eit Urban Mobility

Co-funded by the European Union

Urban Mobility Next 7

Demand Responsive Transport:

recommendations for successful deployment

EIT Urban Mobility | October | 2022

Supported by

EIT Urban Mobility

October 2022

EIT KIC Urban Mobility S.L.

Torre Glories, Diagonal 211

08018 Barcelona

Spain

© 2022 EIT Urban Mobility

Cover picture: TMB

Pep Herrero, TMB's photographer

Contact

Yoann Le Petit

Business Development Manager, Future Mobility Factory

yoann.lepetit@eiturbanmobility.eu

eiturbanmobility.eu

eit Urban Mobility

Co-funded by the European Union

Contents

Acknowledgements

EIT Urban Mobility wishes to thank the following experts for their contributions and insights.

Daniele Berselli

Mihai Chirca

Lucia Cristea

Juan Carlos Escudero

Miquel Estrada

Ana Faria

Thomas Geier

Martí Jofre

Laura-Sue Mallia

Rui Martins

Jenny Milne

Milos Mladenovic

Miquel Nadal

Piotr Rapacz

Deborah Rim Moiso

Lidia Signor

UITP ADVANCING PUBLIC TRANSPORT

Uli Wessing

AMB Àrea Metropolitana de Barcelona

List of abbreviations

DRT	Demand Responsive Transport
ITF	International Transport Forum
PT	Public Transport
PTA	Public Transport Authority
PTO	Public Transport Operator
SMS	Short message service
Sq.km	Square Kilometer
UK	United Kingdom
VTC	Spanish acronym for Private Hire Vehicles

Key outcomes & recommendations

DRT is a form of public (and in some cases also private) transport that provides flexible mobility options between classic mass transportation and individual transportation. It is particularly suited to cater for mobility needs in low density areas (e.g. sparsely populated regions) and/ or when demand is low (e.g. nighttime or off-peak hours)

In densely populated urban areas, DRT has the potential to reduce private car usage by providing a door-to-door alternative. However, in order to offer the level of service needed in terms of vehicle availability and reduced waiting times, DRT services will require large-scale fleet operations with high costs involved. Moreover, DRT struggles to compete at a reasonable cost for the PTA given the extensive range of public transport (PT) services available, shared mobility options, and private vehicles. There are several documented failed experiences in urban contexts, and as such DRT are expected to remain niche services in the coming years with more scaling potential in peri-urban and rural areas by:

- Complementing existing mobility offerings, acting as first-last mile services feeding into the regular public transport network (fixed route, fixed schedule)
- Increasing public transport attractiveness and accessibility by providing, at same cost as regular public transport, more geographic coverage, a denser network of stops and a reduction of travel times.
- **Mitigating transport poverty** in areas or regions with scarce public transport options, providing mobility options for people who do not have access to private cars

The DRT value proposition should be considered beyond service costs and revenues. Benefits in terms of delivering access to education, healthcare, culture, work opportunities, should also be considered to assess the performance of DRT services.

- Given the fact that they are normally highly subsidised services in areas with poor or non-existing public transport, optimisation of available resources should be a key driver for designing the DRT service. In that sense, **semi-flexible and hybrid models are more likely to provide** an optimal balance between level of service and operational costs.
- To unlock the high potential of DRT in terms of addressing transport poverty and improving PT services beyond the core urban networks and main corridors, further policy action is needed at both EU and national level including:
    - Better access to guidelines, tools, and best practices for PTAs, in order to **enhance their capability to improve specifications in their tendering procedures**
    - Clearer legal framework which brings flexibility in provision of PT services and modification of existing offer

- **Structured funding programmes going beyond pilot phase only**, allowing the deployment of technical planning and operation skills and reaching the desired outcome in terms of significant modal shift and improved accessibility to jobs, education, health, and social services.

1. Introduction

1.1 Report's background

Insights presented in this report draw on discussions facilitated by EIT Urban Mobility during an online workshop on 17 and 20 June 2022. The report puts into perspective the different views expressed by the experts who contributed to the discussions (see Acknowledgement section), in a consolidated and reader-friendly manner. Views and opinions expressed do not necessarily reflect the position of EIT Urban Mobility.

1.2 DRT definition, history and use cases

DRT services provide an intermediate solution between classic mass transportation services with fixed routes (e.g. traditional bus services) and individual transportation with flexible routes (e.g. taxi services).

Flexibility is central to all DRT services and is DRT's main added value compared to traditional forms of PT from the users' perspective. In this paper, flexibility is understood as service features that enable time savings for users through proximity to and from bus stops, high frequency of service, short reservation time, and route optimisation.

The spectrum of possible design between these two existing alternatives is fairly wide, which makes planning and service analysis crucial especially with regards to the balance between reliability, flexibility, and low costs (see Figure 2). Notably, several types of DRT services exist:

- **Hybrid**: service with fixed schedule and lay-out (similar to regular public transport) on which certain stops or off-peak hours are placed on demand.
- **Semi-flexible**: DRT with pre-defined physical or virtual stops, and flexible but delimited layout and schedules. The service is adapted to actual demand, but number of detours and possible pick-up times are limited by design.
- **Full-flexible**: door-to-door services (or point-to-point between a network of virtual stops) with open schedules and dynamic routing tailored to the demand.

- **DRT with flexible layout and stops**: the stops within this kind of service are fully adapted to the demand.

While Demand Responsive Transport (DRT) is not new - first pilots were launched back in the 1970s as shown on figure 1 - one of the major recent changes impacting DRT has been the use of internet-enabled, app-based technology. In addition to better technological tools, DRT has also benefited over the past years from a more attractive user-centric design, better economics, and partnerships with technology providers. Such evolutions have opened up more use cases and helped DRT become increasingly mainstream and integrated with the wider mobility system. As one of the experts who took part in the online workshop states: **"Before DRT was a nice to have, now it is a must have."** However there are still some challenges to address, as some DRT projects fail to survive.

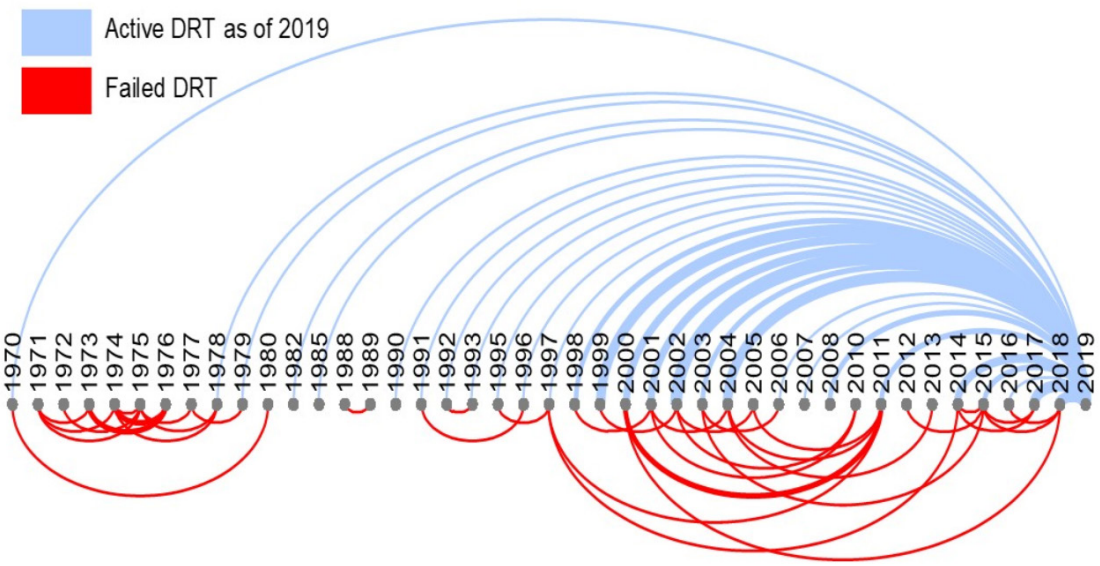

Figure 1. Overview of worldwide DRT services since 1970 (Currie & Furnier, 2020)

The variety of DRT services has led to an issue of definition. For instance, in Germany the digitally enabled DRT services are qualified as "on-demand ride pooling"; the Portuguese law provides a definition of DRT as a "public collective transport service with flexible features that is carried out, in part or in full, at the express request of the user and may include the use of information and communication technologies." These various DRT definitions have not prevented the market from growing: **between 2019 and 2021, more than 450 DRT projects worldwide have been launched** – mostly in Europe, North America, and Asia. Many different DRT use cases have been developed, including first and last mile services, night services, substitution of underutilised fixed-route buses, point to point, specific user groups, premium services, etc.

The core part of any DRT definition is that the service needs to be carried out at the express request of the user. Usually, DRT is deployed especially in low demand areas (rural areas, peri urban areas – fringes or peripheries) or/ and at low demand periods (time of the day, days of the week, seasons).

Four main flexible features of DRT services can be singled out: vehicle size, flexible route, flexible stops, and flexible schedules.

