ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2024) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

AIIT 4th International Conference on Transport Infrastructure and Systems (TIS ROMA 2024), 19th - 20th September 2024, Rome Italy

Transforming travel experience in low density areas: evidence from a DRT pilot study and simulation model

Gabriele D'Orso[a], Vincenza Torrisi[b,]*, Pierfrancesco Leonardi[c], Marco Migliore[a], Matteo Ignaccolo[c], Riccardo D'Angelo[d]

[a]*Department of Engineering, University of Palermo, Viale delle Scienze, Building 8, Palermo 90128, Italy*
[b] *Department of Electric, Electronic and Computer Engineering, University of Catania, Catania, Italy*
[c]*Department of Civil Engineering and Architecture, University of Catania, Catania, Italy*
[d]*Edisonweb s.r.l., Via Ignazio Silone 21, Mirabella Imbaccari 95040, Italy*

Abstract

In low density areas, due to limited economic resources, public transport (PT) companies usually operate services with low frequency, poor accessibility and reliability and high waiting times at stops. Several studies highlighted that introducing Demand Responsive Transport Services (DRTs) can improve PT performance in these areas. In Italy, several DRTs have been launched, characterized by flexible schedules with different operational configurations: fixed route, with and without detours and flexible route. Considering the importance of sharing lessons from pilots, the paper presents a DRT pilot study, conducted in Palermo (Italy) within the WEAKI TRANSIT project, identifying strategies for planning and designing on-demand shared systems. The pilot was conducted in a suburban area in the north of Palermo, covering about 10.5 km^2 with the neighbourhoods of Partanna Mondello and Tommaso Natale. This area is poorly served by PT companies with low-frequency and low-reliability bus lines, thus a stop-based DRT service with two fixed routes and detours was hypothesized. The pilot was conducted during November and December 2022, with four cars, operating from 3 to 7 p.m., except Sunday. The service, free of charge, was addressed to students and teaching staff by University of Palermo. Through SP surveys, simulation model and pilot, we evaluate operational performance of the services (i.e. travel distance, waiting and in-vehicle times). We found the introduction of DRTs lead to increasing accessibility to main transit hubs and facilities, and a decrease in waiting times at stops and travel times. Nevertheless, considerations about financial feasibility and legal framework are highlighted.

Peer-review under responsibility of the scientific committee of the Transport Infrastructure and Systems (TIS ROMA 2024)

Keywords: on-demand transport system; low-density areas; macro-simulation; fixed routes and flexible schedule;

* Corresponding author
E-mail address: vincenza.torrisi@unict.it

2352-1465
Peer-review under responsibility of the scientific committee of the Transport Infrastructure and Systems (TIS ROMA 2024)

1. Introduction

In the last decades, a wide range of transport services that are not conventionally scheduled or do not follow fixed routes have grown in popularity, being launched in many countries worldwide to overcome the shortcomings of conventional bus services. Demand Responsive Transport (DRT) services provide on-demand transport options to passengers, picking them up and dropping them off in accordance with their needs without a fixed schedule and using a fleet of smaller vehicles (Mageean and Nelson, 2003). The SAE taxonomy called DRT service as microtransit defining it as "a privately operated, technology-enabled transit service that typically uses multi-passenger/pooled shuttles or vans to provide on-demand or fixed-schedule services with either dynamic or fixed routing" (SAE, 2021). Therefore, microtransit is a mobility option between conventional public transport and taxis, incorporating flexible routing and scheduling and is often run by publicly funded transit agencies. It is particularly suited to cater for mobility needs in low-density areas (e.g. sparsely populated regions, suburban and rural areas) and when demand is low (e.g. nighttime or off-peak hours), mitigating transport poverty and reducing car dependency. In many cases, DRT services act as first/last mile services feeding into the conventional public transport network and complementing existing mobility offerings (Mayaud et al., 2021). From this perspective, microtransit can alleviate access inequality for vulnerable social groups, creating travel opportunities that are less spatially concentrated than those provided by fixed-route public transit (Liezenga et al., 2024).

