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The combination of e-bike-sharing and demand-responsive transport systems in rural areas: A case study of Velenje

Francesco Bruzzone[a], Mariangela Scorrano[b], Silvio Nocera[a,*]

[a] Università IUAV di Venezia, Venice, Italy

[b] Università degli Studi di Trieste, Trieste, Italy

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ABSTRACT

An analysis of the operational characteristics of the transit system serving the town of Velenje (Slovenia) revealed poor performance and the need for improvements. This paper describes the potential integration of an electric bike-sharing system and a semi-flexible demand-responsive transport system to effectively solve this issue. Additionally, general guidance is provided for transit systems with low travel demand. Appropriate transport system schedules are proposed to facilitate customers' use and thus to move demand shares away from private motorized transport. Focus group interviews, implemented to directly involve local stakeholders, revealed an overall positive perception of the proposed transport system. Furthermore, the cost analysis demonstrated that the costs of the new system would not be much higher for the municipality than those currently incurred, making it an important performance improvement achieved at low cost.

1. Introduction

The considerable growth of mobility in urban centers over the last century has been accompanied by issues of sustainability. Estimates show that while the world population has grown fourfold over the past century, passenger-kilometers in passenger transport and tons-kilometers in freight transport have increased by about 100 times during the same period (Ksenofontov & Milyakin, 2018; Mulrow & Derrible, 2020). Although this massive travel development has had numerous positive effects, the intensity and extent of the negative local and global consequences on the environment are clearly evident, especially in terms of air and noise pollution, soil consumption, and land degradation (Benintendi, Merino Gòmez, De Mare, Nesticò, & Balsamo, 2020).

The current global strategy has thus become reducing the overall consequences while still keeping performance efficiency high. Public transport is a key piece of the sustainable mobility puzzle. It can help move more people with lower energy consumption per passenger, provides a more affordable alternative for getting around, has a track record of fewer accidents, has significant potential for electrification, reduces congestion, improves air quality, and makes cities more livable and inclusive. Outside of these benefits, however, public transport service is plagued with many challenges that reduce its attractiveness, including long waits at transfer points, insufficient coverage of more dispersed areas, insufficient integration with green modes such as cycling, and a sometimes negative perception or attitude towards public transport. This is especially true in suburban areas. These are larger than traditional cities and have significantly lower densities, implying greater travel distances for most trips, fewer origins and destinations within walking distance of any single route, and more kilometers travelled to reach activities.

Conventional public transport in such areas is often unable to meet accessibility needs and requirements of different user groups, resulting in large portions of the population relying on private motorized transport, high operational costs, and thus increased fares and low revenues. This leads to a vicious circle (Fig. 1) of service cuts, further ridership fall, even lower revenues, and so on, to the point where services are discontinued (Dirks, Frank, & Walther, 2019; Organization for Economic Co-operation and Development [OECD] & International Transport Forum [ITF], 2015; Velaga, Nelson, Wright, & Farrington, 2012).

To tackle these challenges, transit planning must respond with appropriate services and policies to allow public transport to compete with private automobiles. There are two possible solutions. First, transit planning can utilize more flexible bus service, thus minimizing travel time by ensuring well-timed connections and providing these connections as effortlessly as possible with short walk distances, tight scheduling, and appropriate frequencies. Demand-responsive transport (DRT) is an effective method for instituting such a service. Second,

* Corresponding author.
E-mail address: nocera@iuav.it (S. Nocera).

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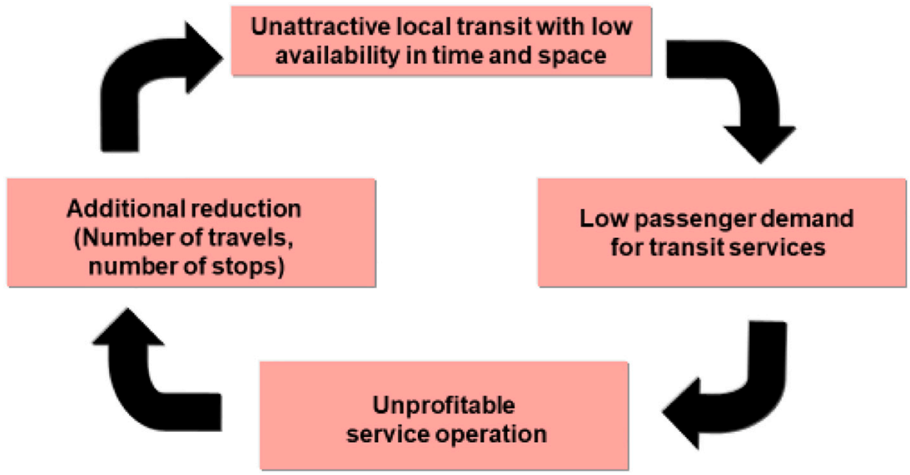