The objectives pursued by these two forms of DRT vary:

- In high mobility demand cases (in time and space), there is usually already a comprehensive public transport offer: the objective of DRT in such environments is to replace private vehicles (see the Kutsuplus example in part 2).

- In low demand cases of mobility (in time or space), there can be two cases:

  - If there is already a PT offer, DRT can improve the convenience for users or the costs of providing the service: with the same costs as traditional PT (or even lower costs in some cases), DRT can provide a more tailored service than PT.

  - If there is no PT, DRT can serve to increase accessibility and create an offer that does not already exist.

In both of the above cases, DRT can serve to improve first and last mile services and help feed mass transit. The main benefits of DRT in these cases are improved accessibility, convenience, and optimised costs.

- Two different use cases of urban and rural DRT provide good examples for these types of services: DART GoLink[i] in Dallas (United States), an urban DRT service targeted at high demand areas: the coverage of this DRT service is not over a continuous area but between specific zones across the city so as to provide first and last mile connection to public transport services. Dallas Public Transport Operator (PTO) has developed its own DRT offering and engaged in cooperation with ride hailing and taxi companies to increase the flexibility of the system.

- Clic.cat[ii] in La Garrotxa (Spain), a DRT service deployed in a low-demand rural area: the service has established routes and timetables but is only provided if requested in advance. Users must indicate their stop of origin and destination to book the service. Reservations can be done either by phone or by mobile application. Clic.cat can serve 30 different stops on a 45km route in the region, providing links to other public transport lines. Further details are provided in section 3.2.

International Transport Forum research[iii] shows that, **by providing flexible shared mobility options, DRT plays a role in accelerating the sustainable mobility transition in rural and peri-urban areas**, as far as the service constitutes an acceptable transport mode for the majority of users. This is a challenge in mobility low density areas where public transport, if existent at all, can only fulfil few and specific mobility needs. As illustrated in this report, proper service planning

and local knowledge are key to successful deployment in lower density areas. There, DRT can yield a wide range of benefits for communities by increasing access to essential services to inhabitants who do not hold a valid a driving license or have access to a private vehicle.

In urban and denser peri-urban areas, DRT has the potential to extend the core network of public transport with first-last mile flexible services, replacing private car trips and therefore reducing (local) air and noise pollution, limiting congestion and inefficient use of space, and offering energy-efficient mobility solutions.

2. Make or break: deploying successful DRT services

2.1 DRT's costs and benefits assessment

A sound costs and benefits assessment of DRT requires a fitting contextualisation of these services in low-density areas and/or low demand period. To become a credible alternative mobility option, collective transport needs to provide adequate:

- Coverage: availability over a specific territory, connections, meaningfulness of the service, activities that can be accessed
- Frequencies
- Operating hours

Applying these principles based on fixed-line public transport is often not effective, even with higher investments in public transport than today. For these use cases we need more targeted - thus more effective – services, such as DRT, which may:

- Serve areas or journeys where currently no public transport option exists
- Replace existing services that do not align with travel motives and journey needs
- Form local and feeder (support) services based on smaller vehicles that allow for fixed-line services to be bundled into meaningful corridors

Similar to traditional public transport services, the economic model of DRT services for users is reliant on public subsidies – although the level of public subsidies varies greatly across geographies and depending on the exact type of DRT service provided (e.g. full flexible or semi-flexible).

In the case of DRT, there is a question of the right pricing level depending on local condition and transport deprivation: with DRT, vehicles stop closer to users' homes and destinations – it may therefore be acceptable for users to pay a "comfort fee" for being collected and dropped closer to origin or destination. This however raises a social justice issue in the cases where people do not have any other transport option but would still be forced to pay more than for fixed bus lines because of this "comfort fee."

Looking at some examples, in the case of the Kutsuplus service in Helsinki (see also part 2.2) users in 2015 would pay an estimated average of EUR 7 (compared to the Helsinki public transport standard fare of EUR 2 for one zone tickets and EUR 3,88 for cross-zonal tickets in 2015). [iv] Still, the subsidy for each trip was EUR 20. The situation is however different in rural areas of

Portugal, where trips are partially subsidized by the municipalities thanks to a national fare reduction program (subsidised both by central state and municipalities). Specifically in the Coimbra region, the rates for transport on demand are similar or lower to those for regular bus trips for a similar distance, with prices ranging from EUR 1.05 to EUR 4.60 depending on the journey.

While subsidies are unavoidable to ensure viability of DRT services, **it is important to note the difference in costs between various type of DRT.** So far, the approach to DRT has been mostly on full flexible services which leads to very costly operations. This impacts the reputation of DRT services as a whole, making some decision-makers reluctant to opt for DRT. To change this perception, subsidies need to be carefully allocated to the most efficient DRT options, otherwise the credibility of DRT services as a whole is at risk.

More specifically, full flexible and semi-flexible services reflect two different approaches to the compromise between low costs, high flexibility (as defined in part 1.2), and high reliability (i.e. punctuality at pick-up and drop-off locations, ensuring connections are reached) that every DRT service needs to accommodate. In practice, only two of these objectives can be achieved simultaneously, as illustrated in figure 2:

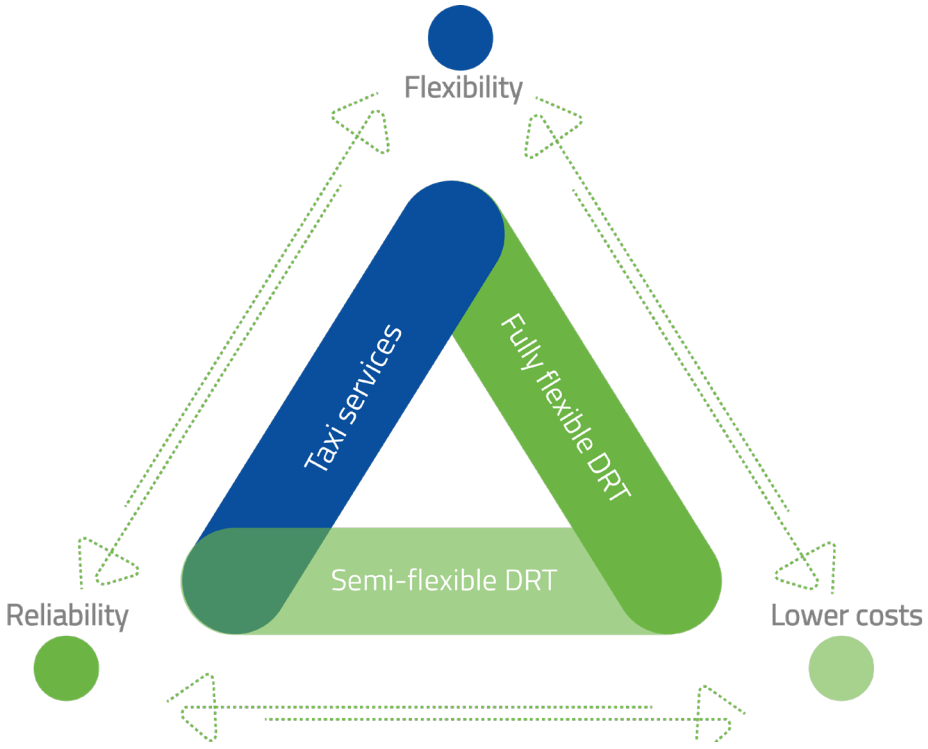

Figure 2. Service compromise between cost efficiency, flexibility, and reliability

Figure 2 shows that:

- Full flexible DRT combines **high flexibility at low costs** by allowing many detours and minimising walking distance for users but has **low reliability** (e.g. higher probability of cancelled trips or long waiting times).

- Semi-flexible DRT associates **low costs and high reliability** but only with **limited flexibility** where users are picked up and dropped off at pre-defined physical or digital stops that can be activated or not depending on actual demand.

- Taxi services are both **reliable and flexible** for users but at a **high cost**.

Each service configuration displayed above serves different environments and circumstances, that very much depend on the nature of the demand and on the political willingness to subsidize specific services or use cases. For example, many full flexible DRT services are subsidised by public authorities for passenger safety reasons (e.g. to minimise harassment risks in late-night or early-morning trips).

In the UK, where the DRT survival rate is lower than the international average[v], some operators do not see DRT as bringing significant added value in terms of reducing emissions due to the low occupancy of vehicles. In low density areas, taxis can be more cost-efficient than larger buses. This underlines the need to support already existing assets that are available, whether these modes of transport are informal or formal. In cases where costs are similar to a taxi service, relevance of DRT and its comparative advantage may be questioned. However, the DRT value proposition should be considered from a wider lens: it is important to measure the benefits of public transport services in terms of delivering access to education, healthcare, culture, work opportunities, for people who previously did not have access. Hidden benefits of public transport (not only time and cost for user) such as the value of access, the value of not having to own a car, should be taken into account and internalised in cost benefit analysis of public transport in general and DRT in particular.

