle operates on a fixed route that includes predetermined initial and final terminals, as well as designated intermediate stops with set departure times. However, the distinguishing feature of DRT is its flexibility to accommodate on-demand transportation requests along this fixed route. The DRT vehicle can stop at any location or at stops, stop points along the selected designated route if passengers have requested transportation, irrespective of whether there is an established intermediate stop at that particular spot. Additionally, the DRT vehicle has the capability to deviate from the fixed route when a request for the trip has been submitted for a location near the existing route.

The system is designed to be responsive to passenger requests, and as such, passengers can request transportation to locations not explicitly designated as intermediate stops. This dynamic characteristic allows DRT to be a more adaptable and personalized form of public transport, catering to passengers' specific travel needs and preferences.

However, it is essential to note that in some cases, if a requested pick-up point is considerably distant from the fixed route, the DRT service may have to decline the request. This is to ensure the overall efficiency and feasibility of the service while balancing the needs of different passengers.

During peak demand periods, the fixed route can be supplemented with traditional public transport services to accommodate more passengers efficiently. This augmentation ensures that the transportation needs of a more significant number of passengers are adequately met, reducing potential waiting times and enhancing overall service quality.

The combination of a fixed route with on-demand flexibility (e.g., extension of a public transport service line) allows Demand-Responsive Transport to strike a balance between the efficiency of traditional public transport and individual taxi services.

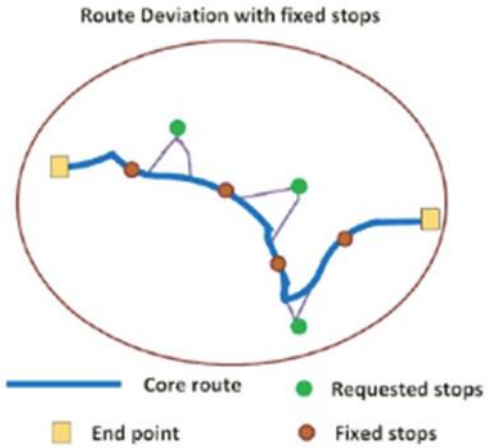

Figure 1. Route deviation with fixed stops 1)]

Point deviation with fixed stops

In this mode of transport, known as zone-based Demand Responsive Transport (DRT), the vehicle operates within a specific geographical area or zone. Unlike the fixed-route DRT, there may or may not be predefined initial and final terminals within this zone, but there are predefined intermediate stops. These intermediate stops serve as reference points for the DRT vehicle's route, ensuring that it follows a structured and efficient path while serving passenger requests.

The key feature of zone-based DRT is its flexibility to accommodate transportation requests that are not necessarily located at one of the predefined intermediate stops. If a passenger requests transportation from a location that is relatively far from any of the designated stops, the DRT vehicle will not reject the request solely based on the distance from an intermediate stop. Instead, it will still consider and fulfil the request as long as it falls within the boundaries of the defined zone.

This flexibility allows zone-based DRT to be more responsive to passengers' specific travel needs, providing a convenient and accessible mode of transport within the designated area. Passengers can request transportation to and from various locations within the zone, even if they are not precisely aligned with the predetermined stops. As a result, zone-based DRT offers a greater degree of personalized service, adapting to passengers' unique travel requirements and enhancing their overall transportation experience.

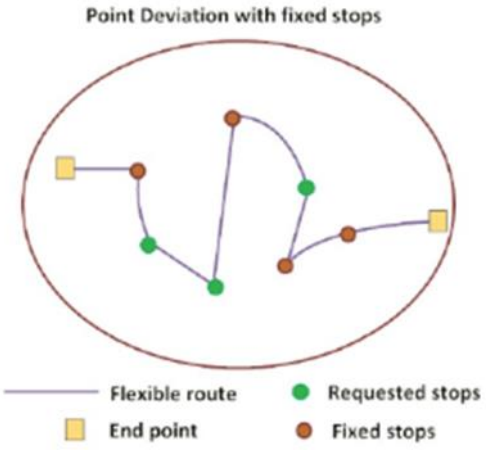

Figure 2. Point deviation with fixed stops [1)

Destination Demand Responsive Transport

In this mode of transportation, the service is specifically designed to transport passengers to a single destination known as the Point of Interest (POI). The POI can be any location or facility that attracts passenger demand, such as a shopping center, market, hospital, airport, or any other place of significance. The primary objective of this transportation service is to efficiently cater to passengers' transportation needs from various locations to the specific POI they have requested.

The process typically starts with passengers submitting transportation requests to the service provider, indicating their desired pick-up location and the corresponding POI as their destination. The vehicle, which is part of the point-to-point transportation service, then picks up the passengers from their respective locations and directly takes them to the specified POI.

This type of service operates on a demand-responsive basis, ensuring that passengers can access transportation when needed.

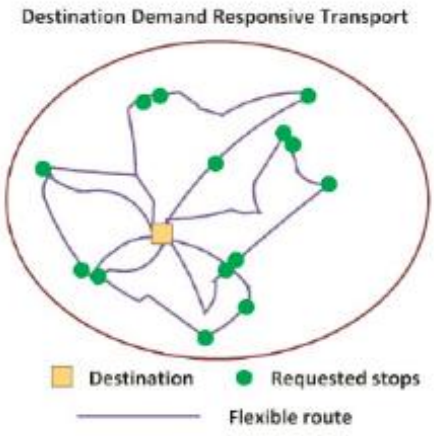

Figure 3. Destination Demand-Responsive Transport [1)]

Pure Demand-Responsive Transport

"Transportation on demand" is a mode of transport characterized by its fully flexible routes and variable driving schedules based on the specific needs of passengers. Unlike traditional fixed-route transportation systems with predetermined schedules, this on-demand transport operates dynamically, responding to passenger requests in real time. The driving time and routes of the vehicles can change daily, adapting to the varying demands of passengers.