Fig. 1. Possible ripple effects of a deficient supply of transit – Adapted from Kirchhoff (1995).

transit planning can offer better sustainable accessibility by connecting public transit with other transport modes, such as bicycles.

Despite the well-known potential of flexible transport systems (FTS; Mounce, Wright, Emele, Zeng, & Nelson, 2018) in increasing the use of transit and accessibility of rural areas, the operational, technical, and—especially—market feasibility of such systems remains an issue. Studies have shown that operational sustainability of FTS is not always granted; funding is often an open issue; and in a number of cases, a need for high subsidies has emerged (Jokinen, Sihvola, & Mladenovic, 2019; OECD & ITF, 2015). Other detected barriers to the appeal, implementation, and use of FTS are poor understanding of mobility needs, the lack of integration with other modes, the difficulty in framing demand and user behavior, and the lack of communication between users and agency (Brake, Mulley, Nelson, & Wright, 2007; Te Morsche, Puello, & Geurs, 2019; Velaga et al., 2012). The last big issue to consider is related to the lack of viable options to cover the "last mile" between public transport stops and people's final destinations. To the best of our knowledge, no experiment has yet been carried out specifically on the integration between a demand responsive transport system (DRTS) and an electric bike-sharing system (e-BSS), with the latter simultaneously acting as feeder and complement to the bus network.[1]

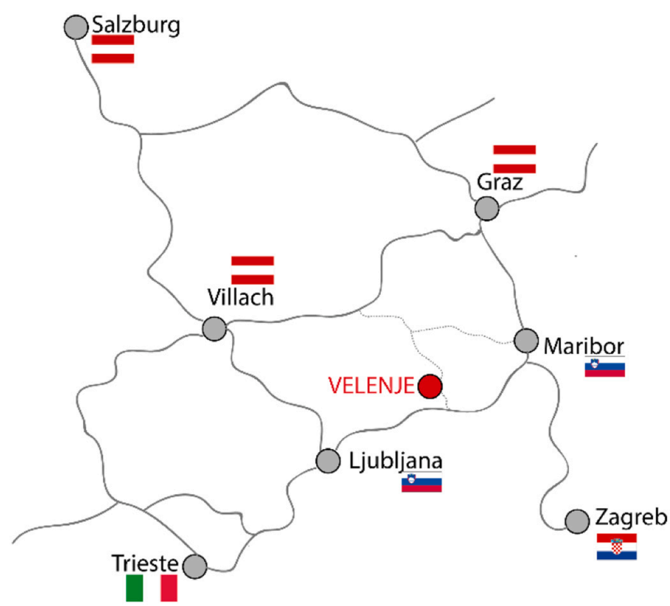

Fig. 2. Velenje's location.

Thus, this paper investigates the potential of the integration of a semi-flexible DRTS and an e-BSS to effectively solve the problem of low transit travel demand. To achieve this aim, we analyzed the Slovenian town of Velenje as a case study. Together with the Municipality of Velenje and through a consultation process with stakeholders and citizens, we developed a feasible and fundable DRTS proposal that integrates an extended version of the existing BSS. We find that within the funding possibilities of the municipality and in full compliance with the objectives and targets of ongoing European Union (EU)-funded programs, numerous progresses can be gained by benchmarking the proposal against the existing traditional bus system.