For this reason, **costs and benefits of DRT should be assessed taking into account externalities compared to other modes** (positive socio-economic externalities of DRT are illustrated by the use cases in part 2.3). Central to the discussion is the question of cities and regions' immediate goal for mobility in low density areas. Either the net monetary costs of DRT are acceptable because of their contribution to public policy objectives – and generation of positive externalities, or such services are simply not provided to community, aggravating transport poverty.

Considering costs and benefits of DRT calls for an assessment of the opportunity to convert fixed public transport lines into flexible ones. In a nutshell, if the priority is to save public money significantly, shifting to DRT does not make really sense as it will not lead to large savings (there's still a fix cost related to the availability of vehicle and driver during operation time). In this respect, pilots over two to three years can be useful to correctly evaluate the evolution in ridership.

However the move to DRT lines can lead to an increase in ridership for the same amount of investment due to an increase in service level

2.2 User-centric planning and communication

It is very important to set clear objectives according to specific use cases and communities to be served, as shown in the circular process of planning and implementation (figure 3):

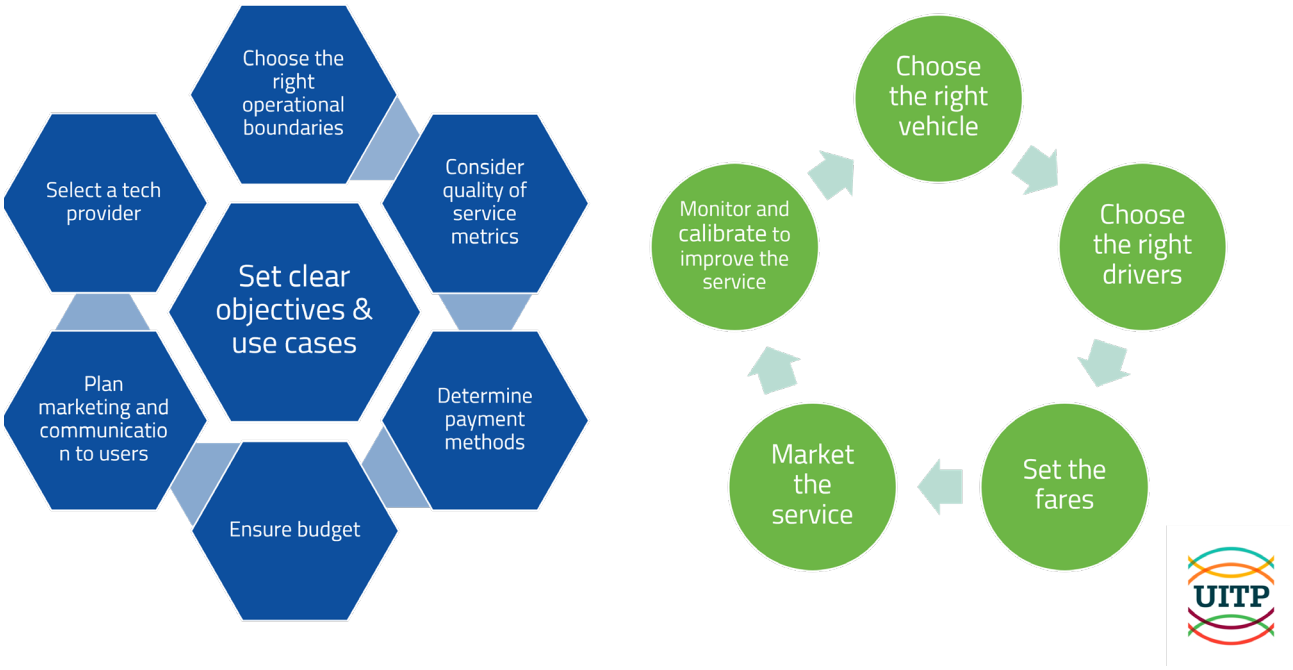

Figure 3. DRT planning and implementation process (source: UITP)

The optimisation of DRT services is a complex dilemma, between revenues and cost management, number of vehicles deployed, population served, as well as travel and waiting times. **It is clear that a sustainable – in all dimensions of the term - mobility transition in low density areas can only succeed if public transport is an acceptable mode choice for many – not few – journeys and travel motives.** However, the issue of dispersed demand (low population density and dispersed activities) needs to be addressed effectively. This implies answering following questions:

- How dynamic can a service be for local journeys, eg. within and between villages?
- What are acceptable short journey lead-times?
- What are meaningful stop locations?
- What are meaningful service hours?
- What are acceptable pooling detours?
- How do we ensure timely interchanges are guaranteed into and from fixed-lined services?

User-focused planning and efficient communication towards communities are essential to provide adequate answers to these questions. However, the majority of transport projects are still planned and deployed based only on metrics like frequency, location, or satisfaction - without proper methods to "think from the eyes of the users", as one of the workshop experts quotes. In fact, **focusing more on travel experience than on average speed and stops would enable to shift from system level to user level, and to improve service alignment and user expectations**. Users' mindsets directly impact the adoption of DRT services and should be seriously considered in DRT communication strategies if service providers are to maximise adoption. This is what the example of the Kutsuplus service in Helsinki illustrates.

USE CASE 1: Kutsuplus

The Kutsuplus service was deployed from 2012 to 2015 in the Helsinki region. It is an insightful use case for urban/ peri urban area DRT in a service area density of 3000 inhabitants/ sq. km, with the main goal to reduce the use of the private car.

At the time when Kutsuplus was deployed, the Helsinki region already had a strong offer of transport options and multimodal services. Public transport was the preferred travel option: 34% of residents travelled by public transport, 30% with private vehicle, 30% walking, and 6% cycling [vi]. In such a context of good public transport level and little congestion problems, promoting the adoption of a new DRT service among the population was a difficult task.

Main features of Kutsuplus:

Kutsuplus was a stop-to-stop DRT service based on an algorithm to connect origin and destination of several passengers, with a lead time of 45minutes. Users would get an offer with an estimated pickup time, arrival time window and a predefined price – which they could accept or reject. At the launch of Kutsuplus ten buses were running the services, and five microbuses were added later to operate on weekdays. Their initial schedule was from 9:00 to 17:00, before being extended from 6:00 to 24:00. Buses were featured with side steps, Wi-Fi, as well as real time passenger info with estimated time of arrival.

The key operational figures below provide additional insights on Kutsuplus:

- 100,000 trips in 2015
- 55,000 vehicle hours in 2015
- 1.8 trips/vehicle hour
- 32,193 registered users
- 35% pick-ups within +/- 30 seconds punctuality
- User rating = 4.7/5.0
- Operating revenue = €895,400
- Net income = - €7,913,200
- Subsidy per trip in 2015 ~ €20

Additionally, a survey conducted among users, lapsed users and non-users of the service, allow a better understanding of trip reason and user profiles. Kutsuplus trips were geographically spread out and trip lengths were mostly up to 9km. **Main trip reasons indicated by users were socio-recreational, along with healthcare or child-related trips** (see figure 4).

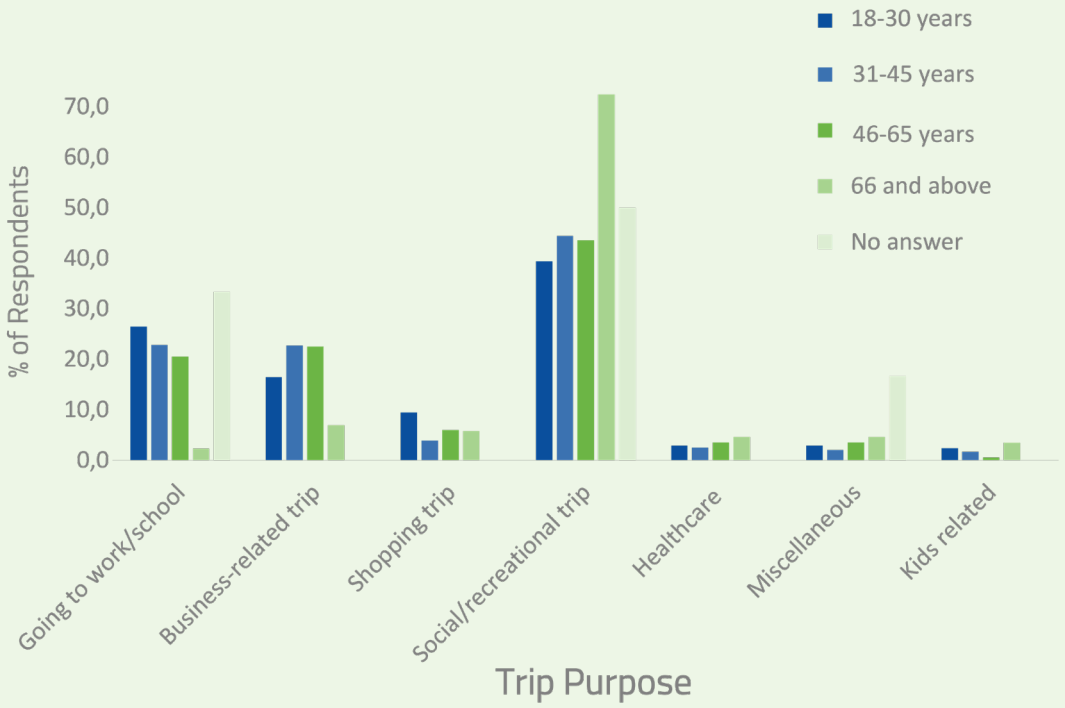

Figure 4. Kutsuplus users' trip purpose (Survey size: 1440 respondents)[vii]

One of the main reasons for people to use Kutsuplus were the lower costs compared to taxi services, the speed of travel compared to public transport, but also to cover trips on routes that were underserved by public transport, especially on connections between the city's outskirts. In that sense, it had the potential to replace private car trips.

