An Analysis of the Integration of DRT Services with Local Public Transport in Post-pandemic Period: Some of the Preliminary Insights in the Italian Context

Tiziana Campisi[1](✉), Antonino Canale[1], Giovanni Tesoriere[1], Nazam Ali[2], Matteo Ignaccolo[3], and Elena Cocuzza[3](✉)

[1] Faculty of Engineering and Architecture, University of Enna Kore, 94100 Enna, Italy
tiziana.campisi@unikore.it
[2] University of Management and Technology, C-II, Johar Town, Lahore, Pakistan
[3] Department of Civil Engineering and Architecture, University of Catania, Cittadella Universitaria, 95125 Catania, Italy
ecocuzza@dica.unict.it

Abstract. Italy was one of the first country in Europe which was severely affected by COVID-19 pandemic. Several critical issues emerged during the different pandemic phases, especially in the health and mobility sector. Restrictions on public transport reduced the supply of transport, highlighting the need to rethink complementary transport systems. Since May 2020, in the post-lockdown phase, the provision of local public transport has been based on ordinary services, such as bus services, which are mainly intended to meet the needs of systematic travel between the places of residence and work on main development routes of the territory. These services have undergone reductions both in the on-board capacity and in some cases the complete elimination of transit routes. The rebalancing in favour of sustainable modes of transport and the reduction of the share of road mobility is pursued through the encouragement of ad-hoc measures aimed at balancing-off the supply-demand mechanism and improving the quality of services. The application of an on-demand responsive transit system has the ability to improve the transit needs in order to reach the places where personal or family services are provided or to enjoy the resources distributed within desired territory. In Italy since March 2020, new areas of weak demand for transport have been created, i.e. areas with a certain number of users that need to be transferred to and from places that have generally never had access to public transport or have had it restricted. The Demand Responsive Transport (DRT) system is, therefore, used in both urban and suburban areas, allowing even those who do not have their own means of transport (for example, disadvantaged social categories or users with a short stay in the area) or who are suitably equipped (people with reduced or no motor skills), to move around in areas easily. The present work focuses on an analysis of the current state of affairs, starting from the literature and regulations concerning the diffusion of the DRT systems in Italy, and offers some ideas for the optimisation of an integrated public transport service.

Keywords: DRT · Post pandemic mobility · Local public transport integration · Italy

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2022
O. Gervasi et al. (Eds.): ICCSA 2022 Workshops, LNCS 13380, pp. 496–508, 2022.
https://doi.org/10.1007/978-3-031-10542-5_34

1 Introduction

The passenger transport and mobility sector has undergone a major transformation in the last decade. This has been caused not only by technological developments that have improved or created new services and enhanced infrastructures, but also by different trends in transport demand, i.e. different modal choices (e.g. due to changes in travel frequencies) [1, 2].

The recent pandemic and even more so the recent energy crisis has highlighted a change in travel choices. Among the mobility services that could be included as complementary to collective public transport are DRT systems [3, 4]. They can be applied through fleets of minibuses with combustion engines but recently some studies are linked to the introduction of hybrid or electric vehicles [5].

Many peri-urban areas are sparsely populated and it is widespread in Italy and in different European contexts. They often have no public transport service. People living in such areas are therefore obliged to use their own cars in order to get around [6]. Demand-responsive transport is an optimal transport service in these areas, allowing people to connect more easily to existing transport nodes, thus promoting multimodality.

Vitality and urbanity are some of the key objectives of the strategies for urban development and sustainable mobility.

These characteristics emerge from the diversity of activities in urban public spaces and have an impact on people's sense of place. They influence the propensity and frequency of travel [7, 8].

DRT complements traditional public transport services in smaller cities with low population density or in areas characterized by population dispersion (mountainous areas, rural locations, etc.) or areas not served by traditional public transport services.

It aims to offer an high quality service, closer to the needs of users, thanks to customization, comfort and a journey time of no more than 30 min.

This service can also be carried out with small vehicles, offering dedicated services and equipment for the transport of disabled people [9–11].

Several case studies indicate the willingness of both car users and those who regularly use the bus mode to use DRT services at a higher rate than current bus fares [12, 13].

Among the countries where this service has become more widespread is the UK, especially in rural areas. Drawing on the experience of a number of UK schemes, research conducted by [14] assessed the reasons for the renewed success of DRT linked to the spread of telematics systems and exemplified a number of factors including service characteristics (particularly route flexibility, flexibility of booking method and advance booking scheme), emerging markets and the overall contribution of DRT to increasing social inclusion and intermodality.