This paper is structured as follows. Section 2 details the current

[1] The integration of bike sharing (including e-bikes) and traditional transit systems has been studied previously and intensively. Regarding the role of biking within modal integration, Félix, Cambra, and Moura (2020) recently considered the effects of cycling infrastructure and the implementation of an e-BSS in Lisbon. They found that the combined effect of both interventions was a game changer for the city's cycling maturity. Ma, Zhang, Li, Wang, and Zhao (2019) showed that demand patterns of commuters strongly impact the relationship between shared bikes and public transportation. Their data showed that the transactions between shared bikes and buses had evident commuting characteristics during weekdays, while on weekends, travelers preferred to use shared bikes as a substitute for public transport. A similar result was achieved by Sun, Chen, and Jiao (2019), who considered how loyal members use a BSS more for commuting while non-members use them more for recreation. Fyhri and Fearnley (2015) found that e-bikes, compared to traditional bikes, increased the number of trips and trip length for all age groups, regardless of trip reason (leisure or work), and are a practical and accepted solution for everyday travel. In a successive study, Fyhri and Beate Sundfør (2020) found that e-bikes resulted in a greater shift away from cars compared to traditional bikes and argued that such mode shifts are long term rather than temporarily induced by good meteorological conditions or novelty. Bronsvoort (2019) and Bronsvoort, Alonso-González, van Oort, Molin, and Hoogendoorn (2020) studied the possible upgrades for conventional PT services in rural settings, considering both the integration with a BSS and the substitution with a DRT, and found that time and cost are more important to users than reliability and flexibility. In a recent

(footnote continued)
study, Sun et al. (2020) found that e-bikes prominently substituted car use for both commuting and shopping, and that those living in rural areas were among the most likely to forgo their cars in favor of e-bikes. Guo and He (2020) studied the integration between BSS and conventional public transport, concluding that areas with lower density of public transport stations have higher incidence of integrated use. From a DRTS planning perspective, studies agree that multimodality is a key driver for service sustainability and success (Dirks et al., 2019; Nelson & Phonphitakchai, 2012).

Table 1
Demography in the municipality of Velenje.

Location	Population	Gender		Age (years)			Nationality	
		M	F	≤ 14	15–64	> 65	Nationals	Foreigners
Velenje	33,331	51.1%	48.9%	15.2%	66.4%	18.4%	87.3%	12.7%
Slovenia	2,102,678	45.0%	55.0%	13.4%	69.8%	16.8%	87.7%	12.3%
EU-27	446,824,564	46.0%	54.0%	15.2%	64.6%	20.2%	90.6%	9.4%

Note: Data as of January 1, 2020. Adapted from Slovenia Statistics, 2020, and Eurostat, 2020.

Fig. 3. Map of the Velenje area. Reprinted from www.openstreetmap.org, retrieved 15 May 2020.

features of the transit system in Velenje. Section 3 describes the method that we propose to improve the service, including an economic analysis. Section 4 discusses the results obtained. Finally, Section 5 concludes the paper.

2. The current transit system in Velenje

Velenje is Slovenia's sixth largest town and is located 75 km (by road) northeast of the capital city Ljubljana, 124 km south of the Austrian city of Graz, and 136 km northwest of Zagreb (Fig. 2). In 2020, the Slovenian Municipality of Velenje[2] was home to 33,330 inhabitants (Table 1) distributed into 25 local communities (SiStat, 2020).

Its morphological and demographic characteristics make it a typical example of a dispersed area: it lies in a relatively wide lake basin surrounded by a hilly and rural landscape, throughout which are scattered settlements (Fig. 3). To the west of the main urban core, the Paka river valley leads towards central Slovenia, hosting the railway towards Ljubljana and a major road. Also on the railway, the town of Šoštanj lies on the lakeshore opposite Velenje.

The modal split in Velenje is unbalanced towards the use of private cars, despite a car ownership rate of 500 cars/1000 inhabitants, which is less than the Slovenian average of 541 cars/1000 inhabitants (European Environmental Agency, 2020; Halilović, 2019). Comparing data collected in the 2016 and 2019 municipality surveys,[3] it is evident that the decrease in the modal share of private cars (61% vs 51%) has been fully compensated by an increase in the share of active modes (walking and cycling increased from 29% in 2016 to 39% in 2019). The role of public transport is therefore marginal (with a share of 10% and 8% respectively). The 2019 survey also investigated commuting distances, finding that a vast majority of respondents (78%) worked within 5 km of their home (Table 2), a distance that the Slovenian Ministry of Transport considered to be cyclable in the 2017 guidelines for building pedestrian infrastructure (as cited in Halilović, 2019). These data demonstrate how the use of private cars exceeds expectations, which may be explained by the fact that public transport is currently not a daily commute option for those living outside the Velenje city center, as schedules do not fit traditional office and business hours.