The older population was not well-represented among the service users (subsidised taxi rides in Finland are available for specific health reasons, which may have been a barrier for the elderly to switch to DRT). Bookings had to be made exclusively on browsers, which was not deemed to be user friendly. The app-based service was not available yet and the SMS booking option was introduced at a later stage.

At the end of 2015, the service was withdrawn. **The key reasons stated by users for ceasing to use the service included the use of other public transport alternatives, the difficulty to book trips, and the cost of the service** (especially for lower income categories). From the non-user perspective, the main reason for not using the service was the lack of awareness about the service itself. This can be linked to Kutsuplus' marketing strategy, which focused on smart and futuristic aspects of the service but did not mention the price of the service on the communication material

or on the vans. These were of the same colour as the regular public transport services in Helsinki (blue), which did not help users to visually differentiate the DRT service.

As far as service design is concerned, the current thinking in Helsinki is that for any future DRT project, the Public Transport Authority HSL should use their own service design capabilities. The use case shows the importance of defining the specificities of different profiles in a very detailed way to anticipate their needs. Such needs have to be taken into account for people to change their habits and travel experience.

Overall, the pros and cons of Kutsuplus can be summed up as in the table below:

Pros

- Good connections with regular public transport in areas of low public transport accessibility
- Low cost for the end user
- Speed of travel compared to public transport
- Reduction in car-related issues, such as finding parking
- Ease to adapt travel behaviour once familiar with service

Cons

- Limited-service area, density, and time
- Fare collection system (mandatory pre-payment), fare structure (price of the service and group discounts)
- Ordering system and user interface
- Information and misconceptions about the system
- Rush hour reliability and availability
- Routing algorithm
- Vehicle accessibility

Further research papers about Kutsuplus are listed in the “Reference” section.

Beyond the importance of communication and user-centric design, the Kutsuplus use case also shows that **in dense urban areas, DRT struggles to compete at a reasonable cost for the PTA with a strong existing mobility offer of public transport, shared mobility options, and private vehicles**. Long-term investment on large scale deployments would be needed.

2.3 Careful consideration of local needs and expectations

Multilevel perspectives of transition shows that there are many socio-cultural aspects to consider beyond only economics and transport in order to grasp and appreciate change in the transport sector. An issue slowing down the uptake of DRT has been - for instance in the UK - a lack of consultation of users. A top-down approach has been followed based on technology and planning, without much emphasis on users' needs and expectations. **User workshops on Mobility as a Service or rural DRT are not common practice, which leads to suboptimal service planning.**

Part of the reality of local contexts requires considering an ageing population in low density areas and remote places (including in coastal and island regions), where car dependency is important. On top of this, access to public transport systems and DRT services can be jeopardised by the lack of digital skills. Successful DRT services need to take into account these factors to cater for the needs of the communities it aims to serve. In this respect, integration of new residential developments with the planning of suitable bespoke public transport options constitutes a best practice. Similar examples have been collected by the SMARTA (Smart rural transport areas) project[viii], which aims to assess how sustainable, on-demand mobility solutions can help enhance the travel experience of diverse rural populations.

From a planning point of view, selected variables can help DRT operators grasp the peculiarities of specific operation areas:

- **Population density**:

Population density is a strong indicator for the suitability of DRT services, as illustrated by the example in Portugal, where 40% of the population resides in communities with less than 2000 people and low-density areas tend to continue to lose population making rural depopulation a key issue. If municipalities struggle to secure (flexible) transport systems, the issue will only worsen with time.

- **Social vulnerability:**

Social vulnerability is also an important factor to consider when devising DRT services. It covers several aspects: aging and dependency, low income, unemployment, precarity and exclusion. Different kinds of services need to adapt to the varying vulnerability profiles. For instance, when deploying DRT services in low-income regions, it makes sense to develop a lower priced ticket offer.

- **Mobility profiles:**

Population density is a strong indicator for the suitability of DRT services, as illustrated by the example of Portugal, where 40% of the population resides in communities with less than 2000 people and low-density areas tend to continue to lose population making rural depopulation a key issue. If municipalities struggle to secure (flexible) transport systems, the issue will only worsen with time.

Areas with a large modal share of short private vehicle trips are potentially suitable for DRT. An indicator linked to this is the percentage of people commuting by car. In Portugal, 55% of the population use a car for daily commuting. These users, as well as the local population with no access to cars, represent a pool of potential users for DRT services.

The knowledge of the regular public transport network is very important when planning new DRT services. A higher density of network does not necessarily imply a better quality of the service, as an area can be covered by regular bus lines with low frequency. Ideally, DRT services should complement the regular services (network expansion) but also serve the regular services (acting as feeder, shuttle, and replacement).

Having a closer look at areas within a region without bus services is a good indicator to identify priorities for the deployment of DRT services. **Good knowledge of a territory is a key prerequisite to identify opportunities for DRT in specific areas.** Likewise, targeted DRT roll out allows to test users' appetite for such services and to collect valuables service data and insights on mobility habits and financial performance before actually expanding the scope. This is the case for instance in Modena (Italy), where since September 2022 a night-time semi-flexible DRT service has been operating. This test market service is only available for existing public transport subscribers so that both the PTA and PTO can evaluate the attractiveness and actual costs of the service based on preliminary data, before deciding whether to extend it or not – or to convert it into a traditional evening fixed bus service.

In addition, when considering DRT services it is often overlooked that the frequency of offer is highly variable throughout the year. In remote areas, high public transport offer with fixed bus lines often correlates with the school period. But in the summer, DRT can be a solution to complement the regular service on traditional routes in areas where there are fewer passengers than usual (see use cases below).

USE CASE 2: Médio Tejo and Coimbra, Portugal

The question of "when" DRT is needed is as important as the question of "where" it is needed. For instance the bus service frequency in the municipality of Sardoal (Médio Tejo region, Portugal) is very low during the summer holiday period and lower in the Christmas and Easter vacations.

Some public transport bus lines are not available at all during the weekend. In addition, there are variations in level of service in fixed-time schedules that show large discrepancies during the hours of service (e.g. three peak hours a day: morning, lunchtime, evening).

In Medio Tejo, a mostly car-dependant rural region with 13 municipalities, population density is quite low at 74 people per sq. km. The DRT service in the region has been growing since 2014. From October 2017 passenger numbers have been growing steadily with a minimum of 60 per month, and by July 2019 there were 150 passengers a month. A peak in service usage during the summer months can be observed.

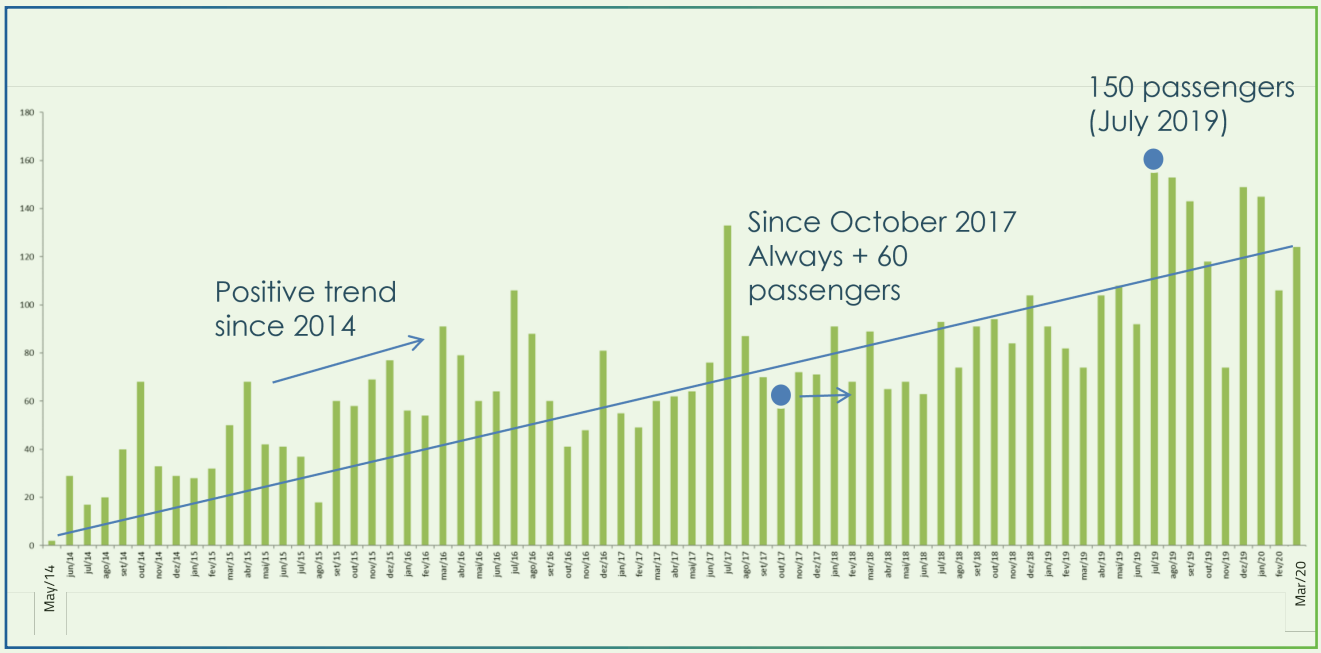

Figure 5. Number of monthly DRT users in Médio Tejo region[ix]

Interestingly, most of the users in this area are older than 51 years (91%), who use the service mostly for healthcare reasons (50%) or for grocery shopping (30%). Overall, 71% of the trips are going to the municipality centre.

