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Design, implementation and monitoring of a Demand Responsive Transport service for student leisure transfers: The case study of University of Trieste

Caterina Caramuta *, Alessia Grosso, Giovanni Longo, Chiara Ricchetti, Lucia Rotaris

Department of Economic, Business, Mathematical and Statistical Sciences, University of Trieste, Piazzale Europa 1, 34127, Trieste, Italy

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ABSTRACT

Given their high flexibility, Demand Responsive Transport (DRT) services have been increasingly implemented in recent years to address mobility challenges associated with environmental and social sustainability. Such transport solutions are particularly suited to satisfy the needs of specific customer categories and territories, and to serve peak-off periods. Efficiency in resource allocation and cooperation among the involved stakeholders represent crucial aspects to ensure the successful implementation of DRT services. To prove this, the study describes the results of the fruitful collaboration between the University of Trieste, Italy, and the local public transport operator in the design and implementation of a DRT service to accommodate the evening and night leisure transfers of university students. To this end, a questionnaire was administered to students in order to perform a demand analysis: notably, a discrete choice experiment was carried out to define the characteristics of the service in terms of city area served, booking time, fare and service timing. According to a logit model, the probability of students of choosing a certain service alternative was defined, suggesting the preferred service configuration. Consequently, a mobile application was developed to digitize the procedures of booking, tracing and paying bus transfers, other than monitoring the performances of the DRT service. Data collected during six months of service operation show promising results, having recorded a peak of 500 served students in one shift. A satisfactory survey revealed that the main service advantages perceived by users deal with an increase in economic convenience, transfer flexibility and personal security.

1. Introduction

Demand Responsive Transport (DRT) services represent ever-emerging solutions characterized by a great potential to address mobility challenges related to environmental and social sustainability [1], especially in periods of economic austerity [2]. At operational level, DRT services constitute an intermediate form of transport combining the "on-demand" and "ridesharing" characteristics, which are typical of the taxi and bus service, respectively [3]. As opposed to conventional public transport, the enhanced flexibility of DRT services enables to accommodate the travel needs of specific customer categories, e.g., disabled people, elders and students [4], of people living in low-density rural and peripheral areas [5,6], and during off-peak periods, like the evening and night times [7]. Different configurations and features are possible for such services, mainly on the basis of the service area and the target passengers [8], determining their implementation as either a complement or a replacement for the traditional public transport service.

However, regardless the purpose of DRT services, critical issues for their inclusion in transport systems are related mostly to financial, legal/administrative and operational barriers, along with a lack in community awareness and positive attitude [9–11]. Analogously to other transport solutions, identifying the potential market niches and investigating the conditions for users' acceptance of DRT services are the primary tasks for their successful planning and thus request detailed investigations [12]. In this regard, the adoption of technology can support market development thanks to the increased flexibility which it guarantees to both the use and the management of DRT services [13,14]. Moreover, considering that these latter services are generally more resource-consuming than traditional ones, the definition of an appropriate fare scheme directly influences market penetration and, as a consequence, the financial viability of services [15]. Other than cost challenges, DRT services face problems related to legal and institutional issues, since the regulating environment affects their competitiveness against the remaining transport services [3]. Finally, arrangements in

* Corresponding author.
E-mail addresses: ccaramuta@units.it (C. Caramuta), alessia.grosso@phd.units.it (A. Grosso), giovanni.longo@dia.units.it (G. Longo), chiara.ricchetti@phd.units.it (C. Ricchetti), lucia.rotaris@deams.units.it (L. Rotaris).

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the service offer with respect to employed vehicles and covered routes also represent key aspects to prevent the failure of DRT services [16].

On the contrary, relevant drivers to overcome the mentioned barriers are represented by the willingness of local governments and transit operators to implement DRT services [17], as well as the effective cooperation among the involved actors [18]. Cooperation among stakeholders is one of the main strengths featuring the case study reported in the present paper, which deals with the design, implementation and monitoring of a DRT service dedicated to evening and night transfers of young people in the Italian city of Trieste. Notably, the proposed service is aimed at satisfying leisure mobility needs of university and high school students, in order to integrate the traditional public transport offer and, thus, to reduce the use of private cars. Indeed, the long-known problem of the lack of connections with the city center in the late hours of the day has been faced by the University in collaboration with the local public transport company, Trieste Trasporti Spa, starting from the administration of a questionnaire to perform a demand analysis. Then, a discrete choice experiment was carried out engaging only students inclined to use a potential DRT service, and a Logit model was adopted to select the preferred service alternative. Therefore, the DRT service was implemented according to the results gained in the design phase, while a mobile application was developed to facilitate the procedures of booking, paying and tracing bus transfers. Such technological solution also supported the monitoring of the performances of the DRT service, revealing a high level of satisfaction among users.