To overcome the transport issues for those rural settlements lying in the northern, eastern, and southern sectors of the Municipality of Velenje, which are not served by rail or interurban buses, and to improve the modal share of public transport and active mobility, the city has established three suburban bus routes. The routes operate on weekdays only as part of a five-route local network (Fig. 4), and they have an inaugurated BSS.

The bus service, which cost €348,700 to run in 2019, is currently free of charge for users (Municipality of Velenje, 2020). In 2017, Velenje's bus service transported 420,000 passengers, mostly aboard the

[2] The Municipality of Velenje has partnered with IUAV University of Venice for the EU-funded projects Smile and Smart Commuting. Data and information about public transport and BSS in Velenje were mostly retrieved thanks to direct communication with the city's municipal offices, the city's public website, and direct interviews (focus groups) carried out in March 2020.

[3] The two surveys were conducted by the Municipality of Velenje as part of the EU-funded project Smart Commuting.

Table 2
Modal split and commuting distances in Velenje.

Daily Commute	2016 Survey (%)	2019 Survey (%)
Modal split		
Private car	61	51
Public transport (bus)	10	8
Walking	20	31
Cycling	9	8
Other	0	2
Commuting distance (km)		
< 2	–	42
2–5	–	36
5–10	–	15
> 10	–	7

yellow line in the city center (Municipality of Velenje, 2018). As shown in Fig. 4, three suburban routes—the blue, green, and orange lines—are currently in operation. The yellow line provides frequent service within the urban core, and the red line is a "virtual" line comprised of a longer interurban route. At peak times (e.g., school hours), the orange, blue, and green lines do not run, and specific students-only services are operated (Municipality of Velenje, 2020b). In total, up to four high-floor midi-buses are used for Velenje's local services: three on the yellow route (two off-peak) and one alternately serving the blue, orange, and green lines (Table 3). The red line does not have dedicated vehicles because it is shared between several longer routes; however, the service is subsidized by the Municipality of Velenje within the contract for the local bus system and has thus been included in the analysis. Table 3 shows the route lengths and frequencies of the different lines. Currently, the Velenje bus system covers 272,480 km/year; thus, the value of the subsidy for public transport operations is 1.28 €/km.

Even if subsidized consistently by the municipality, the current public transport offer in Velenje is underutilized. With the exception of the yellow line, it cannot be used to commute on a daily basis, as it does not operate during the morning rush hour and it offers a limited number of daily connections. Its only, clear imprinting is that of facilitating weak categories such as the elderly and those impaired to drive in getting to the city center and making use of its functions, a common approach in Slovenia's recent policy (Gabrovec & Bole, 2009). The yellow line, in contrast, provides relatively frequent service within central Velenje. In short, Velenje's public transit is characterized by a low frequency of service, lack of time coordination, low load factors, and a lack of ambition on the part of the municipality to fund it further.

The only ways out of the vicious cycle in which deteriorating quality, tariff increases, and/or reduced routes lead to a lack of service are consistent resource investments from the authority in charge or a