In Coimbra, a region spanning across 19 municipalities, the local DRT service saw a large increase in ridership despite a launch during the Covid-19 pandemic, with a somewhat higher usage in early 2022 (369 passengers in May) compared to December 2021 (269 passengers). Quite similarly to Medio Tejo, the average users' age for the DRT service in the Coimbra region (SIT FLEXI service) is 69,6 years, and the main trip purpose is healthcare (69% of users).

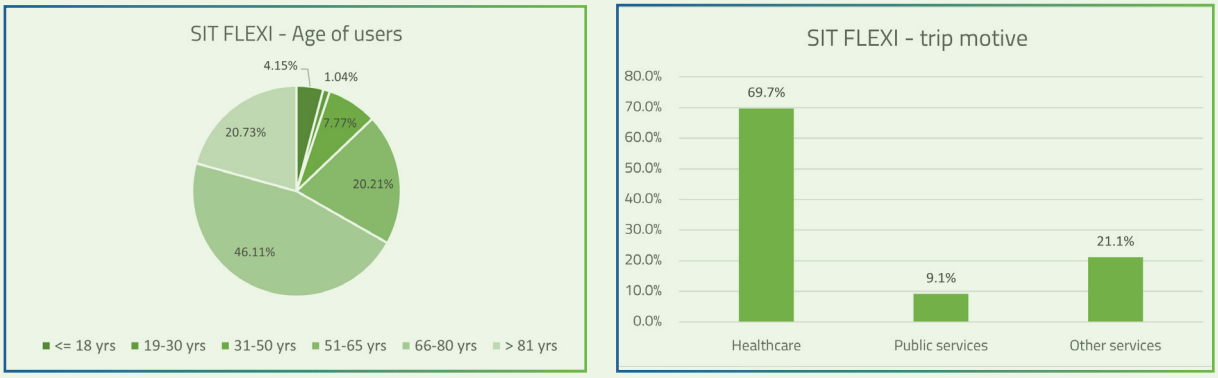

Figure 6. SIT FLEXI - age of users and trip motive (Source: IMT)

Based on the importance to consider communities' local specificities and needs, it is possible to identify more general questions about the planning and deployment of DRT services, which can serve as input for further research:

- Is there enough data about regular bus services?
- Is it possible to identify the territorial gaps?
- How to best identify the schedule gaps (often overlooked but very important)?
- How much information is there about the social profile of the potential passengers?
- Should one of the service's objectives be to nudge young people into using DRT?
- How can DRT be linked to the other services used by passengers?

3. Finding the optimal DRT model

3.1 Different types of DRT and their implications

As more flexibility is introduced to a DRT service, user occupancy and travel times are expected to decrease at the expense of raising operating costs. Each planning process should aim to find the optimal balance between operating costs and user performance. Likewise, an optimal subsidy and fee structure is needed to make the service sustainable. Figure 7 puts cost and performance in context, looking at indicators such as user travel time, operator costs, and vehicle occupancy. Interestingly, as already shown in figure 2, there is a clear correlation between the higher flexibility of the service (reduced travel time) and higher operator costs.

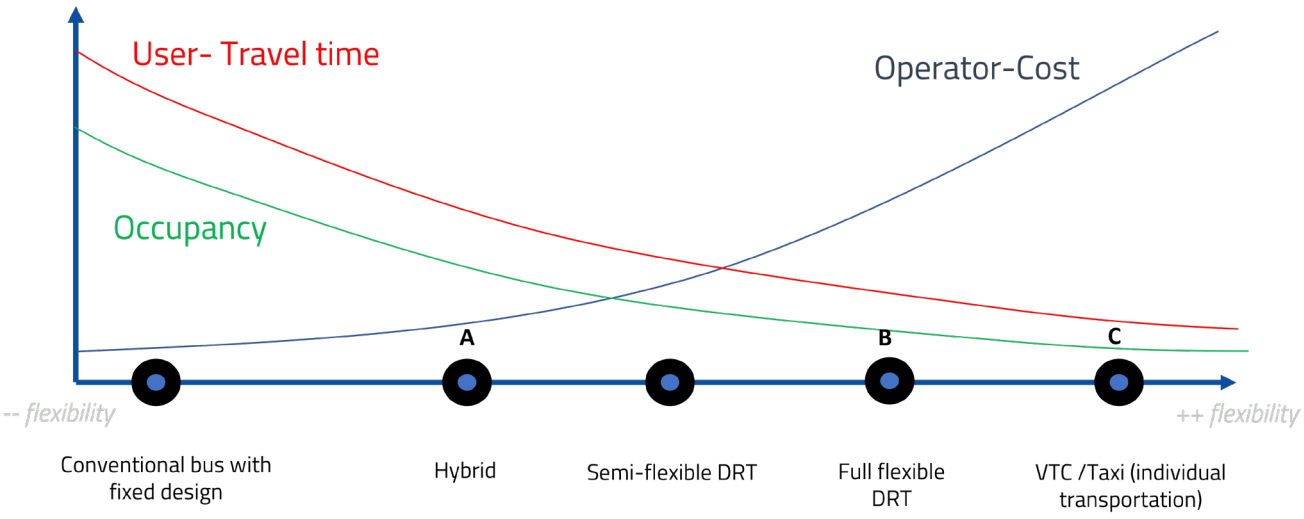

Figure 7. DRT cost-performance ratio across various service types (source: Multidepart)

USE CASE 3: Multidepart

Multidepart is a planning toolkit developed in the framework of a project supported by EIT Urban Mobility[x]. Its aim is to support transit agencies, local authorities, and municipalities in the design, operation, management, and financing of Demand Responsive Transport services.

The Planning tool presents three levels of analysis:

- Level 1. **Strategic**: most suitable design for a target demand density calculating fleet size, distance run, transportation cost incurred and incomes.

- Level 2. **Strategic & Operational:** most suitable design for an on-demand service, with detail of the available transportation infrastructure.
- Level 3. **Aimsun Ride:** integration of Strategic & Operational approach in the shared mobility service simulation platform Aimsun Next.[xi]

Figure 8 illustrates the application of the Multidepart tool to a specific use case in Lisbon, Portugal. The bus operator Carris introduced a new planning paradigm. In this case, the Multidepart tool helped identify which is the best service that can be provided with a limited number of vehicles (two in this case). For weekdays in Lisbon the full flexible service is more expensive than the semi-flexible one, and would only make economic sense during the weekends, when demand is reduced, and costs of full flexible DRT are comparable to semi-flexible.

Carreira 731 Carreira 76B

Figure 8. Application of the Multidepart tool to a new planning paradigm in Lisbon

One of the key questions addressed by the Multidepart project is the servicing of additional demand (e.g. a new user to be picked up and dropped off) with limited impact on the other passengers' travel and waiting times. This is done by defining a maximal additional travel time threshold (detour) according to occupancy.

When assessing the total costs of operations, it is important to calculate the number of buses needed, not only the distance covered. Conventional tenders usually compensate for the distance travelled, but efficient DRT planning requires proper anticipation of the number of vehicles and drivers needed. The Multidepart tool also estimates the farebox recovery ratio, i.e. the percentage of a trip's costs that is covered by the ticket price itself. This ratio is essential in understanding the minimum level of subsidies required to deploy DRT services. Within the project, the Multidepart tool has been implemented in the cities of Thessaloniki (Greece) and Lisbon (Portugal).

There is no one size fits all service, as each type of DRT service has its optimal use case where it can maximise the cost versus performance ratio. Importantly, vehicle capacity and running costs must be adapted to the expected demand density.