Flexibility is the core of all DRT services, which may range from semi-flexible services with pre-defined physical or virtual stops and flexible schedules, to door-to-door solutions with on-demand schedules and dynamic routing. Moreover, hybrid services operate like conventional public transport services with fixed routes and schedules during peak hours, but schedules and routes become flexible during off-peak hours. According to the number of origins and destinations served, there are many-to-one, many-to-few, and many-to-many services.

Microtransit projects could be more convenient to launch than fixed-route lines, especially in low-density areas with scarce transport options and poor public transport services. Indeed, replacing fixed public transport lines with a DRT system in rural areas could lead to a reduction in operational costs and greenhouse gas emissions per passenger (Coutinho et al., 2020). However, many challenges need to be addressed since DRT systems are very failure prone due to high costs, especially for many-to-many services and in the urban context (Currie and Fournier, 2020), and significant budget cuts to public transport subsidies. Microtransit can be better planned for resilience if lessons from DRT pilots are shared and discussed. For these reasons, the project WEAKI TRANSIT (WEAK-demand areas Innovative TRANsport Shared services for Italian Towns) was funded by the Italian Ministry of Education, Universities and Research in 2017. Four research units belonging to the Universities of Cagliari, Catania, Enna, and Palermo, have been involved in the project, aiming to identify strategies for planning and designing on-demand shared transport systems in low-density areas also through the implementation of pilots, providing a legal framework (Torrisi et al., 2023) and analysing the criticalities and the potential of these services.

In this perspective, within the framework of the project, several DRT pilots have been launched, considering different operational configurations and application contexts. The first pilot was launched in Sardinia, connecting the railway station in Iglesias to the tourist spot of Porto Flavia through on-demand buses. The piloted service was an on-demand shuttle service with a fixed route between two locations. Targeting a specific group of users such as tourists, this pilot highlighted that on-demand services can be used to increase access to tourist spots that are not accessible enough by conventional public transport services. A second pilot was launched in Catania, launching a service called CTMover. This service was implemented in the industrial district of Catania with a fixed route and possible detours that are traveled only if there are trip requests made by users through a mobile app. This service is currently only for workers in the industrial zone, and the fare is paid through employer-paid transit subsidies. The third pilot was launched in Palermo, creating a new reliable transport option and a feeder to high-quality transport services for people living in a suburban area.

In this paper, we focus on the pilot implemented in Palermo, analyzing the performance of the service through simulation models with varying operational parameters. The interest in this case study is multiple: firstly, the research goes beyond the traditional field of application of DRT services, i.e. rural areas, exploring their potential in suburban areas, not far from the city centre; secondly, it investigates the potential of microtransit as complementary to conventional public transport services, having the aim of improving the mobility offered in the area and better addressing passengers' needs. This additional role of DRT as a feeder system to conventional public transport and as a first-last mile solution is in line with the Mobility-as-a-Service (MaaS) paradigm and could be important to build more attractive and innovative models intended for those user groups who are usually not public transport users (Alonso-González et al., 2020). Moreover, the usage of DRT as the first or last leg in longer fixed-route public transport journeys may result in large accessibility improvements for users, especially for some underserved origin–destination pairs (Alonso-González et al., 2018). Thus, a feeder DRT service may be an opportunity to attract users of individual transport, as it offers a better level of service than buses, at a competitive cost (Coutinho Costa et al., 2021). The remainder of the paper is organized as follows. Section 2 presents the pilot study in Palermo, describing the design process, the simulations performed to evaluate the possible performance according to different scenarios and the small-scale pilot of the service to test the microtransit routes. The results of the simulations are discussed in Section 3. Concluding remarks are drawn in Section 4.

2. The pilot study in Palermo

2.1. Study Area

Covering about 10.5 km^2, the study area encompasses the suburban neighborhoods of Tommaso Natale and Partanna Mondello, and the small seaside villages of Mondello and Addaura, located in the northern part of the city. This area is mostly residential and characterized by a discontinuous urban fabric, made of small agricultural parcels, scattered houses and street-along villages (ribbon development). Few traffic attractors are present in the study area: a shopping mall in the southern part, some sports centers in the central part, and restaurants and beaches along the coast. This study area is not a transport desert, with some public transport services connecting it to the city's other parts. However, having low frequency and low reliability, these services force residents to use their private vehicles for their trips and lead non-car owners to an increasing risk of social exclusion. Therefore, these neighborhoods are very car-dependent. Stopping at Tommaso Natale station, a low-frequency railway service connects the study area with the city center with 1 train per hour. There are also 7 bus lines, operated by the municipal transportation company AMAT S.p.A, having low frequency and low reliability; thus, users often face high waiting times at desolate bus stops. This is a problematic issue especially for older people, women, and minority groups, experiencing a sense of insecurity, especially in the evening or on winter afternoons. It's not surprising that only 9% of the residents in the study area use public transport (Capodici et al., 2022), having the bus service as single transport option, if non-car owners.