It should be considered that in recent years there has been a new potential market for DRT in workplaces outside urban areas.

Innovative solutions could be linked to the combination of freight and passenger transport systems in rural areas. In some countries the postal service operator is also a major bus operator (UK for example). Minibuses driven by volunteers are also emerging as a solution for rural areas but are not necessarily comprehensive in their coverage (popular in Japan). Although several DRT services have failed, it is not easy to identify bad practices in the development and planning of DRT services.

The main failure factors found in the literature are related to the fact that many DRT pilot projects developed and tested in past years throughout Europe were closely linked to and dependent on national, regional or EU funds. Therefore, the main reason for the discontinuation of activities is linked to the lack of public funds.

Furthermore, the service management schemes were unbalanced between private and public DRT operators.

The role of the public authority is to find the right balance between these two transport operators in order to avoid conflicts and integrate all the different mobility offers in the best possible way. Instead, the success of DRT is based on the coexistence of technological and service evolution [15, 16].

Therefore, it is possible to define three main pillars related to technological development as defined in Fig. 1

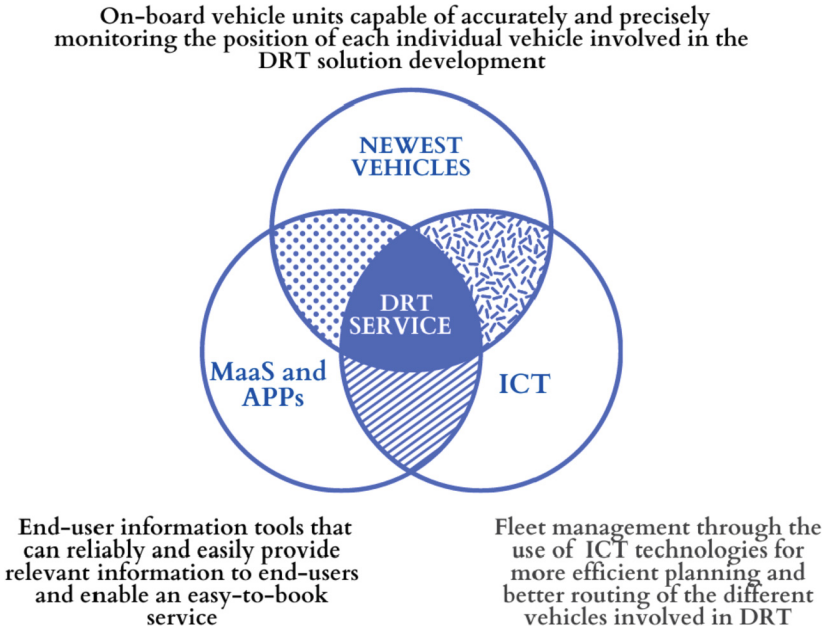

Fig. 1. Technology and DRT correlations

Several research have investigated the evolution of the main technologies that can be used in DRT, including those with fixed routes (Flexible-Route Segments, Request Stops) and those without fixed routes (Demand-Responsive Connector, Feeder Service, Zone Route, Point Deviation) [17–19]. The literature review shows that despite extensive international experience in implementing DRT in practice, there are no clear criteria for determining the conditions under which it is reasonable to introduce a particular flexible passenger service technology [20]. In the following paragraphs, the literature related to DRT diffusion is presented, followed by an introduction to the European projects that have promoted DRT diffusion since 2010, and finally, attention is drawn to the Italian

context, highlighting the benefits and criticalities of the current services diffused in the Italian context.

In particular the objective of this research work is related to the evaluation of the current state of the DRT service in Italy and the possibility of integrating this service as a complement to local public transport.

The research evaluated the European projects relating to the development of DRT services, subsequently focusing attention on the Italian national case.

The research is a first cognitive step of the state of affairs and of the project in Europe that provides ideas for the implementation and strengthening of these services for areas with low demand, i.e. peripheral or rural areas or even those areas in which, due to the pandemic, public transport services have been reduced or limited.

The first results of this research lay the foundations for the improvement of an integrated public transport service.

2 Literature Review

The idea of demand responsive transport (DRT) has developed since the 1970s [21]. Initially it was a call transport dedicated to specific user groups or specific areas. Among the first experiences there are replacement of regular services by shared taxis, application of "dial-a-ride systems based on telephone calls to report demand to local public transport providers" [22].