Finding the optimal DRT options requires tackling questions that tools such as the Multidepart can help answer:

- How to deal with peak demand (e.g. pupils on their way to school)? In many areas large buses and more drivers are needed in the morning and afternoon. How to reconcile this with DRT? Can drivers of large vehicles provide the DRT services as well?
- What is an acceptable balance between trip length and interchange requirements?
- What is an optimal vehicle size?
- How to calculate an adequate price for the service procurement?
- What is an adequate price for the customers?

3.2 Semi-flexible DRT: the right balance?

In a low demand context, compared to fixed public transport, the semi-flexible model aggregates more demand, with wider geographical coverage, and higher frequency. Thanks to smaller-sized vehicles, it can operate at lower costs compared to fixed-line bus services, while avoiding empty trips.

Compared to full flexible models, a trade-off between cost and performance can be observed: with a large fleet, the DRT full flexible model brings more convenience to users but at a higher cost, closer to taxi services: a very large fleet is needed for the full flexible model, otherwise users become frustrated if they are too far away from the main route (sometimes large delays to be expected). The higher the demand, the more challenging it becomes to satisfy this demand with a reasonable fleet with limited delays.

In case of limited resources (i.e. vehicles), **semi-flexible services can provide more convenience at lower costs.** On one hand, the service becomes more reliable since waiting times become more predictable, with vehicle detours being limited thus avoiding large deviations in travel and pick-up times. A user in a rural area with limited access to Public Transport more likely to be tolerant to longer waiting times as long as they are predictable. On the other hand, the reduction of flexibility increases the aggregation of demand into the same vehicle, reducing the average cost/passenger of the whole service. Figure 9 illustrates the different DRT models and their advantages and drawbacks in terms of flexibility for users and demand aggregation.

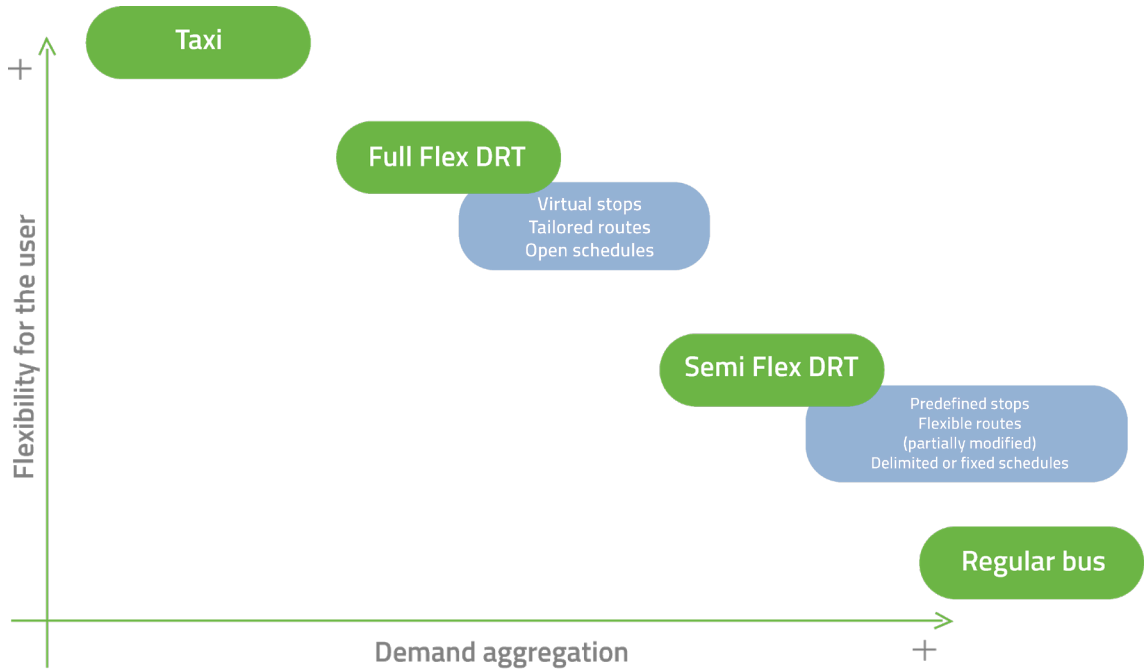

Figure 9. Trade-off between flexibility and demand aggregation (Source: nemi)

In conclusion, **semi-flexible DRT services are more convenient and cost-efficient in a low demand context, unless there is a large economic contribution from the subsidising public authority in deploying and operating a large fleet of vehicles**.

The example of nemi illustrates the semi-flexible DRT model.

USE CASE 4: nemi

In July 2021 the transport on demand system (TAD) Clic.cat was put into operation in Vall d'en Bas in the Garrotxa region in the province of Girona, north-eastern Spain. Clic.cat is a public transport service of the Generalitat de Catalunya using nemi's technology as an on-demand transport platform.

The region of Garrotxa has a total population of 59,000 spread over a remote area of 735 sq.km making for a sparsely populated area with an average density of 70 inhabitants per sq.km. Specifically, the municipality of Vall d'en Bas has a population of 3115 spread over a remote area of 90,7 sq.km giving an average density of just 33 inhabitants per sq.km. The solution involved creating a flexible bus line connecting villages in the Vall d'en Bas where there was previously no bus service, to the region's urban core of Olot with a population of 36.000.

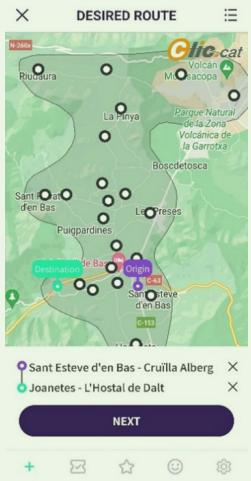

Figure 10. User view of the Clic.cat app

Main feautres of nemi:

Nemi is a software solution that enables the operation of on demand transport services through a user app, a driver app, a web back-office, and a route optimization algorithm. To use the service, it is necessary to first register (a quick two-step process using a valid email address) then make a reservation through the user app or the call centre, by indicating the origin and destination stops, the day and time of the trip, and the requested number of seats. The available options are shaped by the fixed stops and schedule previously defined by the public transport operator and the competent public authority.

The back-office web application allows mobility operations managers to define the stops to be deployed in a territory, all the possible routes resulting from all the combinations of requested stops, as well as the expeditions departure times and duration delimitation. For each defined expedition time slot, the requests from users are collected and processed either from the mobile application or the web back-office reservation tool (telephone reservations), for the routing algorithm to then go through all the options and compute the most optimal itinerary for the expedition. As the departure time approaches, each expedition sets the final route, which is communicated to the assigned driver through the dedicated driver app, available for mobile phones and tablets.

Reservations can be made through the nemi application (TAD-TEISA) no later than 15 minutes before the scheduled departure time of the first stop of the corresponding line. Through the application, and when there are 15 minutes before the departure of the bus, the customer receives confirmation of the exact pick-up time, and has real-time information on the position of the vehicle. Reservations can also be made by telephone from Monday to Friday (8:00 am - 8:00 pm). The service runs hourly departures from 7am until 8pm.

3628 passengers used the on-demand bus line during the first nine months of the service peaking at a daily number of passengers of 26. **It is also interesting to note that 80% of reservations are made by the mobile application and just 20% by telephone, adding to the increased efficiency of the solution.** The number of registered users reflects an element of seasonality of the service being more users registered with nemi during the spring and summer months than the autumn and winter months.

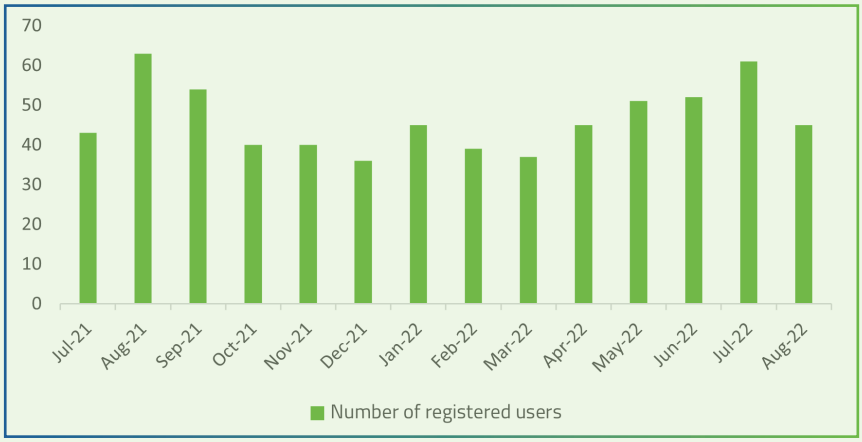

Figure 11. Number of registered users and seasonality of the demand

The total impact:

In terms of impact, as well as over 3000 residents gaining access to a PT hub with connections to employment and education and essential regional centre services (fresh food, health care and leisure), it is notable that:

- The average length of the optimised route is 20kms compared to the 45kms of a conventional fixed line regular service. **This means ca. 50% saving on emissions and fuel.**
- Only 85% of the expeditions are undertaken, with the bus only leaving the depot if there is at least one reservation.
- **Half of all expeditions have four or more than four passengers aboard** (see figure 12).