2.2. Design of the microtransit network and demand estimation

We wanted to implement a hybrid service: during peak hours it should operate like a conventional public transport service with fixed routes and schedules, but during off-peak hours schedules and routes become on-demand. Therefore, this microtransit service should be made up of some fixed routes along which minibuses run following a specific sequence of stops to pass through, and some detours along which vehicles run only if a trip request involving an optional stop as origin or destination occurs. Depot areas should be identified since vehicles travel during off-peak hours only if trip requests were made by users, without having a fixed schedule; therefore, these areas are the ones where vehicles return when they drop all the passengers off, waiting for new trip requests. Since we wanted to implement a pilot, the design of the microtransit network was made considering the travel demand and some constraints due to the use of a specific mobile application for routing and service operation. We used a mobile application for the operation of microtransit services having stops, fixed routes and detours.

Dividing the study area into Traffic Analysis Zones (TAZ), after the administration of a Stated Prenference (SP) survey in November 2021, we calculated the choice probability for microtransit and estimated the daily O/D matrix for non-commuting trips made by microtransit. The SP survey was addressed to the population living in the study area through face-to-face interviews conducted during off-peak hours randomly stopping respondents near the main points of interest (POIs). We asked each respondent to perform a total of four discrete choice exercises considering scenarios in which the DRT service operates during off-peak hours in the study area, serving the main POIs and operating as feeder to Tommaso Natale railway station. Scenarios were constructed developing full factorial designs. Respondents could choose between private car, motorcycle, walking, and microtransit as travel option. The attributes associated with the different modes of transport, e.g. costs, waiting time, walking time, and in-vehicle time varied in the discrete choice experiments, having a lower and an upper level. For example, we considered 5 and 10 minutes as levels for the waiting time associated with the DRT service. The SP survey allows for assessing the propensity to use the microtransit service and developing a four-step demand model calibrated for the study area, estimating the daily O/D matrix. More details about the results of the survey can be found in Capodici et al. (2024).

The daily O/D matrix for non-commuting trips made by microtransit was assigned to the road network to identify the desire lines of the users between each O/D pair. An "All or Nothing" (AoN) assignment based on the Dijkstra algorithm was performed, assessing the passenger flows per direction for each link. Most of the passenger flow is assigned to the two main roads of the study area (Viale dell'Olimpo and Via Partanna Mondello), having in some road segments about 800 daily passengers per direction. To identify the potential microtransit routes we considered slope, road surface degradation, road type and width as spatial constraints since we wanted the minibuses to have enough space to circulate and stop safely, without excessively impeding the traffic flows. Two fixed routes, named A and B, have been planned along Viale dell'Olimpo, Via Partanna Mondello, Via Tommaso Natale and Via Mattei (see Fig. 1a and Fig. 1b). These two routes cross the study area clockwise (route A) and anticlockwise (route B). This choice has been made to allow users to reach the desired destination without having to make a complete round, reducing waiting times at stops and in-vehicle time. Both fixed routes are about 11 km long and the travel time is 33 minutes for route A and 34 minutes for route B, considering a commercial speed of 20 km/h. Some circular detours have been added to reach some areas with points of interest that fixed routes do not cover. As shown in Fig. 1, 8 detours are associated with each fixed route. The detours were defined considering the extra time that passengers already on board must eventually spend due to a detour request, limiting it and guaranteeing the reliability of the service. For each detour, inversion nodes were identified to avoid vehicles driving the whole detour and reduce the detour time. The stops were identified starting from the existing bus stops, located in safe places and along roads having sufficient width for stopping without hindering the traffic flows. We added some stops in locations without bus stops to improve accessibility and the coverage of the area by the service. A technical constraint was added to meet a condition required by the mobile application: stops belonging to the same line should be at least 200 meters apart to allow the GPS-based mobile application to distinguish each stop from the other during navigation. Thus, some bus stops included in the set of possible microtransit stops were removed.