The flexibility of "Transportation on demand" ensures that passengers in rural areas can access transportation when and where they need it, making it a reliable and customer-centric option. For instance, passengers can request transport for medical appointments, grocery shopping, school drop-offs, or any other travel needs. This personalized service not only improves the overall mobility and accessibility for rural residents but also enhances their quality of life and socio-economic opportunities.

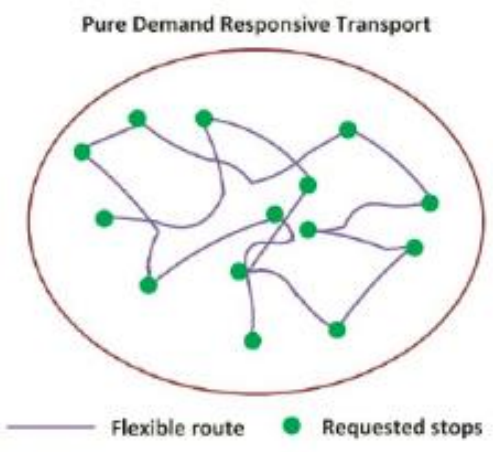

Figure 4. Pure Demand Responsive Transport [1)]

2.2.2. Technological components of DRT system

DRT can exist without any digital elements or with partly digital elements, or it can be fully digitalized. For instance, in the absence of digital elements, vehicles operate according to a fixed schedule and only depart when there are passengers at the initial stop; otherwise, the vehicle won't start. The driver must manually record whether they have completed each trip at a specific time.

Full digitalized on-demand transport technology system consists of four main architectural components, without which this service could not function normally, namely:

- Travel Dispatch Center – TDC;
- DRT vehicle device;
- End-users' devices / customer devices;
- Communication network.

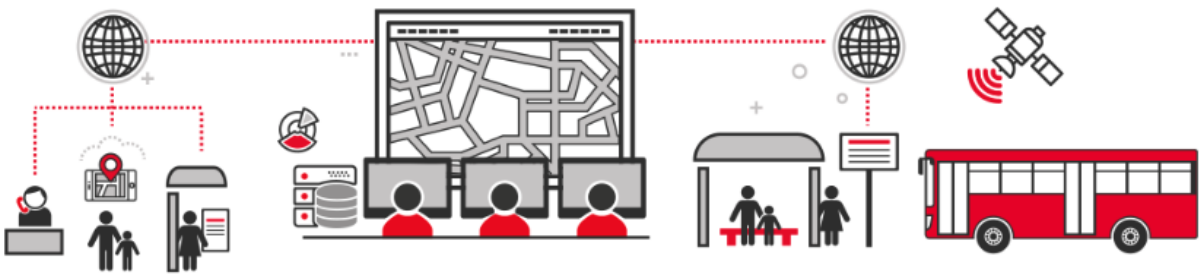

Figure 5. DRT service technological components [1)

The following subsections describe the architectural components that are key to functioning on-demand transportation technology systems.

2.2.2.1. DRT Travel Dispatch Center – TDC

The DRT control center, also known as the Travel Dispatch Center (TDC), plays a crucial role in providing users with a seamless and efficient service, minimizing delays, and optimizing the system's overall performance. Some of the key actions performed by the TDC in real-time include:

- Real-time Traveling Information: The TDC continuously provides real-time travel information to both service users and drivers. This includes updates on vehicle locations, estimated arrival time, current traffic conditions, and any delays that may occur during the trip. This real time information enables users to stay informed on their journey and helps drivers make informed decisions on route adjustments;
- Order Management: When a user requests transportation through the DRT service, the TDC handles the order management process. It can accept or reject the requested transport based on various factors such as the user's location, coverage area, and safety considerations. If the requested pick-up point is inaccessible or unsafe, the TDC may suggest alternative pick-up points or reschedule the trip to ensure a smooth and safe service;
- Trip Planning and Scheduling Reservations: The TDC is responsible for optimizing routes and scheduling reservations efficiently. It assigns vehicles to specific routes based on real-time demand and dynamically adjusts routes based on new requests. By optimizing routes, the TDC aims to minimize delays and improve the overall efficiency of the service. It also provides users with estimated travel times, allowing them to plan their journeys better;
- Monitoring Services: The TDC continuously monitors the DRT service to ensure that everything is running smoothly. It tracks vehicle locations, performance, and adherence to schedules. This monitoring helps identify potential issues or delays, enabling the TDC to take proactive measures to address them promptly;
- Data Statistics and Analysis: In addition to real-time operations, the TDC also performs data statistics and analysis for the DRT fleet. It collects and analyses data on passengers, drivers, vehicles, warehouses, and other relevant metrics. This data provides valuable insights into the service's performance, such as passenger demographics, usage patterns, profitability, and overall service effectiveness. By leveraging the statistical data, the TDC can identify trends, areas for improvement, and opportunities to enhance the service's quality. This data-driven approach allows the DRT system to make data-backed decisions, optimize operations, and continually improve the user experience.