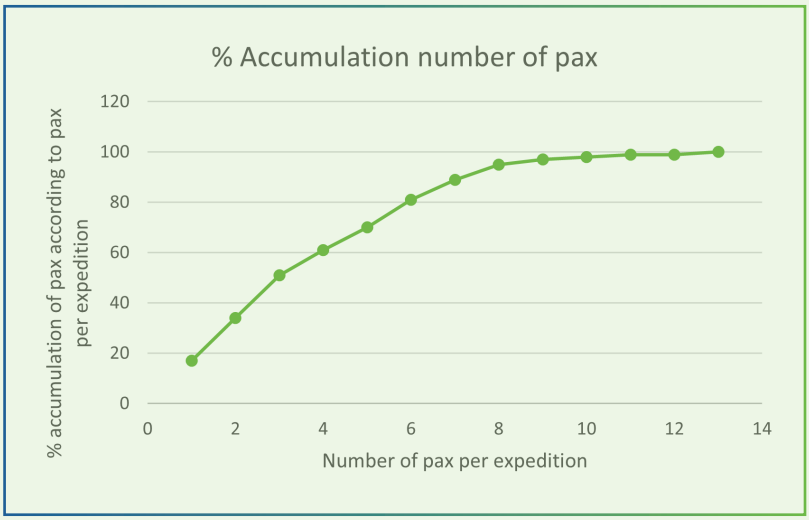

Figure 12. Accumulation of passengers per expedition

Passenger numbers are centred on two peak travel time slots: from 8am until 10am in the morning and from 5pm until 7pm in the evening, collectively making up more than 50% of demand. The service in the Garrotxa has now been extended to include weekends from July 2022 and will be later assessed in terms of usage and whether to include the weekend service permanently.

4. Stimulating DRT uptake

4.1 Addressing barriers to uptake

The uptake of DRT services faces barriers embedded in the mobility system and behaviour in urban, peri-urban, and rural areas:

- On the one hand, it is difficult to run successful DRT services in urban context where they compete with a lot of other modes. Behaviour change literature[xii] suggests that people might be stuck within their own modal habits as long as they do not experience major disruptions.

- On the other hand, low density areas are typically sub- or peri-urban and rural areas characterised by lower-than-average population density and sparse or dispersed functions, amenities, and activities. This leads to larger distances being travelled and a higher need for motorised transport. At the same time, the affordability and ease of use of private motor vehicles reinforces the car-orientation of functions and reduces public transport connectivity, patronage, and viability.

There is a self-selection problem behind this path dependency: people have locked themselves in owning a car in periphery of cities. **Therefore the form and shape of DRT has to cater for user needs.** To change behaviour in rural and remote rural areas it is important to acknowledge that people are dependent on cars to access basic services of everyday life.

According to one of the workshop participants, changing behaviour also implies enhancing public transport service level, as price elasticity of transport is quite low, and people do not adjust their habits just because of price signals.

Indeed, research shows[xiii] that what drives ridership is service level, not prices. A high frequency or flexible service level that creates enough trust in the systems for users to feel confident they will reach their destination is key. Addressing this barrier begs the question of whether more travellers are needed first to fund a higher quality service, or whether the public transport service should be improved first in order to attract more users.

Running DRT services only as limited pilots does not create the necessary trust users need to adopt the service and change their behaviours. From the long-term perspective, it is important to consider the larger path dependency of our transport systems. The service needs to be considered from the user perspective, taking into account their value systems (even colour choice / preferences). In parallel, cross-sector cooperation, for instance with housing development companies can incentivise more sustainable mobility choices and favour DRT services.

For many PTAs, there is a skills and experience gap to be closed to better understand how DRT works and include these services in their tenders, to then receive the most suitable offers.

DRT procurement procedures also need to be reviewed. Before focusing on the regulation, it is important to enhance PTAs' capability to improve specifications in their tendering procedures. On the one side public authorities are eager to deploy DRT services and see the potential. But processes are slow and require new budget allocation to cover for additional drivers and vehicles. In other cases the conditions with PTOs are already fixed by current contracts, that PTAs cannot or do not wish to renegotiate.

Another barrier is the disproportionate focus on costs in public procurement which explains why in a lot of tenders for public transport services, often the cheapest offers win. Currently, DRT services are a little bit more expensive and often ruled out from the tendering process. For instance for a flexible DRT offer two vehicles (and two drivers) would be needed to cover the same capacity as one bus with a single driver. So the transport offer needs to be richer, with more people riding the service, to justify higher costs.

4.2 Unlocking structural enablers

Overall, **a coherent governance model for DRT operations (e.g. the conditions and specification of PTA tendering DRT services in rural areas and/or cities) is missing at European level**. Looking at different large scale DRT services, the governance varies with more or less focus on the PTA or on the PTO. It also depends on countries and their legal systems: for example in the UK DRT is considered to be close to a private service, with a focus on economic viability, whereas in France the public transport service aspects are especially important.

Regulation is a key enabler as it can either block or unlock DRT services. Different frameworks (national, regional, and local) impact DRT at different levels. In some EU countries for instance, there are strict vehicle requirements for public transport that limit the deployment of more flexible alternatives. Similarly, **flexible transport systems created as bottom-up systems should be better integrated with others to maximise synergies between informal, DRT, and formal modes of transports.** Indeed, informal flexible collective mobility solutions, which are often organised ad hoc and on a voluntary basis, fit better the needs of communities.

The case of Berlin illustrates the importance of regulation: the legal framework was not favourable to DRT, but an exception granted by the parliament allowed to the Berlkönig service to be run. The exception was granted along with the obligation to make vehicles wheelchair accessible.

In rural areas, DRT has also a huge potential to improve mobility, as research from the International Transport Forum shows.[xiv] However regulatory frameworks for rural mobility across Member States are lacking, with the exception of Slovenia.[xv] This lack of guidance calls for a more target-oriented regulation of mobility systems in rural areas. **In this regard, the scheme proposed by the ITF on DRT is a reference, as it considers the DRT systems' operating environments in different contexts.**

The transition from DRT pilots to permanent operations needs not only an enabling, clearer legal framework, but also structured funding programmes going beyond pilot phase only, allowing the deployment of technical planning and operation skills. Indeed, DRT projects are complex projects that require the right cross-disciplinary skillsets to manage strategic partnerships - including on data-sharing - and ensure a strong business case based on accurate demand planning and sound cost-benefit analysis. This relates to the experience with Kutsuplus in Helsinki (see part 2.2): is the objective just to conduct an experiment or is it to drive change more broadly – which implies strong political support - beyond just one or a few DRT trial(s)?

An all-encompassing approach that fosters the transition towards more sustainable mobility behaviours is crucial.

The "Avoid Shift Improve" approach is known, and the contribution of DRT to these objectives is clear. But in the meantime, it is key to develop a coordinated approach to mobility (e.g. in cities and regions where DRT services are available also address complementary mobility topics such as parking policy or vehicle access) because a DRT project on its own is unlikely to trigger the essential long-term shift toward sustainable mobility.

5. Conclusions and recommendations

Experts contributing to this report see the **semi-flexible and hybrid models as the most likely to be widely adopted** (Figure 13).

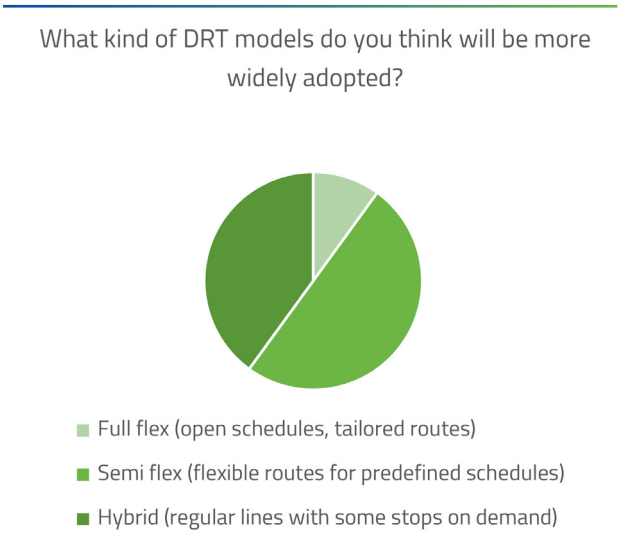

Figure 13. Expert survey #1

Tendentially, workshop experts expect that **DRT will remain a niche service** (see Figure 14), which will not lead to massive replacement of fixed bus lines. There is a place for DRT on a feeder level within very localised contexts where DRT services can complement the existing network of regular bus lines.

In large cities, DRT use cases are mostly deemed suitable in specific circumstances such as night bus services. **Outside urban areas, there is a potential for DRT services to go beyond just the niche in a context of transition toward less car-dependant mobility systems.**

In peri-urban and rural areas, DRT fulfils essential social functions, highlighting the tension between operational efficiency and public policy objectives. Indeed, in low demand areas already affected by transport poverty combined with long travel times, public transport offers are often unattractive and costly. This increases operation deficits, which leads to a reduction of offering affecting territorial coverage and causing services to be suspended or their frequency to be reduced. **DRT can stop this negative circle and limit the social exclusion of remote territories as illustrated in figure 15**.