Other experiences have focused on on-call services for people with reduced mobility, "often community-based and provided by volunteers" [23]. However, the concept of demand responsive transport was formulated in the USA at the beginning of the 90s of the last century, as a solution to the rising disaffection of potential users, in particular during the night [24]. In fact, starting from the 1990s, the gradual introduction of increasingly efficient information and telecommunication technologies began, thanks to which services take on a greater level of automation and efficiency, which allows the optimization of routes and offer solutions that displaces between bus stops. The "stop-to-stop" modality spreads in opposition "of the "door-to-door": instead of picking-up and dropping users at the "doors of their houses" [25]. The DRT becomes an opportunity to offer public transport in areas with low demand and for special purpose services [26].

Thus, the implementation of innovative solutions has definitively changed the traditional concept of public transport. Several EU projects on DRT services in rural and peripheral areas and EU projects pilots have been carried out. Numerous and different solutions have been tested in Europe between 2012 and 2018, some of which, however, have already been completed as short-term pilot projects. Between these, the Kutsuplus, a service launched in 2012 in Helsinki and made operative from 2013 to 2015: a real-time demand responsive public service that uses shared 9-seater minibus, which uses a website and an app that can be used with normal smartphones. Various stops have been identified in the area identified and covered by the service, it is an on-demand micro-transit pilot [27]. Another pilot project was tested as part of the European project System for Advanced Management of Public transport Operations, SAMPO, financed within the 4th EC Program.

The objective is to improve the mobility of citizens, especially disabled and elderly people, in different rural and urban areas through integrated transport services responsive to demand. Pilot projects have been launched in several sites: urban, Florence and Campi Bisenzio (Italy) and Goteborg (Sweden); rural and peripherical area of Seinajoki and TuusulaKerva-Jarvenpaa (Finland) and the Kilkenny region (Ireland); rural, Hasselt (Belgium).

Several innovative systems are now well established in Europe. In several cities are launched bus DRT lines, that provides services for the urban and surrounding areas, both during the day and at night. The ViaVan, an on-demand transit system that takes multiple passengers heading in the same direction and books them into a shared vehicle, initially experienced in London, then in Amsterdam and Berlin, today spread around the world in more than 20 countries.

The on demand collective transport services have also spread to Italy. In 1991 a call system service was activated in Venice on a night-time line for the "Vignole" stop. The first experiments are "dial-a-ride" services booked by telephone dedicated to general users or specific user groups, like elderly or with reduced mobility people, tourists. Numerous services were launched in cities of various sizes and in different context, urban and peripheral areas and in areas with low demand, both as complementary and connection services with traditional transport services. Some services operate in extra-urban areas and offer interurban movements and connections between different cities in the same provincial region.

Other services allow to reach the interchange stops with public and rail transport. The most common are flexible transport service that use bus and mini-buses, with a schedule and a predefined route. Subsequently, thanks to technological innovations, DRT services were developed which include systems and software products for the planning and management of the service and GPS satellite systems for the location of vehicles or GIS information systems for the management of territorial information.

3 The Diffusion and Development of the European DRT Service

This paragraph illustrates the development of European projects related to the implementation and/or enhancement of DRT services in Europe in the last twenty years. After a brief analysis of the recently concluded or still active projects, attention was paid to the development of DRT services in Italy, paying particular attention to the post-pandemic period.

3.1 The Evolution of European and National Projects for DRT Deployment

Several European projects have been financed in recent years concerning the analysis of last-mile and collective and DRT mobility. Figure 2 shows the main projects and their aims.

Among the EU projects that have promoted the dissemination of DRT through the creation or promotion of certain services and the definition of test pilots, it is possible to mention the Regio-Mob project (https://projects2014-2020.interregeurope.eu/regio-mob/), which ran from 1 April 2016 to 31 March 2020.