The DRT control center, or TDC, is the nerve center of the entire demand-responsive transport system. Its real-time actions and data-driven analysis enable the DRT service to provide users a seamless and efficient experience while ensuring that the fleet operates optimally and adapts to changing demands and conditions.

Figure 6. DRT Travel Dispatch Center – TDC [1)]

2.2.2.2. Vehicle/fleet and DRT vehicle device

When implementing a Demand-Responsive Transport (DRT) service, selecting the appropriate vehicles or fleet is crucial to ensure the service's success and efficiency. Several factors must be carefully considered during the decision-making process, considering the service's specific needs, passenger capacity requirements, and the operational environment.

On-demand transport vehicles are a mode of transportation that allows individuals or groups to request rides as needed. These vehicles are generally smaller than traditional public transportation options, making them well-suited for personalized or group travel. The three common types of on-demand transport vehicles are cars, minibuses, and vans, and they can be equipped with either internal combustion engines or electric motors. The point is to provide an alternative vehicle size adapted to needs, midibuses and solo buses are also common.

DRT vehicles are equipped with onboard computers that enable seamless communication between the driver and the communication center (TDC). Moreover, they are outfitted with position-determination systems to precisely track their location.

The onboard device provides essential travel information to the driver, ensuring a smooth and efficient ride. This information includes the vehicle's real-time location, optimal travel routes, passenger pick-up and drop-off points, any potential vehicle delays, estimated travel times, scheduled stop times, details about passengers requiring assistance due to reduced mobility, and emergency information for prompt response in critical situations.

By utilizing the travel computer or tablet, the driver can optimize their routes and efficiently reach users in the shortest possible time, ensuring timely transportation to their desired destinations. This optimization process results in an overall enhancement in the quality of service the DRT system provides.

By incorporating advanced technology and considering real-time data, DRT services can offer users a seamless and convenient experience while maximizing operational efficiency. The efficient selection and deployment of vehicles and effective communication between the driver and the TDC contribute significantly to the success and satisfaction of both passengers and service providers in the Demand-Responsive Transport ecosystem.

Figure 7. DRT vehicle device 1)

2.2.2.3. Costumer interfaces

Demand-Responsive Transport (DRT) service users have multiple convenient options to request transportation. They can access the service through various channels, making it accessible and user-friendly. The users can request the service by using the following:

- Mobile Apps: One of the most popular and efficient ways to request the DRT service is through mobile applications. Users can download and install the DRT app on their smartphones or tablets. The app allows them to input their travel details, such as the origin, destination, and desired pick-up time. It can also provide real-time information on vehicle availability and estimated travel times. Users can track the vehicle's path on the app, informing them about the vehicle's location and expected arrival time;
- Phone Calls: For users who may not have smartphone access or prefer a more traditional approach, the DRT service can be requested through phone calls. They can call the DRT control center (TDC) and provide their travel details to a customer service representative. The TDC will then manage the request, optimize the route based on other passenger requests, and provide the user with relevant information about the pick-up time and location;
- Web Pages: Users can access the DRT service through web pages by visiting the service provider's website. They can fill in the required travel details in an online form, similar to mobile apps. The web page may also display real-time vehicle locations and estimated arrival times, informing users about their upcoming rides;
- SMSs (Short Message Service): Some DRT services also offer the option of requesting transportation through SMS. Users can send a text message with their travel details, and the TDC will process the request and provide them with the necessary information regarding their trip.

The DRT service offers flexibility in terms of booking time. Users can request transportation in advance, ranging from a few days before their departure to as close as 30 minutes before they need to travel, depending on the given service. This adaptability allows users to plan their trips conveniently, making the service more user centric.

One of the significant advantages of using mobile apps or web-based booking system is the ability to optimize routes based on passenger requests. The DRT system uses sophisticated algorithms to optimize the route, considering the locations of all users requesting the service. This ensures that the vehicles pick up passengers along the most efficient path, reducing travel time and minimizing detours.

Additionally, the DRT service considers the needs of passengers with reduced mobility. Vehicles with ramps and other accessibility features are available to accommodate individuals with disabilities, ensuring that the service remains inclusive and accessible to all community members.

By offering multiple request options, optimizing routes, and accommodating passengers with diverse needs, the Demand-Responsive Transport service provides a convenient and efficient transportation solution for users, enhancing the overall mobility experience.

2.2.3. Types of different digital frameworks (including communication, marketing, and passenger information system etc.)

Digital frameworks are crucial in modern transportation systems, enabling efficient communication, marketing, and passenger information dissemination. Here are several types of digital frameworks commonly used in transportation for passengers and public transport operators:

1. Communication Frameworks:
    - Mobile Communication: Mobile communication frameworks facilitate real-time communication between drivers, operators, and passengers. This includes phone calls, SMS notifications, and mobile applications for booking, tracking, and updates;
    - Radio Communication: Radio communication frameworks provide a means of communication between drivers, dispatchers, and control centers. It allows for efficient coordination and response during operations;
    - Internet of Things (IoT): IoT frameworks connect various devices and sensors within vehicles and infrastructure, enabling data exchange, remote monitoring, and control. It enhances communication and allows intelligent transportation systems;
2. Marketing Frameworks:
    - Digital Advertising: Digital advertising frameworks utilize online platforms, social media, and targeted advertising campaigns to promote transportation services, attract passengers, and increase ridership;
    - Customer Relationship Management (CRM): CRM frameworks manage customer interactions, track passenger preferences and behaviour, and enable personalized marketing and communication strategies;
    - Data Analytics: Data analytics frameworks analyse large volumes of data collected from various sources to identify trends, patterns, and passenger preferences. This information helps tailor marketing efforts and improve service offerings;
3. Passenger Information Systems:
    - Real-Time Passenger Information provides up-to-date information on vehicle schedules, arrival times, delays, and service disruptions through various channels such as digital signage, mobile apps, websites, and SMS alerts;
    - Navigation Systems: Wayfinding frameworks offer digital maps, navigation, and routing guidance to help passengers plan their journeys, locate stops or stations, and navigate through transportation networks;
    - Ticketing and Fare Systems: Digital ticketing and fare collection frameworks enable passengers to purchase tickets, manage payments, and access fare information through online platforms, mobile apps, or smart cards;
4. Collecting user feedback
    - Collecting user feedback refers to the process of gathering opinions, comments, and suggestions from passengers or users of the DRT service. This feedback can be collected through various means, such as surveys, online forms, mobile apps, or direct interactions with passengers. The purpose of collecting user feedback in DRT is to assess the quality of the service, identify areas for improvement, and make data-driven decisions to enhance the overall user experience. It allows DRT operators to understand passengers' needs, preferences, and concerns, ultimately helping them tailor and optimize the service to better meet the demands of the community it serves.

2.2.4. Integrations with the existing PT systems

Integrating Demand-Responsive Transport (DRT) with existing Public Transport (PT) involves leveraging various technical solutions to facilitate seamless communication, data exchange, and coordination. Here are some key considerations and approaches for integrating DRT with existing PT systems:

- Data Sharing and Standardization: Establish data-sharing protocols and standards to enable interoperability DRT and PT systems. Implement mechanisms for real-time data exchange between DRT and PT systems. This allows for sharing information such as vehicle locations, estimated arrival times, service disruptions, and passenger load data. Real-time data exchange enables better coordination and enhances the overall passenger experience;
- API Integration: Develop Application Programming Interfaces (APIs) to facilitate seamless integration between DRT and PT systems. APIs enable the exchange of data, enabling DRT and PT systems to communicate and share information effectively. APIs can be used for real-time data sharing, fare integration, scheduling coordination, and passenger information exchange;
- Intermodal Journey Planning and Ticketing: Integrate DRT services into existing journey planning and ticketing systems. This involves incorporating DRT routes, schedules, and fare information into PT journey-planning applications and ticketing platforms. Passengers can then access a single interface or mobile app to plan and book multimodal trips involving both DRT and PT services;
- Fare Integration and Payment Systems: Establish fare integration mechanisms between DRT and PT systems to enable seamless ticketing and payment options for passengers. This may involve interoperability between smart card systems, contactless payment methods, or mobile payment platforms. Integrated fare systems ensure consistent fare calculations and enable passengers to use a single ticket or payment method across both modes;
- Passenger Information Systems: Integrate passenger information systems to provide consistent and synchronized information across DRT and PT services. This includes real-time schedule updates, service disruptions, route changes, and general service information. Passengers can access accurate information through multiple channels, such as mobile apps, websites, or digital displays;
- Operational Coordination and Dispatch: Implement operational coordination and dispatch systems between DRT and PT services. This includes sharing information on vehicle availability, capacity, and scheduling to optimize resource utilization and service efficiency. The integration allows for better coordination and reduces service conflicts or duplications;
- Mobile Applications and Digital Platforms: Develop mobile applications or digital platforms that integrate DRT and PT services, providing a unified interface for passengers. These platforms can offer features such as journey planning, real-time updates, ticketing, and multimodal routing, enabling passengers to navigate between DRT and PT options seamlessly;
- Data Analytics and Performance Monitoring: Utilize data analytics and performance monitoring tools to analyse DRT and PT systems data. This allows for insights into passenger demand, usage patterns, and service performance across both modes. Data-driven analysis can inform service improvements, resource allocation, and decision-making for integrated DRT-PT systems.

By leveraging technology solutions and integrating DRT with existing PT systems, transportation authorities and operators can create a more connected, efficient and passenger-friendly transportation network.

3. DRT digital models and trends: relevant case studies from partner regions

3.1. Operational framework

Austria

The organization of public transport is defined through several layers of national legislation. One of the layers regulates the organization and provision of passenger transport services. This includes private and public services on roads and railways. It also provides for the regulation of regular transport services and DRT. All acts in this layer are laws that create prerequisites for transport services of general interest in the form of public (i.e. non-commercial) transport services, which the national and regional governments largely finance. Laws and organization are related to Regulation 1370/2007, which prescribes the general framework for public financing of public transport services. The legal basis for the services provided ensures that they meet specific quality criteria and are provided based on uniform tariffs established in public transport associations. One of the layers refers to the regulation of the mobility platform. This layer is relevant for information and intermediary services related to transport. The organization at the national level starts with three main goals: providing a mobility service, non-discriminatory access to mobility for daily trips, and encouraging the use of sustainable forms of mobility. [2)]