The paper is structured as follows. The second section includes a literature review with respect to the purpose of DRT services in previous studies and of the use of Stated Preferences (SP) methods in applications concerning such services. The third section explains the methodology adopted to design and monitor the DRT service for the examined case study, which is described in the fourth section. The results of the research study are illustrated and discussed in the fifth and sixth section, respectively, and finally, some conclusions are drawn along with insights on possible service advancements.

2. Literature review

The literature review was performed based on a twofold perspective. On one hand, attention was concentrated on existing scientific papers dealing with the implementation of DRT services to accommodate the mobility needs of young people (especially students) and/or in the evening and night time. On the other hand, previous articles were examined to investigate the purpose of adopting the SP technique in the context of DRT services. To the authors' best knowledge, just a few papers covering the mentioned topics are available, while a more extended number of research studies concerning DRT services serving rural areas and/or older people are present, like in [19–22].

Regarding the first aspect of the literature review, for instance [23], describes the development of the technology behind a DRT service for the University of Malta, whose implementation was successfully tested on field by means of some key service level parameters. At transport level, given the highly urbanised environment characterizing the study area, the designed DRT system proved to be a valid alternative for students to commute to/from the campus instead of using private cars. Besides, the study demonstrated that ICT-enabled DRT systems can actually be sustainable from both a technological and economic point of view, thanks to a trade-off between service quality and costs and to appropriate initiatives promoting modal shift.

The study reported in [24] also addresses an evaluation of a DRT service dedicated to university students, with reference to the city of Arlington, Texas. The investigation consisted in an analysis of the ridership trends of different transport services connected to the university campus, which differed in terms of route flexibility. Notably, an ordered logistic regression was carried out to examine the likelihood of students of switching from fixed-route services to DRT services, based on data collected from service platforms and an online survey. Although the results of the study could be biased by the fact that analyzed data was referred to the Covid-19 pandemic period, the research revealed that students preferred DRT services over fixed route ones. In this regard, the most influential parameters for such preference were safety, convenience, accessibility and low cost of the DRT services.

Together with the resident population and the commuters, university students represented one of the target groups of the DRT service which was planned in [25] with the aim of better connecting the railway station of the Sicilian city of Enna, Italy, with the main areas of interest for each group. Given the low levels of transport demand, the implementation of a DRT service was considered a promising solution, which could also meet future travel needs generated by the increasing tourist vocation and the expected expansion of the city. Notably, in this study, two alternative services, i.e. the existing conventional bus service and the DRT service, were assessed and compared by estimating the respective total social cost, whose analytical formulation encompassed a transport operator cost function and a user cost function. It turned out that, although the bus and DRT operator costs were not influenced by low demand, the DRT service constitutes the most efficient solution with respect to the operator, passenger and opportunity cost standpoint.

The potential of DRT services for young people was examined even in [26], with the aim of filling the research gap concerning the suitability of those services to such specific category of users. Notably, the study aimed at providing understanding of the travel needs of a group aged between 6 and 18 years, considering urban and rural areas of the Scania region in Sweden. To that end, a structured questionnaire was administered to both parents and young people, investigating their attitudes and preferences for school-related and recreational journeys. Then, descriptive analysis was used to summarize the main insights coming from collected data, while multinomial logistic regression model and factor analysis were adopted to determine the most relevant drivers for the intention to use a potential DRT service. It resulted that the performances of this latter service should be high enough to compete with private cars, which are considered the most preferred travel mode by respondents, other than guaranteeing safety and security for young people.

As regard previous investigations on the implementation of DRT services during off-peak periods, the study illustrated in [27] examines the influence of on-demand transit on users' nighttime activity participation in Belleville, Canada. Indeed, given the great increase in ridership following the replacement of the evening and nighttime fixed route service with a flexible one, the authors of [27] administered a survey to collect information on users' travel experience, satisfaction and perceived changes in activity participation in relation to the DRT service. The application of a factor analysis and the estimation of structural equation models revealed that reliability and service quality positively affected activity participation the most, and that shorter wait times would enhance it even more. The analyzed DRT service actually demonstrated the contribution of such transport solution in reducing the risk of social exclusion for disadvantaged segments of the population, with respect to their participation to various activities at night.