Once the passenger flows on each link was obtained, the next step was to quantify the number of vehicles needed to satisfy the demand. For the fleet sizing, the road section characterized by the highest number of passengers, located in Via Partanna Mondello, was taken into consideration. On this road, we predicted 115 passengers per hour in one direction and 114 passengers per hour in the other. Considering the probability of receiving requests from stops located on detours and the addition of an extra time to meet these requests, an average turnaround time of 50 minutes was hypothesized. This led to a fleet of ten 22-seater minibuses to meet the demand.

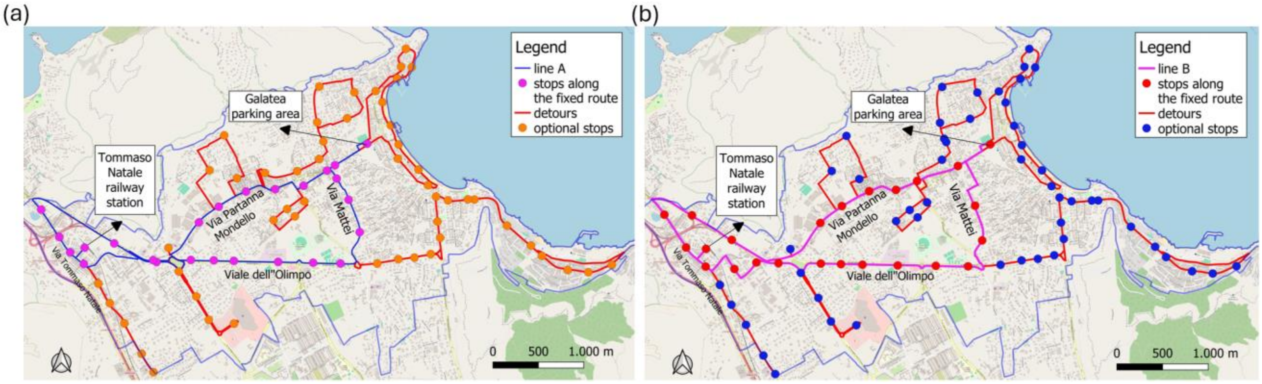

Fig. 1. (a) The Line A and detours; (b) The Line B and detours.

2.3. The simulation model

The microtransit network (i.e. routes with detours and stops) was used as input data to develop a simulation model and assess the service performance. Considering the demand estimated through the SP survey, the simulation allows us to understand if the users could experience good performance in terms of average travel time, waiting time and walking time, using 10 minibuses to perform the service. First, the road and pedestrian networks were imported from OpenStreetMap within the macrosimulation tool VISUM, identifying all the links enabled to the microtransit circulation characterized by the two fixed routes (i.e. lines A and B) and detours. We also represented stops as Pick-Up and Drop-Off (PUDO) nodes, where users can get on and off the minibus. Specifically, we used the DRT module of VISUM, allowing us to simulate this on-demand service without scheduling. The simulated service is slightly more flexible than the one implemented in the pilot, since at U-turns if there is a trip request, the vehicle can turn back to pick up the passenger, switching from line A to line B and vice versa.

The simulation process consists of two steps: (i) the generation of trip requests and (ii) the dispatch. A vehicle dispatcher needs information on the departure time of requested trips to schedule them. However, the O/D matrix only contains information on the number of trips between the TAZs during a specific period, e.g. the operating hours in the morning. Moreover, the trips originate in and are destined for locations other than the TAZ centroids. Thus, in the first step (i), the microtransit demand represented by the O/D matrix is disaggregated to individual trip requests using a departure time profile, moving from a zone-based model to a node and time-based one. The trips generated from a TAZ *i* and attracted to another TAZ *j* are converted into trip requests made by the users at given times having nodes of the pedestrian network within zone *i* as origins and nodes within zone *j* as destinations. The result of the first step is the generation of a list of trip requests that the fleet must attempt to respond to during the service operating hours.