Croatia

Municipalities are organized by local self-government units independently or in agreement with several local self-government units. A written contract regulates mutual rights and obligations, and competent representative bodies make decisions. The law stipulates that a concession can be used to acquire the right to perform communal activities and use communal infrastructure to perform communal activities of regular passenger transport. Regulation 1370/2007 provides guidelines and basic rules for organizing passenger transport. The model of the organization of the provision of public transport services can be in the form of a concession contract or a public service contract. When entering a public service contract, the county pays the service provider the net financial effect. The compensation to the public transport service provider must not amount to more than the net economic effect calculated according to the equation defined by Regulation 1370/2007. The procedure for concluding contracts for public services is carried out by public bidding following Regulation 1370/2007 and the Law on Public Procurement (OG 120/16, 114/22). According to the relevant law, a network in the field of public transport is considered to exist if the service is provided by the conditions established by the competent authority Law on Public Procurement (OG 120/16, 114/22), Law on Concessions (OG 69 /17, 107/20), Law on Road Transport (OG 41/18, 98/19, 30/20, 89/21, 114/22). [1)]

France

Areas with low population density and a risk of depopulation are among the main territorial objectives of the law, also through the decentralization of decision-making, which allows local authorities to propose and organize alternative mobility solutions such as car-sharing schemes, carpooling, on-demand services, social services, etc. At the national level, the Agence nationale de la cohésion des territoires promotes a range of policies aimed at mitigating territorial disparities, focusing, for example, on improving the quality of life in medium-sized cities, encouraging local production activities, revitalizing smaller centers by strengthening territorial networks, and ensuring public service accessibility throughout the territory, mitigating the negative effects of progressive centralization that occurred in previous decades. Actions promoting sustainable mobility are encouraged, ranging from the use of new technological solutions to the gradual replacement of private mobility with shared solutions. In France, according to the Traffic Code, Demand-

Responsive Transport (DRT) services are part of the local public transport offering. They are operated with fixed fares and vehicles with a minimum capacity of four seats. They can be organized to meet the mobility needs of specific categories of users. [1)]

Germany

Public transport in Germany is organized through various authorities, transport authorities, and public and private carriers. Local transport is further divided into road and rail. The federal and local levels traditionally fund public road transport. The Act on Passenger Transportation sets the framework for obtaining a license to operate public transportation. The organizational framework is different in each of the 16 provinces. Provinces and cities organize public transport. Most often, it is a single carrier, but it can also be a separate agency or just an agency that organizes public transport at the local level. It is most often organized as a concession through a public bidding process. The main framework for organizing the process is Directive 1370/2007. The primary transport services in rural areas are regular bus lines and a wide choice adapted to requirements (calling buses, taxis, shared taxis). In some places, buses are managed by the local community in the form of a registered voluntary association. DRT as an organizational model of public transport in Germany, has been present for about 40 years. Other forms of shared mobility (cars or bicycles) can be organized more flexibly and informally and are not part of Regulation 1370/2007. The federal legislator created the legal basis for new digitally supported mobility offers by defining two categories of "scheduled on-demand transportation" and "on-demand collective transportation." In the first case, call service means an extension of regular public transport that meets the related public service obligations. In contrast, in the second case, it is a "market" offer not ordered by transport authorities. [1)], 3)

Hungary

The organizational framework of public transport in Hungary includes a combination of national and local authorities, public and private transport operators. Railway services are provided by MÁV-Start as national operator, and on some Western-Transdanubian lines by GySEV (Raaberbahn). Regional and long-distance bus services are operated by the national company Volánbusz, being in the same company group as MÁV-Start. Local services are operated by local companies in Budapest and some bigger or medium sized cities, in other ones Volánbusz operates local services too. Contracts in the field of public transportation, as well as the funds allocated for the DRT area, are different for every region. Each region has a unique organization and regulations governing public transport. Different studies' proposals provide guidelines for DRT to be organized so that it is part of the public service, and the calculation of fees for discount tickets should be part of the public service contract.

For a long time, the legal and regulatory background was the main obstacle to the take-up of Demand-Responsive Transport, as it could not be considered a public service, i.e. it could only be operated on a commercial basis. However, as it was not a public service, it could not receive subsidies, as these were only available for services with a fixed route and timetable.

According to Act XLI of 2012 on Passenger Transport Services :

- a demand-driven service is "a passenger transport service organised by a service provider licensed for such services under a public service contract or a route licence, using information technology tools, and operating on a variable route or at variable intervals, or on a variable route and at variable intervals". In the latter case the services are subject to the public service rules (except for timetables). The service may be provided by any vehicle required by the conditions, subject to the necessary authorisation;
- Public regional and suburban passenger transport services may be provided by means of a partially demand-driven passenger transport service in the case of dispersed settlements, in areas with a lower

population density than the national average, and in settlements where the lack or state of road infrastructure justifies it.