As anticipated, other than analyzing the literature against the target group and the operational time slot of DRT services, available papers were reviewed based on the scope of using the SP method in relation to such services. In various papers, such as [28–31], SP experiments were carried out to investigate the preferences of respondents over different transport alternatives, mainly including private cars, traditional bus services and DRT services, in order to estimate the potential demand of these latter services. Similarly, in [32], the authors performed an SP experiment to define the market uptake of DRT services comparing the following two scenarios: on one hand, the status quo, which considered only the conventional public transport service and, on the other hand, a new service combining the DRT and the usual bus service. In such survey, the attributes of the new proposed service were based on trip information retrieved from Google API. An analogous study is reported in [33], where a SP survey was administered to a sample of Korean rural households questioning their preferences regarding the introduction of DRT services. In addition, the contingent valuation method, which is defined as an SP method, was adopted to examine the willingness to pay of participants for DRT services. Rural inhabitants were the target group also of the SP survey illustrated in [34], which was designed to capture the preferences of bus users in the Netherlands with respect to a few alternative services. Notably, three modes were taken into account in the study, which means the traditional bus service, a DRT service and an express bus service integrated with the bike-sharing system to cover the last-mile transfer.

Among all the reviewed articles, only the research study illustrated in [35] presents common features with the one included in this paper, in terms not only of the target group and operational time slot of the suggested DRT service, but also of the scope in the application of the SP method. Indeed, motivated by the problem of women harassment on board means of transport, such contribution deals with the design of a gender-dedicated paratransit service aiming at providing evening university-to-home transfers to the female community of the Sapienza University of Rome, Italy. The feasibility analysis of the transport service was carried out by means of a multistep methodology starting with the development of questionnaires and focus groups to investigate the travel preferences of the Sapienza women community, as well as the willingness to pay of respondents. The survey revealed that the two main drivers for the acceptance of the service were security and comfort, and that the most favored transport options consisted either in a shared door-to-door taxi service or a shared shuttle service connecting the university campus to rail or subway stations. Then, collected data were used first to identify the service coverage area and secondly to determine the characteristics of the service. It turned out that participants involved in the survey were interested in a fixed schedule service operating from Monday to Friday, between 7 p.m. and 10 p.m. Both the service solutions resulting from the survey were designed accordingly, although with differences in frequency, employed vehicles and fee. Finally, the profitability of the service was tested against two alternative scenarios, which means in case of an optimistic or pessimistic estimation of the potential demand.

Despite some similarities, the scope of the case study illustrated in this paper exceeds the one reported in previous contributions according to multiple perspectives. At operational level, the proposed service differs from the other ones, because it was specifically designed to serve university students in the late off-peak time period, and the extent of the service coverage area is not related to a single origin. In fact, since the DRT service was intended to accomplish the mobility needs of students for recreational purposes, its operational area includes a wider set of possible origins, which increased the complexity of the service planning. At methodological level, in this research study, the SP method was adopted to define the features of the DRT service, and not just its potential demand as compared to traditional transport solutions. Furthermore, the paper not only explains the development of the DRT service, but also discusses the results of the service implementation based on data gathering during the monitoring phase.

3. Methodology

For the sake of clarity, the methodology adopted in this study has been visualized in the flowchart reported in Fig. 1, synthesizing all the steps which are explained in detail in the followings. As anticipated, the objective which motivated this study, and thus the developed methodology, consisted in the efficient design and monitoring of a DRT service, which aimed at satisfying the late evening and nighttime leisure mobility needs of university students.

SP methods are commonly employed in transport economics to estimate the potential demand for transport services, particularly when market data are unavailable, such as in the case of new services or hypothetical scenarios [36,37]. These methods involve collecting data from respondents regarding their preferences in hypothetical choice settings. Each alternative is characterized by a set of attribute levels, and respondents are presented with a series of choice sets containing two or more alternatives. The resulting data are then analyzed to estimate the relationship between transport service attributes and the likelihood of choosing a specific alternative. Typically, discrete choice models, such as the Multinomial Logit Model [38], are used for this analysis. The model parameters reflect the marginal utilities of the attributes, which can be used to predict demand and assess how changes in attributes (e.g., fare reduction or increased service frequency) influence the likelihood of choosing a particular service [39].