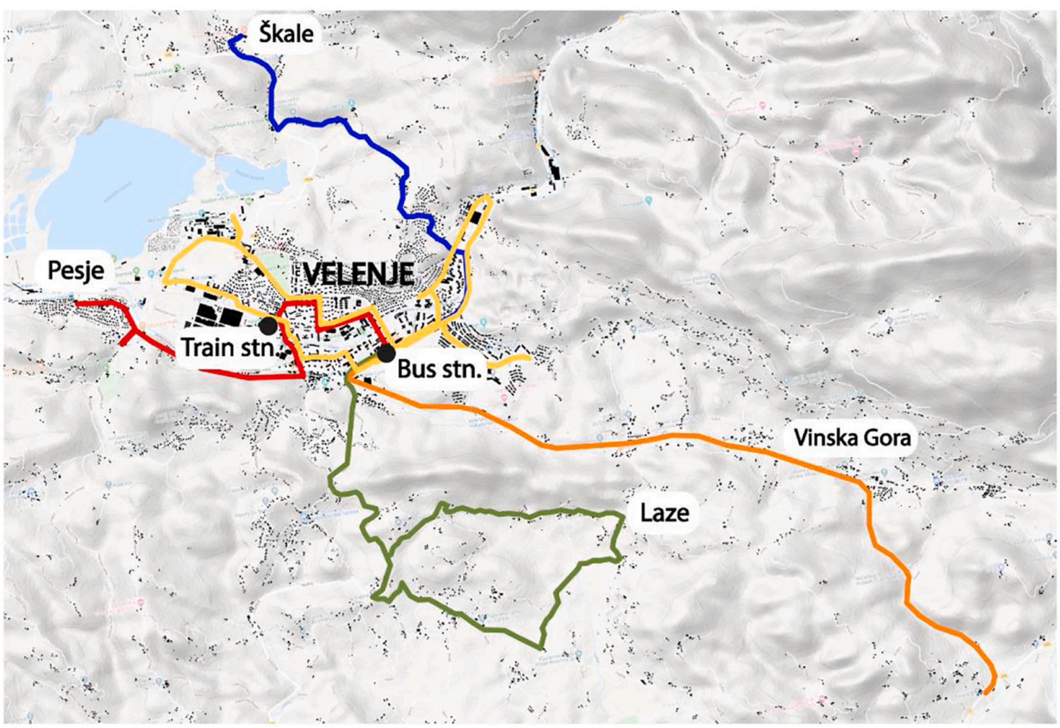

Fig. 4. Urban and suburban bus routes in Velenje.

Table 3
Current public transport operations in Velenje (Mon.–Fri.)

Route	Number of buses	Route length (full tour; km)	Daily departures	Daily distance travelled (km)	Yearly distance travelled (km)	Yearly expense (€) for bus service provision (2019)
Yellow	3 peak, 2 non-peak	21	36 (every 15 min. at peak, 30 min. at non-peak)	756	–	–
Green	1 (shared between green, blue, and orange)	11	4	44	–	–
Blue		10	4	40	–	–
Orange		16	4	64	–	–
Red (virtual line)	0 (passengers use interurban buses)	18	8	144	–	–
Total	4 peak, 3 non-peak	76	56	1048	272,480	348,731

change in the service provision. This paper addresses these issues by proposing a different, integrated transportation concept for Velenje and its suburbs that aims to increase the accessibility and ridership of its public transport, reducing the perceived distances between Velenje and its nearby settlements while allowing the municipality to keep investments in public transport affordable.

3. Proposal of a new mobility system

In this paper, a different strategy for Velenje's mobility patterns that is based on a combination of a semi-flexible DRTS and an e-BSS is discussed and evaluated through citizens' involvement (focus groups) and a preliminary cost analysis. The municipality of Velenje has been successfully involved in EU-funded projects aimed at empowering cycling, walking, and public transport as a means to reduce externalities from the transport sector, enhance sustainability of commuting patterns, and increase accessibility throughout the region (recent and ongoing projects include Chestnut, Smile, and Smart Commuting). A discussion on possible options for changing the current underutilized public transport system began within the municipal offices and was later expanded as part of the Smart Commuting project. This paper is framed within that context and aims to design a financially sustainable transit network to best serve Velenje's settlements. The combination of DRTS and e-BSS has been identified as a promising solution through the analysis of the existing literature; this combination was refined thanks to a productive dialogue with the Municipality of Velenje and its citizens. Relevant stakeholders and citizens were involved in this research through the EU-funded Smart Commuting project (which includes various engagement activities within the drafting of a Sustainable Urban Mobility Plan—SUMP—for the area) and through an interview campaign developed specifically as part of this research and carried out in the form of focus groups in March 2020.

3.1. Focus groups

A preliminary part of this work aimed at identifying daily mobility issues that people living in Velenje face and exploring how citizens may perceive a change in the transit system. Focus group interviews were hence implemented to examine citizens' willingness to use the new transport system and the trade-off between travel modes. The results have guided the service design and policymaking.