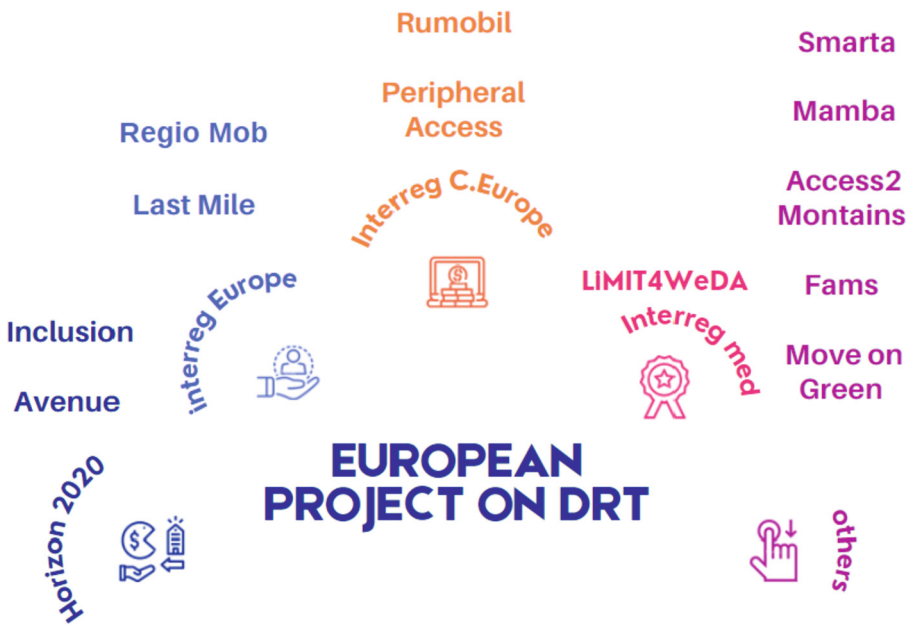

Fig. 2. European project of last 2 decades on sustainable mobility and DRT services

This project envisaged the promotion of an on-demand transport service for people with disabilities in the Ljubljana Urban Region, as well as the implementation of a Tele-bus service in the city of Krakow. The project also promoted the deployment of real-time bus passenger information systems in Edinburgh, Scotland and the application of test pilots for the analysis of light mobility for areas of weak demand (Lazio Region, Italy). In the same time frame and in particular from April 1, 2016 to September 30, 2020, the Interreg Europe project entitled LASTMILE (https://projects2014-2020.interregeurope.eu/lastmile/) on last mile mobility took place. It focused on the implementation and study of a train service with on-demand stops from Lleida to la Pobla (High Pyrenees) (Regional Government of Catalonia) and a Nightrider, a door-to-door night bus service on demand (Luxembourg). In September 2020, the Horizon 2020 project entitled INCLUSION (http://h2020-inclusion.eu/news-and-events/final-conference/) was completed, and participatory processes were disseminated for the definition of a new DRT service in rural areas of Florence, Italy, while DRT services were tested supporting public events in Barcelona and DRT services for families with young children in the Rhein-Sieg region of Germany.

During the period May 2011–April 2014 for 36 months the Access2Montain project defined in South East Europe (http://www.access2mountain.eu/en/project/default.html) focused on the integration of different flexible transport services in Alpine areas, Alpen region Gesäuse National Park in Austria. Previously, the MOVE on GRENN-Interreg IVC project (https://keep.eu/projects/5429/MOVE-ON-GREEN-EN/) which ran from 2012 to 2014 enabled the implementation of the DRT Virtual Transport Centre in Burgos Province (Spain) and the integration of RC and taxi services. This project allowed to

test a dedicated service for school children in Southern Burgenland, Austria and a DRT service in low density areas in the Regional Unit of Ioannina, Greece. On 1 May 2018, a 4-year project entitled AVENUE- H2020 (https://h2020-avenue.eu/summery/) started, which allowed to define a real-time monitoring system for DRT buses, Lyon; test an autonomous shuttle system, Luxembourg; extend an existing DRT service in Geneva and analyse DRT in Copenhagen. Even earlier, the MAMBA- Interreg Baltic Sea project (https://www.mambaproject.eu/), which ran from 2014 to 2020, allowed the study of rural route sharing and on-demand transport in the Bielsko-Biała area in Poland as well as the analysis of on-demand transport in Plön County, Germany, and also in Lithuania and Latvia. From March 2002 to 29 February 2004, the FAMS project (FP5-IST) was carried out, in which the Flexible Agency for Collective Demand Responsive Mobility Services in the Florence Metropolitan Area, Italy, and the Flexible Agency for Collective Demand Responsive Mobility Services in the Angus Region, UK, collaborated.

Particular attention was given to the project entitled DRT bad practice which focuses on the Innisfil city experiment where public transport was replaced by Uber [25]. From 2004 to 2007 the TWIST (Transport WIth a Social Target) project was carried out on a national and transnational scale (http://www.twistproject.org/EN/aspbite/categories/index.asp?tim=18:17:09). Through the partnership of the areas involved, the project envisaged the creation of an on-call transport system aimed at reducing the social and economic gap between mountain and rural areas and urban areas.

The regions that participated in the TWIST transnational project were respectively.