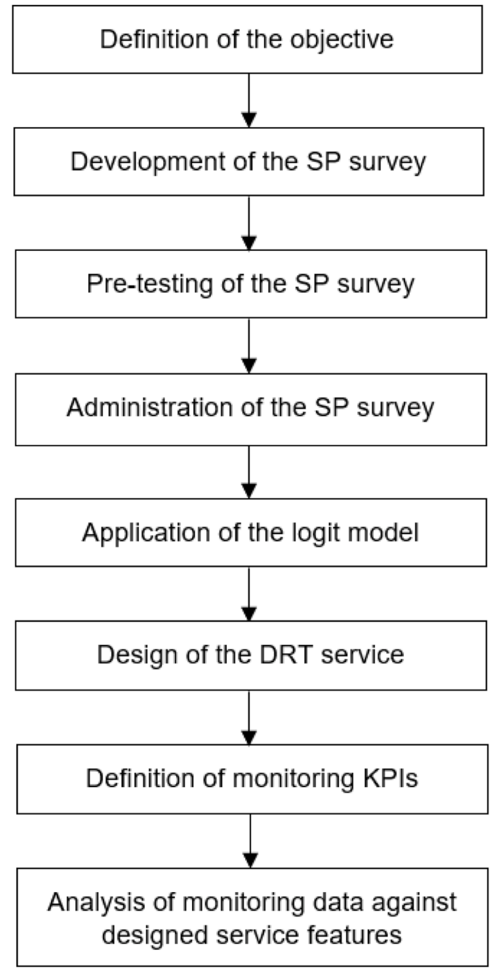

Fig. 1. Flowchart of the methodology.

In this study, SP data was collected to investigate specific attribute combinations of interest and to explore scenarios that were not observable in the analyzed context, i.e., the city of Trieste, since DRT services were not provided at the time of the survey. This approach enabled to examine how individuals trade off key attributes, such as the city area served, booking time, fare, and service timing (Table 1), which were critical for the planning and design of the service. One limitation of SP data is the potential for respondents to either overstate or understate their preferences due to the hypothetical nature of the scenarios, as they do not face the real-world consequences of their choices [40]. To

Table 1
Key attributes and corresponding levels.

Area served	Booking time	Fare	Service time window
Small	20′	3.5€	12 p.m. - 2 a.m.
Medium	30′	3€	11 p.m. - 3 a.m.
Large	40′	2€	10 p.m. - 4 a.m.

minimize this bias, attribute levels and scenarios were carefully selected to be as realistic as possible and closely aligned with the characteristics of the existing transport services.

In Table 1, the levels tested for each attribute are listed. It was deemed important to limit the number of levels to three because, as the number of attributes and levels increases, the number of observations required to obtain statistically significant results also increases. Additionally, the cognitive burden on respondents would dramatically rise, potentially leading them to adopt rule-of-thumb strategies, which could reduce the quality of the collected data. For these reasons, although the importance of travel time was originally intended to be tested alongside the other attributes in the SP experiment, it was decided to treat such attribute as a separate question. This question was administered after the choice tasks, rather than as a characteristic of the alternatives to be evaluated by respondents.

Designing the choice tasks was complex, as it required a thorough understanding of how the service was provided at the time of the survey, how it could be realistically modified, and which changes would be most impactful for potential demand. To this end, a focus group was conducted by the service operator, in collaboration with academics in the field of transport engineering and transport economics. Rather than using all possible combinations of attribute levels (full factorial design), an efficient experimental design was employed to reduce the number of choice sets while ensuring robust estimates [41].

As the service primarily targeted young individuals, the questionnaire was administered to students of the University of Trieste over a period of 15 days, between October and November 2022. Prior to distributing the full questionnaire, a pre-test was conducted on 30 students randomly selected from the university's enrollment to determine the need for any changes or additional questions. Then, a link to the survey was posted on the webpage of the University of Trieste, and an email describing the DRT project was sent to the students, along with a request to complete the online questionnaire. The response rate was satisfactory, covering 12,2% of the target population (i.e., 2200 out of 18000 students). Given an estimated true proportion of the population willing to use the service of 63% (based on one of the questionnaire items), a sampling error of 5%, a confidence level of 95%, and a population size of 18000 individuals, the minimum required sample size was 360. Since the sample of the questionnaire respondents consisted of 2200 individuals, with a good degree of confidence it was considered sufficiently large to ensure robust results.

The questionnaire was divided into three main sections to explore the transportation habits and preferences of respondents, particularly in relation to the potential use of DRT services in Trieste. In the first part of the questionnaire, basic demographic and mobility-related information were gathered. Respondents were first asked whether they resided in Trieste or commuted to the city to reach the University. For those who lived in Trieste, an additional question was inserted to inquire about the specific area of the city in which they resided. This allowed to assess potential geographic differences in mobility patterns across different parts of the city.

