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# An Evaluation of the Key Features for Designing a Sustainable Demand Responsive Transport Service (DRTS) in Urban and Suburban Contexts

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**Abstract.** In the last decade there has been a change in the mobility habits, with the need to have greater flexibility to move. This derives from the urban sprawl which has characterized modern cities, recently smart working policies and changed lifestyles.

The lack of flexibility associated with Public Transport (PT) binds the user to own a private vehicle because it has the advantage of being always available and allows to move without limitations. Alongside, the PT services supply has decreased, especially at the national context (i.e. Italy), due to both limited resources and rising costs, with a consequently reduction in the associated demand. This has led to a massive use of private vehicles, with increasing high motorization rates and associated negative externalities. Hence, comes the need to attract users of private vehicle both for systematic (i.e. home-work) and non-systematic (i.e. home-leisure) trips.

To cope with this, in addition to traditional PT, innovative mobility services have been promoted, including the Demand Responsive Transport Services (DRTS). This is a “hybrid” service that, depending on specific characteristics, can be closer to the flexibility offered by a private car or more similar to the use of PT. Moving in this direction, DRTS can constitute the right solution to meet the users’ mobility needs.

Based on this premise, this paper aims to analyze different case studies of DRTS, both in urban and suburban context, by proposing a bottom-up approach in order to evaluate the Key Features (e.g. type of stops; path; service; reservation; pre-booking; price of the ticket) to design a cost-effective transport service and greatly contribute to the community wellbeing.

**Keywords:** Demand Responsive Transport Services (DRTS); mobility needs; flexibility; Key Features; transport mobility.

## INTRODUCTION

Cities play a key role towards the low-carbon transition and, in this direction, there are several actions achieving carbon mitigation. This urban transition is unavoidable in the light of sustainability, although there are some limitations [1-4]. In the earlier of the nineteenth century, the shape of the cities was compact and this allowed the population to travel short walking-distances to work [5, 6]. However, over the years, there has been a continuous evolution of cities, characterized by a change in the urban spaces, which implies a radical transformation not only of the urban planning, infrastructural and transport solutions, but also of the mobility habits and travel behaviour of citizens, more inclined to use the private vehicles [7-9].

From the environmental point of view, the massive use of cars leads to increasing congestion levels and pollution due to emissions produced by exhaust fumes. The Octo-Ambrosetti Report underlines that, in Europe, the transport sector is the only one to have increased the traffic emissions since 1990 (+24%) [10]. According to the Higher Institute for Environmental Protection and Research (Istituto Superiore per la Protezione e la Ricerca Ambientale – ISPRA), in Italy the transport sector accounts for 46% of Nox emissions [11]. Furthermore, Italy is the second country in the EU for motorization rate, with about 663 vehicles per 1,000 inhabitants, second only to Luxembourg (681 vehicles per 1,000 inhabitants) and with a very high rate even compared to other European

countries (Germany 574, Spain 513, France 482, United Kingdom 473). This also underlines a low propensity to use Public Transport (PT) [12, 13].

Following the pandemic, analyzing the data referring to the last months of the past year, the mobility of Italian citizens settles on values close to those before the health crisis, whose effects seems to have been overcome [14]. From the data of the "19<sup>th</sup> Report on the mobility of Italians" drawn up by ISFORT, a distinction can be observed: while the mobility demand for private transport is very close to 2019, for PT and rail the pre-pandemic values have not yet been reached. Looking at the individual mobility options, the share of cars in 2022 was just under 65% (63.5 in 2019), while PT at 7.6% (10.8 in 2019) [15].

The reduction in local PT volumes is mainly due to the poor efficiency of the service, which is not able to meet the changing mobility needs. It is noted that PT services are not implemented in some areas, i.e. those with low population density and weak-demand. This happens both in terms of reduced coverage compared to the entire territory and of low service frequency. Another cause of the service inefficiency is linked to the lack of information and poor accessibility resulting from the stops location [16,17]. In Italy, local PT services are not sustainable from a financial point of view, due to the reduced ratio between revenues and costs to provide a regular bus service frequency. At this stage, the increase in the use of private cars and the sharp decrease in the share of PT require a major overhaul of the transport planning strategy [18].