- Germany (city of Berlin and Brandenburg)
- Greece (Province of Ioannina)
- Italy (some cities in the regions of Abruzzo, Marche, Molise and Puglia)
- Czech Republic (the Ceske Budejovice region)
- Hungary (the PECS region)

The aforementioned areas were/are all characterized by a lack of services and infrastructures in mountain and rural areas. Starting from the analysis of the demand and supply of local public transport in the territories identified for the pilot projects, the TWIST project conducted local experiments of on-demand transport in order to develop a model for the organization and evaluation of transport to call transferable to all regions with similar characteristics of internal area and presence of weak demand. Finally, the PRIN2017 project entitled WEAKI TRANSIT is underway.

This project sees the creation of test pilots in some cities of Sicily and Sardinia and focuses on innovative shared mobility systems for areas with low demand. The goal is to study the feasibility, planning and design of demand responsive shared transport services (DRSTS), capable of providing “on demand” mobility in real time through fleets of vehicles shared by different passengers.

The project will adopt a holistic approach, studying the demand (i.e., passengers), supply (i.e., infrastructures, vehicles and technologies) and all external factors that can hinder or favour the diffusion of DRSTS, such as the regulatory framework and related constraints, and using advanced simulation tools to support the design of the service (https://sites.unica.it/weaki-transit/home/).

3.2 The Evolution of DRT in Italy

Launched in Italy in the late 1990s, on-call public transport services (in English: Demand Responsive Transport, DRT) consist of using a fleet of small public transport to allow for personalized transfers based on to the requests of the users with origin and destination chosen each time, managing the concatenation of the paths with a certain level of flexibility to be able to satisfy all requests.

The system has undoubted advantages, first of all the flexibility of timetables according to the movements, among which a not secondary aspect is represented by the rationalization of the transport lines, with the consequent reduction of trips. The benefits and criticalities of the services active in the Italian territory are briefly described below with reference to the characteristics of the services analysed up to December 2021.

The distribution of the service in the analysed context is described in Fig. 3

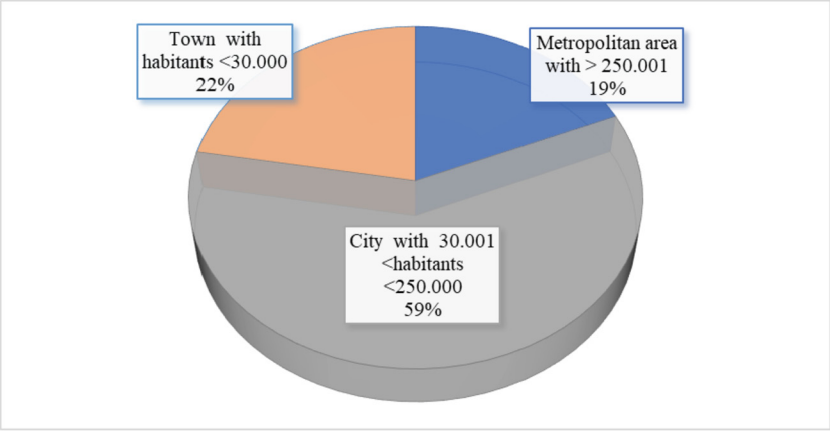

Fig. 3. DRT services distribution on Italy (2019–2021)

The regions that have benefited from pilot projects linked to national and international research projects are mainly: Abruzzo, Marche, Molise and Puglia through the TWIST project (https://www.interregeurope.eu/good-practices/the-drt-system-of-twist-transport-with-a-social-target) and Sicily and Sardinia through the WEAKI-TRANSIT project (https://www.unict.it/it/ricerca/progetti/weaki-transit). In Tuscany, on the other hand, it took place through the cooperation of the local administration with the transport service operators through the international project SAMPO (System for Advanced Monitoring of Public Transport Operations) (https://algowatt.com/en/portfolio-items/sampo/). As regards the services promoted by local administrations in synergy with the service managers, it is possible to compare three different situations corresponding respectively to a small city, a medium-large city and a metropolis, the benefits and criticalities produced are described below. To date from the DRT service. As regards the small city, the centre of Vimercate was analysed, which is located in Lombardy and is characterized by a population of about 26.200 inhabitants. Considering this context, the implementation of a DRT service took place in an experimental way from 9 to 17 from

February 2020 to July 2020 with a minivan and activation of a permanent service from September 2020 with two minivans. On 2021 a frequency of about 260 was reached/300 passengers a week, but the important fact is that they are all new users of the public service who previously had no alternative to the private vehicle. Service defined by users as fast, useful and efficient. The main benefits were:

- reduction in the use of private vehicles
- complementary service to public transport
- optimal function of the service
- simple control of stops and waiting
- simple travel reservation via the free app

Among the critical issues instead

- service not accessible to a woman with wheelchair/disabled
- bus forbidden to children (children up to 4 years in the lap of an adult instead of from 4 to 12 not access)
- it cannot be booked outside Vimercate area
- means easily recognizable by logo

As far as the medium-sized city is concerned, the city of Spoleto in Umbria has been selected, which has about 37 thousand inhabitants and is located in the center of Italy and the Call Bus service guarantees, from Monday to Saturday, for eight hours a day, possibility for the elderly over 65, for civil invalids, for the disabled with a companion and for people with reduced autonomy, an additional transport service (cemetery, pharmacy, relatives, visits, etc.). Each user has only one trip per week (round trip) to the municipalities of Spoleto, Giano, Castel Ritaldi and Campello. Among the benefits that emerged and noted by users it is possible to include:

- reduction in the use of private vehicles
- service for weak users
- booking through SUIC (citizen counter)
- partially free service

Among the critical issues instead

- service limited to certain segments of the population
- limited to 1 trip per week

Milan was selected as the metropolitan city in Northern Europe with over 1 million and 390 thousand inhabitants. The service called “Neighborhood Radiobus” has been active in the metropolis for some years, the public transport on call active every day from 10 pm to 2 am and which accompanies the user to the door of his home, at the cost of an urban ticket. (or subscription).

Starting from 4 March 2020, the "Neighborhood Radiobus" can also be booked through the ATM Milano app, which already has an average of 50,000 users per day in addition to the toll-free number. To use the service, all you need to do is have the ticket or pass that is regularly used on all ATM vehicles, or you can purchase the ticket from the app or on board at no extra charge. Two lines (Q55 and Q76) will also be activated in the coming months. In total, 15 districts of the city will be able to take advantage of this on-call service.

Among the benefits found among users, it is necessary to point out:

- reduction in the use of private vehicles
- public transport service increasingly easy to use, widespread and interconnected. In addition, the routes of some already existing Radiobus lines in the Neighborhood change with more stops and more rides.
- 15 evening and night lines for 15 different areas of Milan, increasing the offer of public transport and better connecting the individual districts within them and with the public transport network, in line with the expansion plan of the Municipality of Milan.
- booking via phone and/or Booking with customizable App ("Favorites" function will allow users to save their favourite stops, view them directly on the home page and then quickly start a booking). Using the App will allow you to reserve the Neighborhood Radiobus up to two days before the chosen date, or in real time.

  Southern Italy is lacking in services with experiences limited to the test pilots of some research projects spread from 2018 to today.

4 Discussion and Conclusions

The analysis of national case studies and transnational projects allows us to highlight that in recent years there has been a growing sensation according to which conventional public transport is inflexible and unreliable as well as a vehicle for contagion. Furthermore, the growing urban expansion has meant that in some cases conventional public transport has become impracticable.

Public authorities show a growing interest in on-demand transport as a means to address the inclusion of some specific target groups, but also to achieve modal shift.

Furthermore, DRT services contribute significantly to decongest the roads, allowing travellers to easily and simply reach the main fixed lines of public transport.

Through the multimodal approach to transport, on-call transport also affects the quality of the road network and all that derives from it (accidents, parking problems, delays due to traffic jams, etc. Furthermore, from the analysis of literature and of European and national projects it is possible to underline that:

- the DRT service is an excellent complementary solution to the public transport service even in the post-pandemic phase;
- the creation of digital platforms can contribute to the improvement of modal choices and the use of the DRT;

Among the critical issues that emerged the most it should be emphasized that:

- shared transport services with highly variable travel times may become unsuitable for serving as a connecting service to public transport centres in urban areas
- There is also a certain difficulty in modelling and optimizing the routing processes of these services.

Some of these complexities arise from the difficulty of predicting behavioural responses to delayed services or customer no-shows.

The on-call services in some cases behave like a taxi service at public transport prices. As a result, they can be perceived as unfair competitors from traditional taxi services. Despite the gradual extension of the scope of services in some countries, the idea has spread that it is only for the mobility of disabled people.