Unfortunately, detailed information on the socioeconomic characteristics of the respondents was not available, except for, as just mentioned, their commuting status and, for those staying in Trieste, their place of residence. Both variables were included in the econometric model proposed in the paper; however, neither of their coefficients was statistically significant.

Respondents were also asked about their late-evening and nighttime mobility habits, to understand whether they typically visited the city center during these specific times. Furthermore, participants were asked to indicate the days of the week when they most commonly went out with friends, providing insight into the social patterns that could influence transportation needs during evenings and weekends.

The second part of the questionnaire focused on respondents' attitudes toward a hypothetical DRT service in Trieste. Specifically, questions were aimed to explore whether participants would be willing to use such a service if it was available in the city. Respondents were asked to indicate the importance of service speed, specifically how quickly the service would need to reach a destination for them to consider using it. This allowed to gauge the priority placed on efficiency in transportation decisions. Additionally, the social context in which respondents would use DRT services was examined. Respondents were asked how many friends or acquaintances they would typically use the service with, providing insight into the demand for group travel options.

In the final part of the questionnaire, respondents were presented with six choice tasks. In each task, they were asked to choose between two hypothetical services, each characterized by different service area, booking time, fare, and service time window. Socio-demographic information, such as age and gender, was collected at the end of the questionnaire.

According to the logit model, Eq. (1) indicates the probability that decision maker n chooses alternative i:

$$\begin{aligned} P_{ni} &= ProbU_{ni} > U_{nj}j \neq i \\ &= ProbV_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}j \neq i \\ &= Prob\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj}j \neq i \end{aligned} \tag{1}$$

being V_{ni} the deterministic observable component of the individual utility function, specified as a linear additive function of the characteristic of the DRT service, and ε_{ni} the random unobservable component, assumed to be independently, identically distributed extreme value. Therefore, Eq. (2) shows that the probability of choosing alternative i is:

$$P_{ni} = \left[e^{Vni} \big/ \Sigma e^{Vnj}\right] \tag{2}$$

The results coming from survey activities were functional to the actual planning of the DRT service, which was integrated with the development of a dedicated mobile application. This technological solution was meant not only to facilitate users in booking the service and to provide them with real-time information, but also to monitor the performances of the service and the users' satisfaction level. To that end, a few performance indicators were defined, especially with reference to some operational aspects and to the number of users' requests accommodated by the transport system. Finally, the outcomes of the monitoring phase have been compared with the insights generated by the former adoption of the two logit models, in order to check the consistency between estimated and real data.

4. Case study

As mentioned, the methodology illustrated in the previous section was applied to the case study of Trieste, which is a middle-sized city in the North-East of Italy characterized by a peculiar morphological configuration due to the presence of many hills. This latter feature motivates the low modal share towards non-motorized transport solutions and, by contrast, the relevant role of public transport. The public transport network (Fig. 2) is composed by 56 lines of traditional bus service and one tram line, which cover around 13 million kms/year using a fleet of 273 buses and 6 trams. The service provider is a private-public company of almost 800 employees, which operates based on a Service contract with the public authority [42].

The University of Trieste is attended by almost 18000 students, but the majority of them are out-of-town students. The lack of transport connections in the late hours of the day constituted a long-known problem especially for that segment of the demand and, as such, it gave reason to the development of the DRT service presented in this paper. The initiative was carried out thanks to a great collaboration between the University and the transport company Trieste Trasporti SpA, with the goal of a more efficient and sustainable management of students' recreational transfers. In this regard, it must be highlighted that, although the DRT service was designed to satisfy students' mobility needs, it was made available to all the potential users of the public transport system, integrating the existing supply of traditional bus

Fig. 2. Public transport network in the city of Trieste [42].

services in the evening and night time. Starting from July 2023, the DRT service was first implemented as a pilot project for a few months, during which data concerning its performances were automatically collected via the related mobile application, in order to envision possible improvements.

5. Results

Based on the collected SP data, two binary logit models were estimated. In the first model, the dependent variable was a binary indicator that equaled 1 if the respondent indicated they would use the service and 0 otherwise. The independent variables included the preferred days for using the service (as reported by the respondents), whether the respondent resided in Trieste, and the area of the city in which they lived. The results showed that the probability of respondents being willing to use the service was significantly and positively correlated with the service being available on Wednesdays, Fridays or Saturdays, and with the respondents' residence in the semi periphery of the city or in the suburban areas within the Trieste province (Table 2).