The second step (ii) of the simulation process is the dispatcher which involves the matching of the trip requests to the vehicles performing a service with flexible, non-scheduled routes. The dispatcher assigns a trip request to the closest vehicle, considering the constraints imposed on the following input parameters: the *maximum waiting time*, the *maximum detour time*, the *maximum detour factor*, and the *always accepted detour time*. The *maximum waiting time* is the time beyond which the user is no longer willing to travel by microtransit. The *detour time* is defined as the additional time over the ideal travel time (i.e. shortest path without detours due to sharing) a user can experience due to the detour to satisfy additional trip requests. Thus, the *maximum detour time* is the maximum extra time that users accept in addition to their ideal travel time. The *detour factor* is the ratio between the travel time including the detour time and the ideal travel time. It represents how many times the travel time is greater than the shortest path time. Therefore, the *maximum detour factor* is the value beyond which a vehicle can't satisfy the trip request since it would make the user's travel time too long. Finally, the *always accepted detour time* is the minimum value of detour time always accepted by users in addition to their ideal travel time.

The procedure of dispatch is basically based on the following rules: for a new trip request, if the detour time of users already on-board is less than the always accepted detour time, the vehicle satisfies the trip request. If the detour time is between the always accepted detour time and the maximum detour time, the vehicle satisfies the trip request only if the detour factor is less than the maximum detour factor; otherwise, firstly the algorithm checks whether one of the other active vehicles could satisfy the trip request and, if not, whether one of the inactive vehicles could do it. Finally, if the detour time is greater than the maximum detour time for all the active vehicles, the trip request can't be satisfied and the algorithm searches for inactive vehicles that could do it.

2.4. The pilot implementation

A pilot study was carried out during twelve days between November and December 2022 using the MVMANT app developed by the startup Edisonweb s.r.l. and testing the microtransit routes. Students and staff of the University of Palermo were involved in the test as users and their trip requests have been satisfied by a fleet consisting of 4 vehicles. Two vehicles were assigned to Line A and its detours and two to Line B and its detours. The service was active every day, except Sunday, from 3 to 7 p.m. and was free of charge. Two depots were identified in front of Tommaso Natale railway station and in the parking area Galatea.

The users could book rides in real time using a mobile application, selecting the desired pick-up and drop-off points among the available stops. The application could show several options with different waiting times and in-vehicle times. Once the desired ride was selected, a virtual ticket with a QR code could appear, and a vehicle could be assigned to satisfy the trip request. The virtual ticket could allow the driver to check in and check out passengers, framing the QR code with the driver app. Being also a navigation app, the driver application enables dynamic routing, showing on a map the route the vehicle must take to reach a user's requested pick-up or drop-off points and the stops to pass through before reaching them. Once trip requests were met, the vehicles could return to the nearest depot to await further trip requests. 94 trip requests were satisfied by the service, while 41 rides were done by the fleet grouping the requests. All the trip requests were made by single users. A single trip request was satisfied in 17 out 41 rides, while the maximum number of trip requests grouped into a single ride was 6. Mostly, users sharing the ride inside the vehicle at the same time were two; however, the maximum number of users inside the vehicle at the same time was 4. Caduti sul Lavoro and Partanna Mondello Dionisio, located along fixed lines, and Tommaso Natale Socrate, located along a detour, were the most requested pick-up points (7 trip requests); Parcheggio Galatea and Stazione Tommaso Natale, both located along fixed lines and allowing the former to connect with a high-frequency bus line and the latter with the railway line, were the most requested drop-off points (30 trip requests).

Through the pilot study the waiting time and the in-vehicle time that users may experience were assessed. Indeed, for each trip request, we recorded the booking time, the vehicle departure time from the pick-up stop and the arrival time at the drop-off stop, considering the time spent picking up and dropping off passengers.

Considering all the trip requests, the waiting time experienced by users varied from a minimum of 1 minute to a maximum of 31 minutes, with an average waiting time of 10 minutes. The in-vehicle time experienced by users varied from 1 minute to 28 minutes, with an average in-vehicle time of 11 minutes. In 34% (32 out of 90) of the rides, users experienced a waiting time within the range 6-10 minutes, while in 36% (34 out of 90) of the rides, they experienced an in-vehicle time within the range 6-10 minutes.