This hampers the inclusion of on-demand transport in the standard public transport offer. Very few EU projects and pilot projects concern the use of on-demand services for tourism. The dial-up system is usually not included in transportation planning applications. When on-call service is provided by public transport companies that are used to serving captive markets, there is usually not enough marketing experience to attract new customers. Online bookings could make on-call transport more convenient for the general public, but not for the "socially motivated" on-call service target audience (such as elderly people or people with mobility problems);

Some niches (such as airport shuttles) have already proven to be commercially viable. In Europe, there is the potential to use on-call transport in orbital journeys in suburban and peri-urban areas, while "traditional" public transport is used for radial journeys. The on-call system could expand into the delivery of goods (e.g., library books, prescriptions and postal/parcel) as an additional source of income.

The data obtained from the analysis of the national context show a greater diffusion of the service in the city compared to the contexts of small rural centres or villages or even subways.

This layout will probably be changed in the coming months following the recent pandemic and the need to reduce pivotal transport in areas that are not characterized by adequate public transport.

The literature review also suggests paying greater attention not only to passenger transport but to combined passenger / freight transport in order to integrate the two systems and at the same time enhance the trade of small local companies.

There may also be untapped potential untapped potential for transportation in the "night economy". Finally, the most important component of variable costs is the driver's wage costs (at least in programs that are not volunteer based). Probably with autonomous mobility, this problem could vanish and this will increase the potential of on-demand transport as a mode for high-capacity public transport.

The implementation of the public transport service is considered both by the service managers and by the local Authorities, as connected to a high strategic value for the changing contexts that are subjected to relevant socio-economic pressures, such as the aging of the population or the change in the quality of life in rural areas.

Finally DRT systems must be seen not only as a more environmentally friendly means of transport, but rather as a strategy for social inclusion and socio-economic development of local communities.

Acknowledgments. This work was partially supported by the MIUR (Ministry of Education, Universities, and Research [Italy]) through a project entitled WEAKI TRANSIT: WEAK-demand areas Innovative TRANsport Shared services for Italian Towns (Project code: 20174ARRHT/CUP Code: E44I17000050001), financed under the PRIN 2017 (Research Projects of National Relevance) program. We authorize the MIUR to reproduce and distribute reprints for governmental purposes, notwithstanding any copyright notations thereon. Any opinions, findings, and conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the MIUR.

References

1. Abdullah, M., Ali, N., Dias, C., Campisi, T., Javid, M.A.: Exploring the traveler's intentions to use public transport during the COVID-19 pandemic while complying with precautionary measures. Appl. Sci. **11**(8), 3630 (2021)
2. Campisi, T., Basbas, S., Al-Rashid, M.A., Tesoriere, G., Georgiadis, G.: A region-wide survey on emotional and psychological impacts of COVID-19 on public transport choices in Sicily, Italy. Trans. Transp. Sci. **2**, 1–10 (2021)
3. Campisi, T., Garau, C., Acampa, G., Maltinti, F., Canale, A., Coni, M.: Developing flexible mobility on-demand in the era of mobility as a service: an overview of the italian context before and after pandemic. In: Gervasi, O., et al. (eds.) ICCSA 2021. LNCS, vol. 12954, pp. 323–338. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-86979-3_24
4. Abdullah, M., Ali, N., Javid, M.A., Dias, C., Campisi, T.: Public transport versus solo travel mode choices during the COVID-19 pandemic: self-reported evidence from a developing country. Transp. Eng. **5**, 100078 (2021)
5. Campisi, T., Cocuzza, E., Ignaccolo, M., Inturri, G., Torrisi, V.: Exploring the factors that encourage the spread of EV-DRT into the sustainable urban mobility plans. In: Gervasi, O., et al. (eds.) ICCSA 2021. LNCS, vol. 12953, pp. 699–714. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-86976-2_48
6. Errington, A.: The Peri-urban fringe: Europe's forgotten rural areas. J. Rural. Stud. **10**(4), 367–375 (1994)
7. Garau, C., Annunziata, A.: A method for assessing the vitality potential of urban areas. The case study of the Metropolitan City of Cagliari, Italy. City Territory Archit. **9**, 7 (2022). https://doi.org/10.1186/s40410-022-00153-6, ISSN 2195-2701
8. Annunziata, A., Garau, C.: A literature review on the assessment of vitality and its theoretical framework. emerging perspectives for geodesign in the urban context. In: Gervasi, O., et al. (eds.) ICCSA 2021. LNCS, vol. 12958, pp. 305–322. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-87016-4_23
9. Logan, P.: Best practice demand-responsive transport (DRT) policy. Road Transp. Res. J. Aust. N. Z. Res. Pract. **16**(2), 50–59 (2007)
10. Sörensen, L., Bossert, A., Jokinen, J.P., Schlüter, J.: How much flexibility does rural public transport need?–Implications from a fully flexible DRT system. Transp. Policy **100**, 5–20 (2021)
11. Poltimäe, H., Rehema, M., Raun, J., Poom, A.: In search of sustainable and inclusive mobility solutions for rural areas. Eur. Transp. Res. Rev. **14**(1), 1–17 (2022)
12. Ryley, T.J., Stanley, P.A., Enoch, M.P., Zanni, A.M., Quddus, M.A.: Investigating the contribution of Demand Responsive Transport to a sustainable local public transport system. Res. Transp. Econ. **48**, 364–372 (2014)