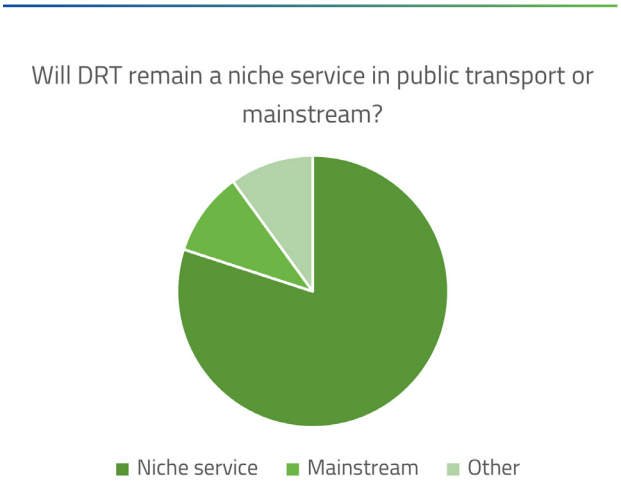

Figure 14. Expert survey #2

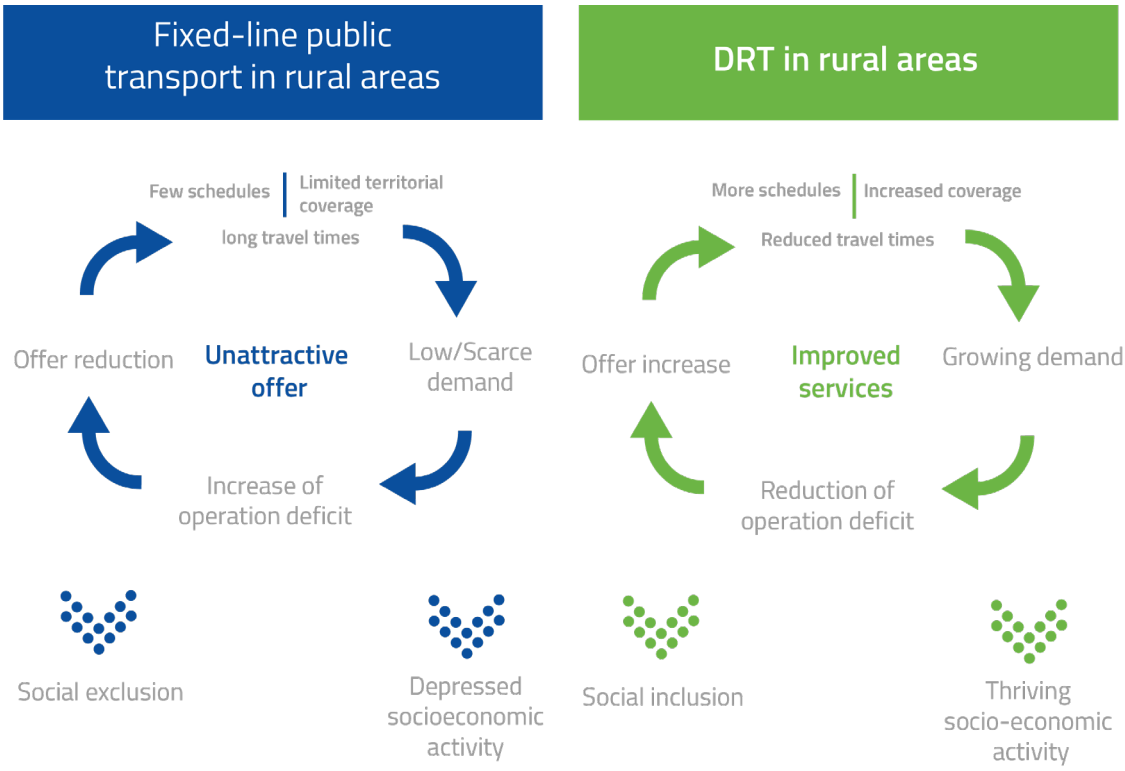

Figure 15. In rural areas, DRT can break the negative spiral of long travel times, unattractive PT offer, reduced service, and social exclusion (source: own illustration, adapted from IMT Portugal)

While it is clear that DRT as a form of public transport needs to be subsidised, this report shows that, in a low demand context, the semi-flexible and hybrid models are more likely to provide sound economic options with an optimal balance between reliability, operational costs, and customer satisfaction. Ultimately, **the level of subsidies needed to ensure operational viability depends largely on the type of DRT service deployed**.

The main scope of DRT is to cater for the particular needs of communities that are currently not catered for by traditional public transport offers. The flexibility introduced by DRT can be both an advantage and a disadvantage depending on the context as well as on the users. Profound knowledge of local requirements provides precious information on the extent to which a DRT should be flexible and linked to the existing offer of formal and informal shared mobility services (including stop and frequency planning). Local knowledge and efficient communication also directly impact service uptake, as seen in the demographics of rural DRT, which highlights the importance suitable booking options for communities to access the service. This is key to deliver the high socio-economic impact DRT can have in rural communities. As one of the workshop experts put it, **"having a good algorithm is not enough to have a successful DRT service."**

In parallel, **regulatory frameworks and procurement procedures should facilitate DRT deployment as part of a broader endeavour to create a virtuous circle of shared, sustainable mobility**. In some cases starting a DRT line in specific areas can be a good way to collect much-needed data about the service, and eventually can lead to a line being consolidated into a permanent bus service; in others, bundling public transport lines into meaningful corridors and providing connecting flexible lines could help shift behaviours and support DRT uptakes.

Overall, integrated decision making across policy areas and transport development is key. A systematic commitment of all actors of the mobility ecosystem to more accessibility, fairness, and sustainability is crucial to change the mobility regime - beyond a few DRT pilots - as the ultimate success of DRT will also depend on a more profound change of mobility habits and structures.

Key actions needed to reap the benefits of DRT:

- Foster knowledge exchange, eg. through a dedicated working group or forum, to streamline guidelines and tools and share best practices and learnings from DRT implementation.
- Facilitate the provision of flexible public transport services and modification of running services (ie. contract modification over the duration of the concession to allow for improvements as implementation goes on). Current regulations should enable a shift in how public transport services are provided in low demand areas.
- Allocate additional funding to new DRT services in rural areas to tackle transport poverty and bring socio-economic benefits to these areas.

References

i. See: https://www.dart.org/riding/golink.asp

ii. https://en.turismegarrotxa.com/plan-your-holidays/news/the-on-demand-transport-service-clic-cat-arrives-in-la-garrotxa-with-30-stops/

iii. International transport forum (ITF): Innovations for better rural mobility, 2021: https://www.itf-oecd.org/innovations-better-rural-mobility

iv. Haglund, N., Mladenović, M. N., Kujala, R., Weckström, C., & Saramäki, J. (2019). Where did Kutsuplus drive us? Ex post evaluation of on-demand micro-transit pilot in the Helsinki capital region. Research in Transportation Business & Management, 32, 100390.

v. Graham Currie, Nicholas Fournier, Why most DRT/Micro-Transits fail – What the survivors tell us about progress, Research in Transportation Economics, Volume 83, 2020: https://www.sciencedirect.com/science/article/pii/S0739885920300937

vi. Modal split figures are estimate.

vii. Weckström, C., Mladenović, M. N., Ullah, W., Nelson, J. D., Givoni, M., & Bussman, S. (2018). User perspectives on emerging mobility services: Ex post analysis of Kutsuplus pilot. Research in transportation business & management, 27, 84-97.

viii. See SMARTA: https://ruralsharedmobility.eu/about/

ix. Transporte a Pedido no Concelho de Sardoal (2018)

x. Project developed by Altran, Polytechnic University of Catalonia, Barcelona, CERTH, Factual, Sant Cugat municipality. For more information: https://multidepart-project.eu/about-us/

xi. See: https://www.aimsun.com/de/aimsun-next-2/

xii. Partnership for urban mobility: promoting behaviour change, 2019: https://ec.europa.eu/futurium/en/system/files/ged/promoting_behaviour_change.pdf

xiii. Geneviève Boisjoly et al. Invest in the ride: A 14 year longitudinal analysis of the determinants of public transport ridership in 25 North American cities, Transportation Research vol 116, 2018: https://www.researchgate.net/publication/327992515_Invest_in_the_ride_A_14_year_longitudinal_analysis_of_the_determinants_of_public_transport_ridership_in_25_North_American_cities/citation/download

xiv. International transport forum (ITF): Innovations for better rural mobility, 2021: https://www.itf-oecd.org/innovations-better-rural-mobility

xv. SMARTA, Slovenia insight paper, 2019: https://ruralsharedmobility.eu/wp-content/uploads/2019/08/SMARTA-IP-Slovenia.pdf

Co-funded by the
European Union