3. Scenario Analysis and Discussion

The simulation model was applied for the implementation of five scenarios, summarized in Table 1. For all scenarios, the number of vehicles for the DRT service was fixed at 10 minibuses with 22 seats, except in Scenario 2d in which we considered minivans with 8 seats. Variations between scenarios were imposed in terms of service performance by varying the following parameters: Maximum Detour Factor, Maximum Detour Time and Always Accepted Detour Time already defined in section 2.3, conferring an important variability to the simulated scenarios as they influence the acceptance interval of Detour Time. For instance, in Scenario 1 there is a variation in detour time between 25 and 30 minutes and a variation between 25 and 15 minutes in Scenario 2d, whereas there is an intermediate variation between 25 and 20 minutes in Scenario 2b. This improves the performance of the service, which is better in the case of Scenario 2c. Therefore, Scenario 2d is evaluated under equal conditions with respect to Scenario 2c to assess whether performance remained the same by using minivans to deliver the service rather than minibuses. In addition, the following parameters were taken into account in configuring the scenarios: the Maximum Waiting Time at the pick-up stop is set at 15 minutes for all scenarios; while the Maximum Walking Time from the origin to the pick-up stop and from the drop-off stop to the destination decreases from 30 minutes for Scenario 1 to 20 minutes for the others, thus always considering improved performance between the first scenario and the following ones. The number of travel requests made in five hours of service was set for all scenarios to 1785 requests, derived from the reconstruction of microtransit demand by performing SP surveys in the study area (Capodici et al., 2022). Also, no differences were made between the scenarios in terms of maximum waiting time, fixing this parameter at 15 minutes.

Table 1. Setting parameters for the scenario analysis.

Input parameters	Scenario 1	Scenario 2a	Scenario 2b	Scenario 2c	Scenario 2d
Number of vehicles	10	10	10	10	10
Seats	22	22	22	22	8
Max detour factor	5	5	3	3	3
Max detour time	30	30	25	25	25
Always accepted detour time	25	25	20	15	15
Maximum waiting time	15	15	15	15	15
Maximum walking time	30	20	20	20	20
Total trip request	1785	1785	1785	1785	1785

Scenario 1 is characterized by the assumption that users are willing to accept a higher maximum walking time than in the other scenario (i.e. 30 minutes). In this case, walking longer distance to reach the pick-up stop or the destination from the drop-off stop allows to satisfy a higher number of trip requests, almost all of them (Fig. 2a).

Scenario 1 is also characterized by "poorer" service operating parameters, as the accepted detour times can be greater compared to the other simulated scenarios. This causes users to share rides more frequently, resulting in an average vehicle occupancy of 7 passengers per vehicle and a maximum number of passengers at one time equal to the seating capacity (i.e. 22 seats), as shown in Fig. 2b.

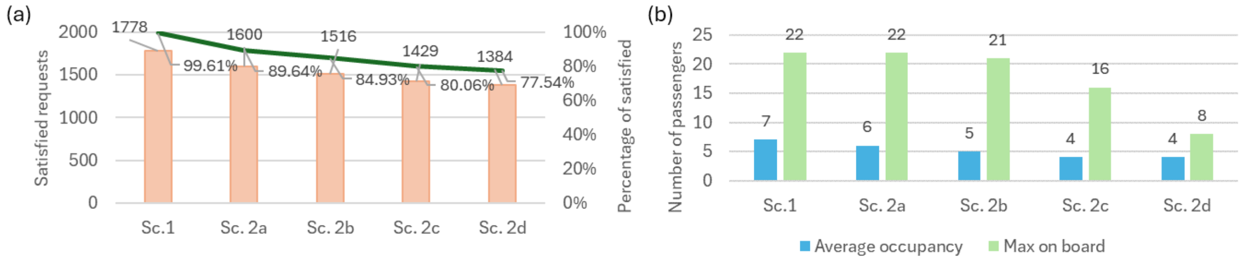

Fig. 2. (a) Number of satisfied requests; (b) Average occupancy and maximum number of passengers at one time