Specifically, it is essential to rethink the PT supply through the introduction of new on-demand flexible services. The Demand Responsive Transit Service (DRTS) can be managed through a platform that dynamically connects users and vehicles, allowing a "point-to-point" travel with fixed or variable routes based on the mobility demand [19]. In Italy, unfortunately, these innovative services are hindered by the difficulty of legal aspects [20]. This penalized the mobility conditions both urban contexts, where DRTS could represent a valid alternative to the possession of a private car, and suburban contexts characterized by weak-demand areas, where DRTS can be integrated with the scheduled PT.

With these premises, the work aims to analyze different case studies of DRTS, both in urban and suburban contexts, proposing a state-of-the-art bottom-up approach in order to evaluate the Key Factors (e.g. type of stops; path; service; reservation; pre-booking; price of the ticket) to design a cost-effective transport service. Recognizing the connection between transport and urban form, these new forms of innovative mobility can support the transition from sprawling urban development and conventional motorized transport, towards mobility choices shaped around PT and shared services [21-23].

This is the reminder of the paper: section 1 discussed the new forms of innovative mobility, introducing the DRTS; section 2 illustrates the methodological approach based on Key Factors to classify different types of DRTS; section 3 reports the analysis of implemented DRTS case studies in Italy; in section 4 these services are discussed and compared, associating the predefined Key Factors to each service type. Finally, this section also provides conclusions and indications for future research.

## METHODOLOGICAL APPROACH

The methodological approach is characterized by a bottom-up approach based on the analysis of different case studies of DRTS, both in urban and suburban context, in order to identify the Key Features associated to their implementation.

The selected case studies have been identified through a targeted investigation to classify all innovative DRTS, activated in the last five years in Italy. In detail, different types of service have been analyzed, considering both the more flexible ones, e.g. without fixed routes and scheduled timetable, to those with predefined routes and a frequency based on users' requests. In many cases, reference is made to experimental services or pilot projects. This is due both to the fact that these innovative services are still in the context of an experimental phase and that their legal regulation is not yet well defined, except for rare exceptions. Therefore, these types of service cannot be associated with conventional PT.

Based on these characteristics, the analyzed case studies are the following:

- Peri-Metrò (Vicenza);
- TSonDemand (Trieste);
- UDonDEMAND (Udine);
- Chiamabus (Scandiano);
- Chiamabus (Riolo Terme);
- Prontobus (Perugia);

- CTMover (Catania);
- Porto Flavia Link (Iglesias);
- ChiamaBus (Peschiera Borromeo);
- Prontobus (Modena);
- Servizio a chiamata (Cuneo, Mondovì; Aeroporto di Levaldigi).

By analyzing the implementation of the DRTS in these cities, the following Key Features associated to the service have been identified. The planning (P) and operational (O) features of the DRTS have been summarized in Table 1, in order to define the type of service. The “flexibility” of these services can be assessed through these characteristics.

**TABLE 1** Key Features associated to DRTS

ID	Description	Option
P-1	Type of Stops	Fixed stops (F); Fixed and optionally stops (F/O); Optionally stops (O)
P-2	Path	Zone based (ZB); Line route (LR)
P-3	Service type	Link service (L); Suburban (S); Urban (U)
P-4	Booking Types	App (A); Call center (C); Web site (W); SMS (S)
P-5	Pre-booking	Time (min/h); Real time (RT)
O-1	Ticket Price	Fixed rate (€); Variable rate (VR); Employer-paid transit subsidies (*EPTS)
O-2	Activation	Date
O-3	Current availability	Available (A), no longer available (NA)

The type of stop is the first feature and it can be classified into two types: *fixed*, if identified through physical items (i.e. street furniture, poles or shelters), or *optional*, only virtually identified via an app or interactive map.

The route can be based on a pre-established path with possible detours depending on users’ requests (i.e. *Line route*), or it can be *zone based*. The zone based route is not pre-established, it is traced within the operating area through routing optimization algorithm. The input parameters for the path identification can be different and chosen by the service provider.

The service type can be: *urban*, if the service takes place in a densely populated area; *suburban*, if it provides a connection between low demand areas and densely populated areas; finally, the service can be defined as a *link*, if it connects intermodal poles or points of interest within the study area.

The booking types define the methods of reservation to access the service. In the past, the reservation was made with *call centers*, while now it is often available through *web platforms* or *smartphone apps*.

The pre-booking time is the minimum *time* elapsing between the trip request and the departure time. The service will be more flexible if it is possible to book the service in *real-time* or if this time is less than one hour, because it allows the user to also make non-systematic trips. On the contrary, a pre-booking time higher than 2 hours force the user to plan the journey in advance, thus greatly limiting the flexibility of the system.