13. Coutinho, F.M., van Oort, N., Christoforou, Z., Alonso-González, M.J., Cats, O., Hoogendoorn, S.: Impacts of replacing a fixed public transport line by a demand responsive transport system: case study of a rural area in Amsterdam. Res. Transp. Econ. **83**, 100910 (2020)
14. Brake, J., Nelson, J.D., Wright, S.: Demand responsive transport: towards the emergence of a new market segment. J. Transp. Geogr. **12**(4), 323–337 (2004)
15. Abdullah, M., Ali, N., Shah, S.A.H., Javid, M.A., Campisi, T.: Service quality assessment of app-based demand-responsive public transit services in Lahore, Pakistan. Appl. Sci. **11**(4), 1911 (2021)
16. Campisi, T., Canale, A., Ticali, D., Tesoriere, G.: Innovative solutions for sustainable mobility in areas of weak demand. Some factors influencing the implementation of the DRT system in Enna (Italy). In: AIP Conference Proceedings, vol. 2343(1), p. 090005. AIP Publishing LLC, March 2021
17. Huang, A., Dou, Z., Qi, L., Wang, L.: Flexible route optimization for demand-responsive public transit service. J. Transp. Eng. Part A Syst. **146**(12), 04020132 (2020)
18. Calabrò, G., Le Pira, M., Giuffrida, N., Inturri, G., Ignaccolo, M., Correia, G.H.D.A.: Fixed-route vs. demand-responsive transport feeder services: an exploratory study using an agent-based model. J. Adv. Transp. **2022**, 8382754 (2022)
19. Huang, D., Tong, W., Wang, L., Yang, X.: An analytical model for the many-to-one demand responsive transit systems. Sustainability **12**(1), 298 (2019)
20. Gorev, A., Popova, O., Solodkij, A.: Demand-responsive transit systems in areas with low transport demand of "smart city." Transp. Res. Procedia **50**, 160–166 (2020)
21. Pettersson, F.: An international review of experiences from on-demand public transport services. Working Paper (2019)
22. Sörensen, L., Bossert, A., Jokinen, J., Schlüter, J.: How much lexibility does rural public transport need? Implications from a fully flexible DRT system. Transp. Policy **100**, 5–20 (2021). ISSN 0967-070X, https://doi.org/10.1016/j.tranpol.2020.09.005
23. Bellini, C., Dellepiane, G., Quaglierini, C.: The demand responsive transport services: Italian approach. In: Transactions on the Built Environment, vol. 64. WIT Press (2003). ISSN 1743-3509
24. Mariz Coutinho F., van Oort, N., Christoforou, Z., Alonso-Gonz´alez, M., Cats, O., Hoogendoorn, S.: Impacts of replacing a fixed public transport line by a demand responsive transport system: case study of a rural area in Amsterdam. Res. Transp. Econ. **83**, 100910 (2020)
25. Mulley, C., Nelson, J., Teal, R., Wright, S., Daniels, R.: Barriers to implementing flexible transport services: an international comparison of the experiences in Australia, Europe and USA. Res. Trans. Bus. Manag. **3**, 3–11 (2012)
26. Haglund, N., Mladenović, M., Kujala, R., Weckström, C., Saramäki, J.: Where did Kutsuplus drive us? Ex post evaluation of on-demand micro-transit pilot in the Helsinki capital region. Res. Transp. Bus. Manag. **32**, 100390 (2019). ISSN 2210–5395, https://doi.org/10.1016/j.rtbm.2019.100390
27. Weigl, D., Sperling, J., Henao, A., Duvall, A., Young, S.: Sustainability, Scalability and Resiliency of the Town of Innisfil Mobility-on-Demand Experiment: Preliminary Results, Analyses, and Lessons Learned (No. NREL/CP-5400–80754). National Renewable Energy Lab. (NREL), Golden, CO (United States) (2022)