Scenario 2a differed from Scenario 1 only by reducing the maximum walking time to 20 minutes. In this case, there is a 10% reduction in the number of satisfied trip requests, which is still quite close to the total number of trip requests, and a reduction in average occupancy of only one unit (i.e. from 7 to 6 passengers). However, by reducing the average walking distance to reach the DRT stop (i.e. just 200 meters from Scenario 1 to Scenario 2a, as shown in Fig. 4b), this implies a slight increase in average waiting times at the stop (see Fig. 3a). This aspect turns out to be quite relevant, since increasing the waiting time by a few minutes reduces the walking distance in the context of the examined study area in which walkability related to road infrastructure is critical. Thus, the propensity to walk greatly influences the performance of the service and it is also influenced by the quality of the pedestrian infrastructures. In Scenario 2b, Scenario 2c and Scenario 2d, a reduction in detour times is assumed to simulate a better-performing service. In these cases, the possibility of sharing the vehicle may be reduced due to possible detours with higher detour times. However, the percentage of satisfied requests does not decrease much, remaining always above 80% (see Fig. 2a). In Scenario 2c, the service is further improved by reducing the always-accepted detour time, which decreases waiting times but not walking distances. Finally, since the average vehicle occupancy is quite low, it has been decided to consider the use of vehicles with 8 seats in Scenario 2d. The percentage of satisfied requests is reduced a bit more to approximately 77% (see Fig. 2a). Providing the service with 10 buses results in an average walking distance of around 900 m (see Fig. 3b). However, an increase in the number of buses would not be justifiable as they already travel with an average occupancy of a third of their capacity.

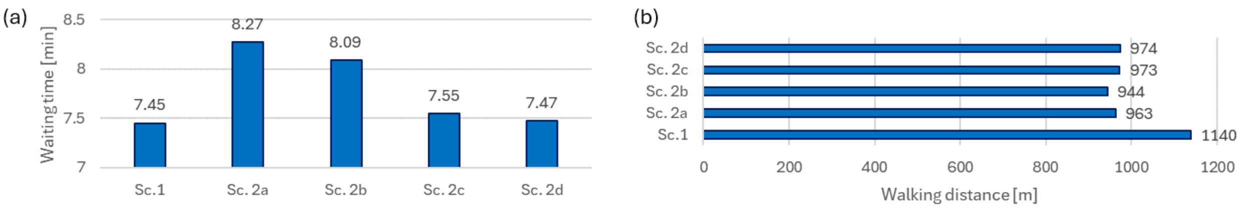

Fig. 3. (a) Average waiting time: (b) Average walking distance

4. Conclusions

DRT services are often reliant on public subsidies and concerns may arise for local authorities about their high failure rates. Thus, understanding the fields for developing successful microtransit services is urgent and implementing pilots could be useful to identify the best practices in designing them. Moreover, the DRT value should be considered from a wider lens: it is important to measure its benefits in terms of improving access to education, healthcare, and job opportunities, for people who previously did not have access. Hidden benefits of public transport (not only time and cost for the user) such as the value of access or the value of not having to own a car, should be considered and internalized in cost-benefit analysis. In this regard, the WEAKI-TRANSIT project aimed to explore DRT systems as transport options serving areas where currently no PT option exists, replacing existing services that do not align with people's travel needs or feeding high-frequency conventional public transport services as first/last-mile solutions. The paper presented a DRT pilot to show how the WEAKITRANSIT project was useful in starting to evaluate how these on-demand services can improve the travel experience of public transport users in low-density areas within the Italian context. The results of a SP survey campaign conducted in a suburban area in Palermo show that a significant demand for a hybrid microtransit service could exist. Thus, the analysis of performed simulations and a small-scale implementation of the pilot resulted in important considerations: an on-demand service with a fleet of ten 22-seater minibuses can satisfy most of the trip requests with good performances; it improves the experience of public transport users, reducing waiting times at stops and connecting people with high-frequency public transport services to make travels beyond the study area; the service covers well the study area, allowing people to walk less than 500 meters to reach the pick-up stop from their origin and also to reach the destination from the drop-off stop. Moreover, considering the existing bus service, it has good coverage: 65% of inhabitants live within a 5-minute walk from a bus stop and 93% within a 10-minute walk. Considering the fixed routes and the detours of Line A, 55% of the inhabitants live within a 5-minute walk of a PUDO (300 m), and almost 92% within a 10-minute walk (600 m). Considering Line B, the number of inhabitants living within a 5- and 10-minute walk are 60% and 93%, respectively. Thus, on the one hand, the DRT service has almost the same coverage as the bus service, on the other users can experience reduced waiting times. Indeed, the bus service has waiting times that can reach up to 20 minutes, while the waiting time may be less than 10 minutes for the DRT service.