The ticket price has been included to consider the cost that users have to bear to access the service. It can be a *fixed* or *variable rate* and in some cases there is the option of *employer-paid transit subsidies*. In this regard, it is important to highlight that this cost is often not proportionate to the offered service. Indeed, experimental services guarantee access to DRTS through the same ticket for conventional PT.

Information has also been reported regarding the *date of activation* of the service and its *current availability*.

## CASE STUDIES ANALYSIS

Following the description and analysis of the implemented DRTS for the selected case studies is reported. It should be noted that, in some cases, information have been found through the websites of the service; while in other cases, however, it has been necessary to contact the administration to obtain the necessary information for carrying out the research.

**Peri-Metrò (Vicenza)** [24]. The "Peri Metrò" DRTS is active in the city of Vicenza. It is characterized by high flexibility, routes and stops not established but determined by the users' requests. The service is active in four zones in the peripheral areas of the municipality and a list of stops has been defined within each one. The service is operated by Società Vicentina Trasporti (SVT) and trip requests are managed through the "SVT Vicenza" application. The reservation can be made via call centers, web browsers, text messages, mobile apps and it is also possible, in correspondence of some stops, to book the service via fixed terminals installed by the provider. To access the service, the user must choose the starting point and the arrival point of his journey. Then, the system checks availability and schedule the journey within the next 30 minutes, indicating the available times. The service is included in the urban and suburban season ticket of the public transport service of Vicenza or the single ticket is €2.00. The service is active from Monday to Saturday (excluding holidays), from 8:30 a.m. to 12:00 a.m. and from 2:30 p.m. to 5:30 p.m. In the evening, the service works from 8:30 p.m. to 11.30 p.m. from Sunday to Friday and on Saturday night until 3.30 a.m.

**TSonDemand (Trieste)** [25]. Since 2019, an on-demand service called SmartBus has been operating in Trieste by Trieste Trasporti. SmartBus was integrated with the conventional scheduled services; it could be booked via web up to thirty minutes before the journey and daily operative from 8:30 a.m. to 9:00 p.m. The service has been implemented in a suburban area with low demand, with fixed routes based on local PT lines. The only difference consisted in the need to make a reservation to access the service. The booking is required via the app or call center, the costs and payment methods are those of the traditional scheduled service.

The experimental service was suspended after a few months due to the pandemic; few months later it was reactivated in the urban context to replace traditional scheduled services to cope the directives on the passenger limit of PT. In the last months of 2022, the new provider Tpl Fvg operator activated a service called TSONDEMAND. This DRTS connects the center of Trieste with the eastern part of the city. The service is active from Monday to Saturday from 9:15 a.m. to 12:15 a.m. and from 1:45 p.m. to 5:15 p.m.

**UDonDEMAND (Udine)** [26]. The UDonDEMAND service is implemented in Val Degano, an area in the Province of Udine which includes the municipalities of Forni, Avoltri, Rigolato, Comeglians, Ovaro and Raveo, with about 3500 inhabitants. The service, operated by Tpl Fvg, is designed to make a connection from weak demand areas to the main modal interchange nodes, making up for the absence of traditional service during peak-off hours of mobility demand. The service operates using both the stops of the traditional PT and new added stop points in areas not served by PT. Booking the service is possible both through the call center and the app, with a pre-booking time of three hours before the departure time, indicating the pick-up and pick-off stops. Once the reservation has been made, the system will communicate the arrival time of the vehicle at the pick-up stop. The cost of the ticket is €1.35 and with the TPL FVG pass it is possible to use the service without further charges.

**Chiamabus (Scandiano)** [27]. Chiamabus was a DRTS activated within the municipality of Scandiano. It is currently unavailable, as the municipality decided not to renew the service due to the low number of users. The characteristics of the service made it extremely flexible, the route was not pre-established but varying according to the trip requests. The reservation was off-line through the call center, so that the user and the provider can agree on the time of departure and arrival. The user had to book the service at least one day in advance. With this type of reservation, the provider could plan in advance the service on the basis of trip requests received every day, in order to optimize the routing and speed up the routes. The cost of the service was 1.5 € for one way and 2.0 € for return, these costs were feasible and sustainable thanks to the municipal contribution for the realization of the service.