The issue of public transport organizations in general and DRT services is aimed at transport policy and decision-makers. The emphasis is that public transport and DRT are organized as part of the public service contract and following Directive 1370/2007 to compensate for costs not covered by the company's income. This implies the need for signing a contract, considered a risk for local authorities. Some studies provide guidelines to introduce DRT as an addition to existing services. Accordingly, it is proposed to transform the existing traditional public transport service into a demand-responsive system to provide a higher level of service without increasing costs. In some cities, DRT was already tested, e.g., under the SHAREPLACE project in Zalaegerszeg in 2019-2020, or is under preparation, like in Nyíregyháza. In Budapest DRT services are operated by BKK for several years, offering more and more advanced booking or operational opportunities. DRT operation would be the clue for many cities or suburban areas, as well as in low-density rural areas countrywide. Although several studies have already proven the feasibility and the great outcomes from economic and financial aspects, the classic operational model oriented national operator cannot easily adapt such solutions yet. [4)

Italy

In Italy, the organizational framework is based on a combination of national, regional, and local authorities, each responsible for a different area of the transport system. The organization and coordination of public transport services involve multiple stakeholders (government bodies, transport operators, and regulatory agencies). Italy is divided into 20 regions, each with its own regional government. Regional authorities are responsible for planning, regulating, and coordinating public transport services within their regions. They develop regional transportation plans and contracts with transport operators to provide services. The agreements define routes, timetables, public transport quality standards, and financial elements between regional authorities and transport operators. Local authorities can call for tenders or directly enter into contracts with transport operators. The Ministry of Infrastructure and Transport and regional and local authorities monitor and supervise public transport operations to comply with regulatory provisions. Regulatory agencies monitor the implementation of regulations, promote fair competition, and protect the interests of travellers. At the local level, municipalities and provinces have the authority to manage and organize public transport services within their area. [5)

3.2. Level of digitalization of DRT

Austria

The DRT access in Austria is organized in a way that the passenger can book a ride in advance by phone or internet. Digital platforms and mobile and web applications are used to book rides, display vehicle availability, and track their location in real time. In addition to integrated information (tariffs and timetables), the concept includes information and advice such as comparing different means of transport, selling tickets, and booking bicycle and e-bike rentals. The implemented systems mostly use algorithms to group passengers with similar routes. [6)

Croatia

There has yet to be an implemented DRT system in Croatia. A solution for areas with lower traffic demand can potentially be an on-demand transportation system as a public transportation service that is inherently more flexible than traditional public transportation and less personalized than a taxi service. [1)]

France

THE DRT access in France is organized in a way that the passenger can book a ride in advance by phone or internet. Itineraries are created based on user requests and optimized with reservations from other passengers registered in the same area. The service can be reserved through an app, website, or telephone call. Departure times are variable (up to +10 minutes maximum), and users receive information about the exact departure time via SMS or notification 15 minutes before the journey. [17)

Germany

In Germany, users of DRT transport can book the service via the app or phone call. On the websites of carriers that offer DRT services, you can see all the information related to the booking method, approximate waiting time, or approximate route the vehicle will take. Analyses that result in simulations are carried out continuously. Simulations show the state of mobility, and based on the results, mobility solutions and combinations are created that are adapted to each area. The system works in such a way that three different applications (application in the control center, application for passengers, and application for vehicles) are connected in one integrated system. Some DRT vehicles are equipped with an automated lift for people with reduced mobility. [7)]

Hungary

In Hungary, Demand-Responsive Transport is currently only available in Budapest, organized by BKK and in Nyíregyháza in case of late evening departures without IT solutions yet. Szombathely had a previous DRT solution for train connecting late evening services, but the actual operator didn't continue it. Several local authorities plan to introduce DRT services (e.g., Nyíregyháza with several technological and flexibility steps, or Siófok during off-season periods at lake Balaton). In case of the DRT system in Budapest, users can request the service by phone or in person with the driver in the vehicle. In addition, the service can be booked online through the website. After registration, a request for the DRT service can be booked in just a few clicks. The most frequently requested routes can be saved under Favourites to make booking faster. Changing or cancelling a reservation is also easy. There is a possibility to be notified by an e-mail. Reservations must be requested at least 30 minutes before departure, while cancellations are accepted up to 15 minutes before departure. Currently, the system faces technological underdevelopment, but new investments are planned. Carriers are planning to introduce the latest technical solutions with the aim of even better population connectivity and public transport attractiveness. [8)

Italy

In Italy, the Via system is expected to soon replace the existing IT system. By combining Autoguidovie's experience with Via's innovative software solutions, there are plans to launch on-demand app-based public transport services. There is currently an application through which users can request transport, which will be updated to speed up the organization of trips and create more efficient routes and simple instructions for drivers. After a passenger books a ride through the app, the software shows other passengers going in the same direction in the exact vehicle, creating fast, efficient shared journeys that make it easy to get to existing bus and train lines. 9)

3.3. Different approaches in DRT operation

Austria

The DRT service in Austria is traditionally organized, so travellers need to book their trip in advance, usually by phone calls. In some implemented solutions, this is possible through a mobile application or online platform. The public transport service provider Rufbus often uses DRT to supplement regular public transport lines in bus, tram, and rail traffic and connects them to major hubs. In Austria, DRT and its integration into the existing public transport system is seen as a solution for the future. [10)

Croatia

Croatia currently does not have a DRT system implemented. Existing projects try to initially implement the service traditionally and gradually integrate it into the existing public transport systems. [1)

France

In France, Demand-Responsive Transport (DRT) services are part of the local public transportation offering and are provided with fixed fares and vehicles with a minimum capacity of four seats. They can be organized to meet the mobility needs of specific user categories. Modern transport services are integrated into the traditional approach. Some services can be organized as a combination of the two described models. An example is the regional service that operates in supply to a fixed destination (generally a node of the traditional network). Another case is the "end of line" call services, where the last part of a traditional line is replaced by a virtual line. [1)