Future research will focus on the financial feasibility of these services, although the replacement of under-used bus lines with on-demand minibuses appears to be economically feasible if the same subsidies currently allocated to buses are used for providing the service. Further considerations about the legal framework will also be addressed so that these temporary pilot implementations can become permanent.

Acknowledgements

This research was funded by the European Union—FESR or FSE, National Operational Programme (NOP) on Research and Innovation 2014-2020—DM 1062/2021. The work of Vincenza Torrisi is funded by the European Union (Next-Generation EU), through the MUR-PNRR project SAMOTHRACE (ECS00000022).

References

Alonso-González, M. J., Liu, T., Cats, O., Van Oort, N., Hoogendoorn, S., 2018. The Potential of Demand-Responsive Transport as a Complement to Public Transport: An Assessment Framework and an Empirical Evaluation. Transportation Research Record 2672:8, 879-889.

Alonso-González, M. J., Hoogendoorn-Lanser, S., van Oort, N., Cats, O., Hoogendoorn, S., 2020. Drivers and barriers in adopting Mobility as a Service (MaaS) – A latent class cluster analysis of attitudes, Transportation Research Part A: Policy and Practice 132, 378-401.

Capodici, A. E., D'Angelo, R., D'Orso, G., Migliore, M., 2022. Demand Responsive Transport Services for Improving the Public Transport in Suburban Areas. 2022 IEEE International Conference on Environment and Electrical Engineering and 2022 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe), Prague, Czech Republic, 1-6, https://doi.org/10.1109/EEEIC/ICPSEurope54979.2022.9854727.

Capodici, A. E., D'Orso, G., Migliore, M., Vittorietti, M., 2024. A stated preference survey to forecast microtransit choice in suburban areas with low public transport ridership. accepted for publication on 02 August 2024, Journal of Urban Planning and Development doi:10.1061/JUPDDM/UPENG-5100.

Coutinho, F. M., van Oort, N., Christoforou, Z., Alonso-González, M. J., Cats, O., Hoogendoorn, S., 2020. 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.

Coutinho Costa, P., Cunha, C. B., Oliveira Arbex, R., 2021. A simulation-optimization model for analyzing a demand responsive transit system for last-mile transportation: A case study in São Paulo, Brazil. Case Stud. Transp. Policy 9 (4), 1707-1714.

Currie, G., Fournier, N., 2020. Why most DRT/Micro-Transits fail – What the survivors tell us about progress. Research in Transportation Economics 83, 100895, https://doi.org/10.1016/j.retrec.2020.100895.

Mageean, J., Nelson, J. D., 2003. The evaluation of demand responsive transport services in Europe. J. Transp. Geogr 11 (4), 255-270.

Mayaud, J., Ward, F., Andrews, J., 2021. Microtransit Has the Potential to Flip Transit on Its Head. Transportation Research Record 2675(11), 77-88. https://doi.org/10.1177/03611981211014523

SAE International. 2021. "JA3163 – Taxonomy of On-Demand and Shared Mobility: Ground, Aviation and Marine".

Liezenga, A.M., Verma, T., Mayaud, J.R., Aydin, N.Y., van Wee, B., 2024. The first mile towards access equity: Is on-demand microtransit a valuable addition to the transportation mix in suburban communities? Transportation Research Interdisciplinary Perspectives 24, 101071,

Torrisi, V., Campolo, R., Barbagallo, A., Leonardi, P., Ignaccolo, M., Longo, A., 2023. Multi-level Perspective Within the regulatory Framework of Shared Mobility: A Case Studies Analysis of Italian Demand Responsive Shared Transport Services (DRSTs). In: Gervasi, O., et al. Computational Science and Its Applications – ICCSA 2023 Workshops. ICCSA 2023. Lecture Notes in Computer Science, vol 14109. Springer, Cham. https://doi.org/10.1007/978-3-031-37120-2_36.ages.