**Chiamabus (Riolo Terme)** [28]. The "chiamabus" DRTS was activated in summer 2020 within the municipality of Riolo Terme, in the urban and peri-urban area. The on-demand service was designed to integrate the scheduled service, already operating in the area with 9 rides per day. The main aim of the service was to ensure a better connection for citizens, users of spa treatments and visitors. The service connected all the villages of the Municipality of Riolo Terme (plus Villa Vezzano) with the center and with the thermal baths with 43 stops widely distributed throughout the territory. The level of flexibility was very high as there was no pre-established route and scheduled time, but the vehicle routing was based on user requests to optimize the service. The reservation was made by calling up to 30 minutes before the ride; during the call the operator managed the reservation by indicating the pick-up stop and the departure time. The cost of the ticket was €1.30.

**Prontobus (Perugia)** [29]. The "Prontobus" DRT service of the Municipality of Perugia was implemented to create a transport service with more flexibility compared to the conventional PT. The service is activated within eight areas of Perugia without scheduled timetables and fixed routes. To access the service, the user must indicate to the call center the pick-up point, the destination and the departure time. The service provided the possibility to book the trip up to half an hour before the departure time.

**CTMover (Catania)** [30]. In the industrial district of Catania, an experimental Bus On Demand service, called CT-Mover, was activated on 29 September 2022. It is a service without a scheduled timetable and with a variable route. The terminus is in Fontanarossa car park, passing through the Fontanarossa railway station and connecting with the industrial area. The service is operated on a pre-established path which can be varied by adding optional stops and detours based on trip requests. The reservation is available through the CT-Mover app: the user can book his journey by entering the departure and destination stop. The access to the service is reserved to workers and guests of the industrial area. Payment is made through Employer-paid transit subsidies (\*EPTS) made available by the companies of the Industrial Zone for its employees and visitors, through QR-codes distributed internally to the various corporate realities.

**Porto Flavia Link (Iglesias)** [31]. Porto Flavia Link is the name of the transfer service, activated from 18th June to 18th September 2022, to directly connect the city of Iglesias to the Porto Flavia and promote the tourist development of this mining site. The service was based on a fixed route and pre-established stops, starting from the Iglesias station and arriving to the Porto Flavia ticket office. There were 15 connections per day, every day of the week. Access to the service was possible by reservation, through the Trenitalia internet portal, at an additional cost of €3 to the railway ticket.

**ChiamaBus (Peschiera Borromeo)** [32]. The "Chiama Bus" service of the Municipality of Peschiera Borromeo is a on demand public transport service. It does not have a defined route and scheduled times. Three groups of stops have been defined, respectively red (falling in the city centre), green (falling in the neighborhoods) and blue (subway station). The only available trips are those with the origin or destination in correspondence of green stations; this is because the service must serve as a transfer to connect the neighborhoods to the city center or to the subway. To use the service it is necessary to make a trip request through the call center, communicating the pick-up and pick-off stop and the departure time (or alternatively the arrival time). The trip request can be made both offline and online. The service rate depends on the trip request and is the same of all ATM lines, based on the SITAM (Sistema Integrato Tariffario Area Milanese).

**Prontobus (Modena)** [33]. The "Prontobus" DRTS is available in six municipalities in the province of Modena: Castelfranco Emilia, Carpi, Maranello, Modena, Mirandola and Pavullo. These services are managed by SETA with the aim of integrate the suburban public transport line. The services do not have fixed routes, but there are established areas within which the stops are then fixed. Being an integration with the PT, it will not be possible to make journeys between stops connected by the traditional line service. The reservation is possible through the call center or app: the user can choose the origin and destination of the journey from the list of stops and decide the departure or arrival time. Booking is possible online up to 60 minutes before the departure. The service is also available for disabled users: in this case the reservation must be made three hours in advance. The cost of the service is the same as traditional line services, with ordinary travel tickets.

**Servizio a chiamata (Cuneo – Mondovì – Aeroporto Levaldigi)** [34-36]. Three DRTS are available in the province of Cuneo. The Cuneo and Mondovì services do not have a pre-established route and timetable, but there are established areas within which it is possible to choose the pick-up and pick-off points of the journey from a list of stops. The services are mainly addressed at those categories who need a personal service to go to work and/or for leisure trips. The trip request must be done via app or call center, indicating the origin and destination stops and the departure time. The third service (i.e. Aeroporto Levaldigi) is implemented to connect the municipalities of Saluzzo, Savigliano, Fossano, Mondovì and Cuneo with the Levaldigi airport, via a call link service. The service can be requested through app or call center: choosing the departure and arrival nodes, the day and the number of passengers, the best transfer solution is proposed. Reservations are offline and it is possible to book up to 4 days from the departure date.