A higher preference was expected for the service being provided on weekends. However, it was somewhat surprising that the Wednesday service was preferred over the other weekdays. Regarding the location of respondents' residences, as anticipated, the service would be perceived as more useful by students living outside the city center but still within the Trieste province. Students living in the city center already have many alternative transport options available to them, and most recreational activities are concentrated there. On the other hand, students living outside the province of Trieste are likely to use private vehicles to reach the city, they would likely not perceive the service as important.

In the second model, the dependent variable was a binary indicator

Table 2
Results of the first logit model.

Variable	Parameter	t-ratio	p-value
Monday vs Sunday	0.11	0.36	0.72
Tuesday vs Sunday	0.03	0.11	0.91
Wednesday vs Sunday	0.87	5.13	0.00
Thursday vs Sunday	0.36	1.43	0.15
Friday vs Sunday	0.77	3.81	0.00
Saturday vs Sunday	0.44	1.94	0.05
City center vs outside Trieste province	0.86	1.46	0.14
Semi periphery vs outside Trieste province	1.62	2.69	0.01
Periphery vs outside Trieste province	1.09	1.78	0.08
Suburban within Trieste province vs outside Trieste province	1.00	1.69	0.09
Commuting vs not commuting	−0.56	−0.97	0.33
Living vs not living in Trieste	−0.37	−0.64	0.52

reflecting the hypothetical alternative chosen by the respondents in the choice tasks. The independent variables consisted of dummy-coded variables for the area served and the service time window, and cardinal variables for the booking time and fare value. The results indicated that respondents' likelihood of using the service was not significantly affected by the booking time. Consequently, a reduced model was estimated focusing on the other three attributes. According to this reduced model, the willingness to use the service was significantly influenced by three factors: (1) the destination of the service (with the city center preferred over more peripheral destinations), (2) the service time window (with a longer time window preferred), and (3) the fare value (with a lower fare being preferred) (Table 3).

The results obtained with the second model were consistent with the previous findings. Most recreational places, including bars, restaurants, cinemas, and theaters, are located in the city center, so it was expected that this area would have been the preferred destination to be served by the service. It was also anticipated that students would have preferred a longer time window, as it would provide more flexibility in using the service and allow them to use it late at night. Regarding preferences for fare values, it turned out to be a significant conditional factor influencing the decision to use the service. However, it is interesting to note that the fare was relatively less important than the service destination and the time window, a result which was not expected a priori.

The final step of the design phase of the DRT service consisted in the definition of its network extension both in the winter and summer time, so as to guarantee an adequate service capillarity in each season. However, regardless the different spatial boundaries in those two main periods of the year, the DRT night service was supposed to use the same stops of the traditional bus transit network, other than analogous vehicles.

In light of the results suggested by the two logit models, the transport operator Trieste Trasporti SpA introduced the new DRT service on Wednesdays, Fridays and Saturdays from 10 p.m. to 4 a.m., mainly serving the city center. The ticket fare for each trip of the DRT service was set to 2 Euros, which are intended to be paid only if the requested transfer is performed, upon the verification of the user identity. The mobile application developed in support to the DRT service enable users to book an individual or a collective trip (i.e., at maximum for 19 other people) with a booking time ranging from 14 days to 45 minutes or, alternatively, to join an already existing trip a few minutes before the bus arrival. Trip reservations are mandatory to use the service and can be performed only via the dedicated mobile application. Users can select the origin and destination of their trip, attributing a specific priority to either the departing time or the arrival time. Once the booking procedure has been finalized, users can trace the position of the reserved bus in real time and receive notifications via SMS, e-mail or the mobile application itself. Tickets can be purchased directly through the mobile application using a credit card.

Table 3
Results of the second (reduced) logit model.

Variable	Parameter	t-ratio	p-value
Alternative Specific Constant	−0.13	−6.81	0.00
City centre vs semi periphery A	0.30	10.37	0.00
semi periphery B vs semi periphery A	0.01	0.29	0.77
Fare (Euro)	−0.21	−7.30	0.00
11:00pm. - 03:00 a.m. vs 12:00 pm. −02:00 a.m.	0.17	3.36	0.00
10:00pm. - 04:00 a.m. vs 12:00 pm. −02:00 a.m.	0.37	6.36	0.00

The implementation of the DRT service was advertised on different communication channels, which means on the local television and newspapers, other than on various social media, by both the University and Trieste Trasporti SpA. Notably, also the student representatives actively participated to the launch event of the service, as well as to the survey activities, facilitating the interaction between the final users and the transport operator.