Germany

DRT services in Germany are mostly integrated into existing traditional services to make the entire public transport offer flexible and efficient. The system is also digitally integrated to display the DRT service on public transport applications. In Hamburg, the service can be used easily with a single HVV ticket with a surcharge of one euro per trip per person. The system is integrated with a single map and tariff system and organizationally complements the existing public transport system. [11)

Hungary

Hungary has a traditionally organized DRT. DRT system operates in Budapest, where passengers can book transport by phone calls, through the website, or in person with the driver in the vehicle. The current approach for DRT is to be organized so that it is part of the public service and integrated into existing systems. Recent studies suggest that the calculation of fares should be part of the public service network. Based on the experiences in Budapest, specific DRT lines enter the public consciousness and within a few years reach the point where it functions as an independent, traditional public transport line. The route and schedule are created based on passengers' experiences gained over the years. [4), 12)

Italy

The DRT service in Italy functions according to traditional public passenger transport principles. The procedure of establishing the service itself went through the procedure of public procurement of the service through which the transport operator contractually undertook to provide defined operational resources, technology, and standards. In most cases, the service can be booked in real-time via digital platforms. DRT tends to be increasingly integrated with traditional services, and such areas are increasingly subject to urban mobility plans and transport policy. [1)], [13)

3.4. Open Data

With the goal of a simpler and more connected sustainable transport system in Europe, much data from transport and mobility is needed. The European Commission considers open transport data an important basis for establishing intelligent transport systems (ITS) to achieve integrated traffic information and ticketing for all types of transport in the EU. Providing open data means providing data that anyone can use, redistribute to plan, operate, and improve transportation in a connected way. The data should be dynamic (sensor data on traffic jams and delays), traffic reports and static data on traffic safety, traffic statistics, geo data, and ticket price information. Directive 2010/40/EU on introducing intelligent transport systems in the transport field has been in force since 2010. 2017/1926/EU supplemented the Directive in multimodal travel information services. The gradual implementation is carried out through National Access Points (NAP), single-user access points for all modes of transport.

Currently, there is a lack of open data in all countries; the only one that stands out is the region of Fuschl – Mondsee (FUMO) in Austria, whose availability of open data is higher than in the other areas and countries. In certain regions or countries in the EU with available data, it often differs from those prescribed by the Directive. There is a general lack of cooperation between service providers and public authorities. Such a situation makes data exchange and integration at the local, national, and European levels difficult. [14), 15)

3.5. Case studies / examples of DRT services

GO – MOBIL - Austria

GO-MOBIL is a flexible passenger transport service (door-to-door) that operates in 37 peripheral and rural areas of the province of Carinthia in Austria. The goal of the service is to provide residents with access to shops, doctors, and the post office or to get them to the first bus stop. Therefore, the service complements the conventional public transport system in the mentioned area. Since the service has the characteristics of DRT, i.e., transportation at the user's request, cars, vans, and minibuses (up to nine people, including the driver) is used in everyday operations. The GO-MOBIL service can be characterized as an example of good practice for areas with less traffic demand and less accessible public transport for passengers, and it can also serve as a supplement to the existing public transport system for passengers. Users order transportation by phone calls. About 1500 companies and associations are members of GO-MOBIL, and with their sponsorships, they provide cheap tickets to users living in rural areas. Digital platforms and mobile and web applications are used to book rides, display vehicle availability, and track their location in real time. In addition to integrated information (tariffs and timetables), the concept includes information and advice such as comparing different means of transport, selling tickets, and booking bicycle and e-bike rentals. The implemented systems mostly use algorithms to group passengers with similar routes. 10)

IOKI Hamburg - Germany

The IOKI Hamburg DRT system is active in Hamburg. IOKI is a public company funded by German public transport provider Deutsche Bahn Group. The service is integrated into classic public transport in the north-western part of Hamburg. The rides schedule is tied to a specific time for booking, and in this area, they are less flexible compared to other modern on-demand offers. The service can be used easily with a unique HVV ticket with a surcharge of one euro per trip per person. The system is integrated with a unified ticket and tariff system and organizationally complements the existing public transport system. Users can book transport through the application. The service is a true example of innovative urban mobility. Research

conducted by IOKI has proven that such innovative offers encourage users to switch to public transport and give up using a private car. [11)

Telebusz - Hungary

In Hungary, BKK Telebusz is active in Budapest. BKK Telebusz includes the service of bus lines that operate with prior notice. The on-demand transport service has two purposes: on the one hand, it complements and extends the primary public transport network in suburban areas, and on the other, it does not operate without passengers during low-frequency periods. Ten such lines are active, fully or partially meeting the requirements. Users request the service over the phone or in person from the driver in the vehicle. In addition, the service can be booked online through the website. After registration, a request for the DRT service can be booked in just a few clicks. The most frequently requested routes can be saved under Favourites to make booking faster. Changing or cancelling a reservation is also easy. There is a possibility to be notified by e-mail. Reservations must be requested at least 30 minutes before departure, while cancellations are accepted up to 15 minutes before departure. [12)

Autoguidovie Miobus- Italy

Miobus is an on-call service in Crema, Italy with flexible routes and times. Trips can be booked through the app or by phone with the desired transportation time. The service has defined periods when it is available. The service has been active since 2005 and has replaced the traditional public transport network in Crema. There is currently an application through which users can request transport, which will be updated to speed up the organization of trips even more and create more efficient routes and simple instructions for drivers. Miobus operates in several locations. One of the locations is Crema, where DRT serves as public transport for the city and neighbouring municipalities. Thanks to flexible routes and timetables, Miobus meets the needs of travel in this area where regular traditional lines would be unattractive. [9)