The table 2 summarizes the Key Features associated to the examined DRT services:

**TABLE 2** *Analyzed case studies of DRT services*

City	Service name	Provider	P-1	P-2	P-3	P-4	P-5	O-1	O- 2	O-3
Vicenza	Peri-Metrò	S.V.T	O	ZB	S, L	A, C, W, S	30 min	2,00 €	06/12/2018	A
Trieste	TSonDEMAND	Tpl Fgv	F/O	LR	U, S	A, C	30 min	1,40 €	04/11/2022	A
Udine	UDonDEMAND	Tpl Fgv	F/O	LR	S	A, C	30 min	1,40 €	20/06/2022	A
Scandiano	Chiamabus	Mantovan trasporti	O	ZB	U	C	24 h	2,00 €	15/10/2006 (S)	NA
Riolo Terme	Chiamabus	C. Trasporti di Riolo Terme	F/O	LR	S, L	C	30 min	1,30 €	06/07/2020	NA
Perugia	Prontobus	ACAP	O	ZB	U, S	C	30 min	1.50 €	2008	NA
Catania	CTMover	AMTS	F/O	LR	S	A	RT	*EPTS	29/09/2022	A
Iglesias	Porto Flavia Link	F.S.	F	LR	L	A, W	30 min	6,00€ A/R	18/06/2022	A
Peschiera Borromeo	ChiamaBus	ATM	F	LR	S	C	30 min	2.00 €	03/01/2022	A
Modena	Prontobus	SETA	O	ZB	U, S	A, C	60 min	1,50 €	ND	A
Cuneo	Servizio a chiamata	Grandabus	O	ZB	U, S	A, C, W	RT	3,00€ - 5,00€	ND	A
Mondovì	Servizio a chiamata	Grandabus	O	ZB	U, S	C	RT	1,50 €	ND	A
Aeroporto di Levaldigi	Servizio a chiamata	Grandabus	F/O	LR	L	A, C, W	RT	VR	ND	A

## DISCUSSION AND CONCLUSION

In this session the results derived from previous analysis are discussed, in order to identify correlations between the characteristics associated with the DRTS and the city within which they are implemented.

The research findings show that several DRTS have been activated in Italy in recent years (i.e last five years). Many of these are experimental services, but this is due to regulations that often prevent the creation of services that differ from traditional PT. Following the analyzed services, it is possible to distinguish three main types of DRTS:

- urban and suburban services with high flexibility;
- urban and suburban services with an intermediate level of flexibility;
- suburban and extra-urban connection services.

Urban and suburban services are characterized by high flexibility in terms of timetables and routes. In this way, these services are able to provide greater accessibility than traditional services. They are not based on a fixed route, but zones where the service is available are defined. In these areas, stops are identified to allow users to access the service through a reservation, specifying the origin and destination of the journey and the desired time for departure. These services are also characterized by the possibility of making an online reservation (in real-time) and, therefore, the user can book the service up to a few minutes before the departure.

Urban and suburban services characterized by an intermediate level of flexibility are often implemented to serve weak demand areas. These services have fixed routes and stops, but it is also possible to have optional stops which, by activating at the users' request, make a variation to the line route with possible detours and extensions. Therefore, it is possible to reduce the length of the routes if there are no requests along the detours. They can have both offline and online (real time) reservations.

Finally, examples of DRTS whose the main aim is to connect intermodal poles or points of interest with maximum flexibility for users have been analyzed. In this case, the service is very similar to that provided by traditional demand services, i.e. NCC (car rental with driver) or Taxi, but with the addition of sharing. This allows to reduce costs for users and decrease the number of vehicles needed to perform the service. This makes the system more sustainable also from an environmental point of view. Likewise in this case, the reservation can be made both offline and online (real time).

Common Key Features to the DRTS have been analyzed, which could highlight the differences between these types of services. It is important to highlight that as these features change, the service can be less or more flexible and able to adapt to different contexts. The flexibility is not only in the operation of the service, but also in adapting to local needs and any remodeling of the service.

The research intends to provide a support to the administrations in choosing the characteristics of these on-demand services, based on a double perspective: the effective needs of the territory (i.e users) and the service manager (i.e provider). In future research, some of the case studies described in this work will be analyzed in detail, to find correlations between the identified Key Features and the qualitative performance of the service.

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