6. Discussion

Referring to the period from November 2023 to May 2024, the performances of the DRT service were monitored based on some indicators coming from the dedicated mobile application. First of all, the diffusion of the service was assessed by recording the number of application downloads, which raised from 200 in the initial months of the analyzed period to more than 900 in May. Such increase can be reasonably attributed, on one hand, to the greater awareness of users of the service availability and, on the other hand, a greater tendency for participating to evening and night time leisure activities in case of fine weather. Nevertheless, the number of application downloads does not reflect the number of users who actually benefitted from the DRT service. Therefore, the number of transfer requests per month has been analyzed, distinguishing among those which were satisfied, rejected by system (in case of transfers requested close to the end of service time window, whose duration would have exceeded the one of this latter), cancelled, or not accomplished (when users did not show up at the requested bus stop). Focusing on the satisfied requests, in Table 4 it can be noted that the highest total average number of passengers per month was recorded during March, in which more than 370 users were transferred. With a total average number of served passengers per day equaling to more than 850, Saturdays represented the peak operational days, followed by Fridays and, lastly, by Wednesdays. This latter result demonstrates that the proposed DRT service was exploited by a variety of user categories and not only by students, among whom especially regional out-of-town students usually carry out leisure activities on Wednesdays, as they go back to their home during the weekends. Such outcome thus confirms the insight suggested by the first logit model on the preferred operational days (Table 2), indicating the benefit of providing the service not only on the weekday in which students are more likely to join recreational activities, but also on Saturdays and

Table 4
Total average number of passengers per day and per month.

Average number of passengers				Total average per month
Month	Operational day			
	Wednesday	Friday	Saturday	
November	50.4	141.5	94.25	286.15
December	33.75	74.4	75.4	183.55
January	28.8	83.5	100.5	212.8
February	46	131	123.5	300.5
March	78.75	128.4	165.4	372.55
April	70	114.5	162.75	347.25
May	57.6	145	130	332.6
Total average per day	365.3	818.3	851.8	

Sundays. Finally, it is worth to highlight that a peak of 500 served passengers transferred in just one shift was recorded during the monitoring period.

Regarding the destination of the DRT service, Table 5 indicates the 4 most used bus stops, in terms of the number of both boarding and alighting passengers. With respect to boarding stops, the first 3 stop locations reported in Table 5 (i.e., Riva Sauro 24, Corso Italia and Riva Caduti Per L'Italianità di Trieste) are situated right in the city center of Trieste, in line with the preferences expressed by respondents when applying the second logit model (Table 2). The only exception is represented by the stop located in Viale Miramare 77, which is positioned in the immediate surroundings of the city center and still turned out one of the most used bus stops. Reason for this is that, during the examined monitoring period, a new night club was opened in the proximity of such stop, which motivates also the significant number of alighting passengers in correspondence to that location. Indeed, in the view of the opening of such recreational activity, the transport operator decided to arrange the DRT service so as to meet the expected mobility needs of the nightclub clients. On the contrary, the remaining most used alighting stops (i.e., Piazzale Gioberti, Via Severo 85 and Via Fabio Severo 143) are located in the area of Trieste where the majority of students reside. In summary, to confirmation of the outcomes of the second logit model, the DRT service was generally not requested to serve peripheral destinations.

With respect to the service time window, Table 6 includes the total number of served passengers in each hourly slot composing the operational time period suggested by the second logit model (Table 2). It can be observed that, considering the sum of the number of monthly passengers throughout the whole monitoring period, the time slot ranging from 12 p.m. to 1 a.m. registered the greatest user load, followed right after by the one between 1 a.m. to 2 a.m. Nevertheless, remarkable values in the number of transferred passengers were recorded in the time slots from 11 p.m. to 12 p.m., but also from 2 a.m. to 4 a.m., therefore underlining the appropriateness of the time window extension proposed by the second logit model.

Finally, users' satisfaction level was assessed through a 5-star likert scale, with the aim of getting feedbacks on the service quality experienced by passengers. The average monthly satisfaction rate of 5-star judgements proved to be more than 90% during the examined monitoring period. Furthermore, as indicated in some open-ended comments, the main service advantages perceived by users dealt with an increase in economic convenience, transfer flexibility and personal security.

Overall, the results obtained in this study comply with the findings reported in the contributions examined in the literature review, enabling to identify some common lessons learned in the design of DRT services. Of course, the comparison refers to previous scientific papers reporting the actual implementation of DRT services, and not to those considering only their design in terms of potential demand. Service flexibility is confirmed as one of the most valued features by users, like mentioned in [23] and [27], and it is needed both at technological, transport and financial level to make DRT services accessible. In addition, bearing in mind the evidence coming from [24,26], security is acknowledged as a very influential property in users' preferences for DRT services, especially when vulnerable people are involved.