Fflecsi - Wales

Fflecsi is a DRT solution in Wales. The solution comes from a partnership between Transport for Wales (TfW) and the Via platform to improve access to essential services for citizens in rural areas. Transport operators and local municipalities in rural, urban, and suburban areas are involved in improving the existing public transport network. The service started with a single zone and quickly expanded to the national transport network. Currently, Fflecsi is present in 12 zones and 11 different carriers. In some zones, the service operates on existing fixed routes; in others, it has replaced fixed lines. The research showed that about 73% of passengers use public transport (DRT) instead of cars. Passengers can request a ride via the app or phone. DRT vehicles change their route depending on demand to get passengers to their destination quickly. 16)

Flex'hop - France

Flex'hop is a Demand-Responsive Transport (DRT) solution in the Strasbourg area. Flex'hop, a public transport service by reservation, complements the existing bus/tram network of the CTS public transport system. It provides direct connections to over 300 stops within 25 French municipalities, including business and industrial zones, thereby supplementing the existing bus and tram lines. Flex'hop offers the possibility of free journeys between two stops when regular bus and tram lines do not allow it or when these stops are not served by regular lines during certain time slots. Travel can be booked up to 15 days in advance or at the last minute. The service is accessible with a CTS transport ticket at no additional cost. Itineraries are created based on user requests and optimized with reservations from other passengers registered in the same area. The service can be reserved through an app, website, or telephone call. Departure times are variable (up to +10 minutes maximum), and users receive information about the exact departure time via SMS or notification 15 minutes before the journey. [17)

4. Conclusions

Based on the conducted analysis of DRT in the CE region, it can be concluded that, in most countries, the problems are similar in organization and digitalization. The research proposes necessary solutions in terms of the involved stakeholders, and DRT's organization, integration, and digitization, as follows.

Stakeholders

According to the current situation, the stakeholders involved are mostly carriers and/or local authorities. The consequences of such an organization are usually a lack of integration with other public transport systems and a mismatch of timetables. Stakeholders that should be involved in the organization of DRT, in addition to carriers and local authorities, are authorities responsible for transport, service providers of technological solutions, providers of local economic and non-economic activities, non-profit associations and citizens. Coordination of a wider approach and involvement of stakeholders can result in a better-quality DRT offering and the entire public transport system.

Organisation and integration

As urban areas continue to grow and mobility needs evolve, traditional fixed-route public transport systems may need help to meet the diverse demands of passengers. Integrating DRT with existing Public Transport (PT) systems can enhance overall transit experiences, improve accessibility, and optimize resource utilization. By embracing the concept of on-demand and dynamically routed services, transportation networks can create a more sustainable and user-friendly future for passengers. The continued development and integration of DRT into existing public transport infrastructure hold the potential to revolutionize the way we travel and ensure a more inclusive and efficient transportation system for everyone.

Most countries have a similar organization of public transport which is increasingly harmonizing in line with Directive 1370/2007. The challenge with the organization is the lack of a single system or exchange platform that would result in integration, single maps, system modernization, improvement of public transport financing measures and better accessibility in suburban areas.

Most countries have a traditional approach to organizing DRT and the public transport system in general. Local authorities and carriers that provide transport services in the area are primarily involved. Some countries, such as Italy and Germany, introduce modern IT solutions into existing systems to improve the system and modernize existing software solutions.

Open Data

In the analysed countries (and for most of the services currently in operation), there is a simultaneous presence of both digital reservation system through an application and the possibility of telephone reservations, mainly intended for specific categories of users. In countries or regions with open data systems, data formats often differ from those prescribed by Directive 2017/1926, which hinders data exchanges and integration at local, national, and European levels. There needs to be more cooperation between transport service providers and public authorities, due to a serious lack of data exchange between different stakeholders.

Future risk areas and related success factors

One of the biggest challenges in DRT service implementation is economically sustainable DRT operation in low-population areas. It is important to identify and implement mobility solutions that are aimed at meeting traffic demand and supporting sustainable socio-economic development.

Among the risk factors to be considered is the issue of digitization. Regarding mobility management-as-a-whole, it is essential to improve the available information databases for better demand modelling and service planning improvement to meet the users' needs, assess transport services' cost-effectiveness more precisely, and determine its market potential.

Finally, challenges related to the coordination of stakeholders (PTAs, PTOs, users/public) should be addressed in a way to ensure the execution of multiple activities (through project portfolios), which should result in unified ticket-issuance and use model, unified route planning, and travel mapping, thereby enabling more attractive public transport service for all users (frequent and occasional).

From examples of good practice in Austria, it is evident that DRT is well organized in 37 provinces. In Germany, DRT is integrated into the existing public transport network with a unified ticket and tariff system. DRT in Hungary is a complement to the existing public transport system. DRT systems in Italy and Wales were recently upgraded with innovative software solutions.

Improving the public transport service quality should be a joint venture aimed at attracting new passengers and ensuring the economic efficiency of the service offers. The development of public transport in rural and sparsely populated areas must be a part of a wider strategy in synergy with local and regional development plans.

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