Table 5
Most used bus stops in terms of number of served passengers.

	Stop location	Number of passengers
Boarding stops	Riva Sauro 24	1934
	Corso Italia	905
	Riva Caduti Per L'Italianità di Trieste	751
	Viale Miramare 77	538
Alighting stops	Viale Miramare 77	1088
	Piazzale Gioberti	752
	Via Severo 85	378
	Via Fabio Severo 143	364

Table 6
Total number of passengers per service time slot.

Month	Service time window					
	10 p. m.–11 p. m.	11 p. m.–12 p. m.	12 p. m.–1 a. m.	1 a. m.–2 a.m.	2 a. m.–3 a.m.	3 a. m.–4 a.m.
November	74	156	292	279	180	214
December	92	141	256	310	175	156
January	140	168	179	199	129	65
February	125	216	244	253	176	188
March	133	279	399	316	250	301
April	155	236	281	257	210	250
May	129	191	330	350	217	267
Total	848	1387	1981	1964	1337	1441

7. Conclusions

This study describes the planning, implementation and monitoring of a DRT service for students' leisure transfers in the city of Trieste, which was developed thanks to an effective collaboration between the local University and the transport operator. The interaction between these latter two entities was first functional to perform survey activities aimed at service planning and, secondly, to advertise and monitor the initiative. Notably, SP data was collected to investigate specific attribute combinations of interest, which were then analyzed using logit models to assess the likelihood of choosing a certain service configuration. The consistency between estimated and real data proved the appropriateness of the performed design activities, with respect to the service operational days, time window, fare and destinations. Referring to the examined monitoring period, it turned out that the DRT service was mostly used on Saturdays from 12 pm. to 1 a.m., at a cost of 2 Euros for each transfer, with passengers boarding and alighting, respectively, in the city center of Trieste and in areas where students reside. The monitoring activities were particularly useful also to detect the influence of new generating and attracting poles, which emerged after the planning of the service. In general, the passengers were highly satisfied by the performances of the implemented DRT service. Based on such results, the transport company intends to keep on running the service and the dedicated technological solution, which represents the first attempt of Mobility-as-a-Service (MaaS) application for the city of Trieste.

The generalizability of the findings of this study is proved by the fact that the main aspects influencing users' mobility choices (which means service availability in time and space, and costs) have been confirmed, attesting their rational behavior. Besides, evidence coming from this research underlines the importance of discussing monitoring data against planned service features, in order to consider possible advancements. Furthermore, the outcomes of this study can be certainly transferred to similar contexts, i.e., to medium-sized cities where the presence of relevant poles generate a high number of transfers in specific time slots, which the conventional public transport service is not able to cover. More broadly, the obtained results demonstrate that the accurate identification of the unmet mobility needs of certain target groups ensures the profitability even of niche transport solutions, which all users can benefit from.

As regard the main limitation of study, the analysis reported in the paper was based on SP data, which are subject to hypothetical bias. At the time of the interviews, the service had not yet been implemented, making it impossible to apply alternative methodologies to estimate the potential demand. It would certainly be beneficial to conduct a follow-up survey now that the service is available, in order to assess the magnitude of the bias and mitigate its impact by combining both revealed and stated preference data.

A second potential limitation of this research study is self-selection bias. While the sample size of the questionnaire respondents was large enough to produce robust statistical results, the composition of respondents may not fully represent the characteristics of the entire population. To address this issue, additional data is meant to be gathered, specifically targeting segments of the population that may have been underrepresented so far.

Future developments of the proposed study consist in the advancement of the monitoring plan, in terms of a more detailed investigation of passengers' features, in order to better define their profile. Indeed, a disaggregated analyses of users' characteristics would enable the transport company to plan more efficiently the DRT service, and thus to meet even further their mobility needs. Besides, at methodological level, the sample of the respondents to the survey administered during the planning and design phase of the service could be extended to a larger pool of students, like, for example, to high school students.

CRediT authorship contribution statement

Caterina Caramuta: Writing – review & editing, Writing – original draft, Conceptualization. **Alessia Grosso:** Writing – original draft. **Giovanni Longo:** Supervision, Methodology, Conceptualization. **Chiara Ricchetti:** Validation, Software, Formal analysis. **Lucia Rotaris:** Writing – original draft, Validation, Methodology, Conceptualization.

Declaration of competing interest

The authors have nothing to declare.

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Data availability

The data that has been used is confidential.

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