Transportation researchers often use focus groups to collect data (e.g., Hwang, Li, Stough, Lee, & Turnbull, 2020; Levin, 2019; Naznin, Currie, & Logan, 2017; Pudāne et al., 2019). Focus group interviews have several advantages over face-to-face interviews or questionnaires (Hwang et al., 2020). They allow for direct interaction with participants, which can help the researcher to get better insight into their needs and opinions than asking them to fill out a questionnaire. In fact, participants can exchange anecdotes, views, and experiences as well as express ideas that otherwise may have gone unheard. Moreover, this qualitative method is a cost-effective way of collecting data because group interviews take less time than individual interviews.

We made a cautious effort to select a balanced mix of individuals in terms of age, gender, professional status, ownership and/or availability of a car, and area of residence. Participants were recruited among residents through snowball sampling, a nonprobability approach that is often used in qualitative research and in which the researcher recruits a few volunteers who, in turn, recruit other volunteers. People were recruited if they lived in Velenje, spoke English, were 18 years old or older, and had internet access. The authors acted as moderators for the focus groups. Older people, who are usually retired and may need to use public transport the most, could be less confident speaking English or using the interview technology. Thus, to prevent them from being overlooked in the focus groups, we invited their grandchildren/family members to help them. For those who did not have English-speaking friends or relatives, we made an interpreter available to ask questions in their native language of Slovenian, allowing them to feel more comfortable.

The participants were invited to the focus groups by e-mail or phone. We informed them about the focus group arrangements and asked for their consent to audio record the sessions and to use the collected data for scientific purpose. We guaranteed them that the data would be anonymized for confidentiality reasons. All participants agreed and gave permission for their quotes to be used in research publications.

A total of 30 people were recruited. We organized three focus groups of 10 participants each. The sample size and group size choices were in line with the best practice literature (Fern, 1982; Guest, Namey, & McKenna, 2017). The groups had to be small enough for everyone to have the opportunity to share insights and yet large enough to provide diversity of perceptions, as suggested by Krueger and Casey (2015). Grouping people with similar characteristics increases the likelihood of shared experiences and fosters more comfortable conversation within each group (Hesse-Biber & Leavy, 2011). We thus clustered the participants into three groups based on the area of residence (the suburban areas vs. the urban center of Velenje) and, for residents in suburban areas, on age and professional status. Since residents of less-served suburban areas might be more aware of the limits of the existing system and would more likely be the main potential users of the newly proposed public transport system, they were overrepresented with respect to people living in the city center. We further divided them into two groups since differences in the choice of transport mode may exist among younger working people and older retired ones.

The interviews were conducted during the last two weeks of March 2020 via the Skype and MS Teams platforms. The COVID-19 emergency prevented us from personally meeting the participants. However, as confirmed by the respondents, receiving a video call at home—an environment that is comfortable and familiar—decreased stress and made them feel more confident. Moreover, it lowered time costs for the participants, allowing us to involve participants who would not have been willing to travel to reach the meeting place. Fortunately, we did not encounter any technical issues, and everyone was able to easily connect to the platform.

In alignment with the previous literature (Krueger & Casey, 2015; Simons et al., 2014), the interviews lasted approximately 50 min in order to avoid exhausting the respondents. Long meetings often lead to decreased attention spans. The timeframe allowed us to avoid this while still having enough time to develop the main topics.

Before each focus group, all participants were asked to complete a short questionnaire to collect data about their sociodemographic characteristics, including gender, age, education, annual income, work status, and the number of cars owned by the family in order to identify users who are more likely to choose the new transport system. Table 1 in Appendix A summarizes this information. The overall sample was balanced between men and women. The majority of the respondents (43%) were between 25 and 44 years old, 33% were between 45 and 70 years old, and 23% were under 25. Additionally, 53% had a full-time job, and 50% had a high school diploma. For half of the sample, the family owned only one car and had children. Finally, 70% of the respondents stated that their annual family income was between €30,000 and €50,000.

We then used semi-structured guided questions for the interviews. A full list of guided questions can be found in Appendix B. The interview began by asking participants their current daily travel mode and the main determinants of their choice (i.e., why they do or do not use the existing public transport system). Thus, we encouraged them to put forward any problems with the current system and to suggest improvements. A scenario-type approach was then employed in which participants were presented with the hypothetical new transit system that we had developed together with the municipality based on public data about the existing system (e.g., routes, areas served, and number of buses) and from previous literature. The newly proposed system

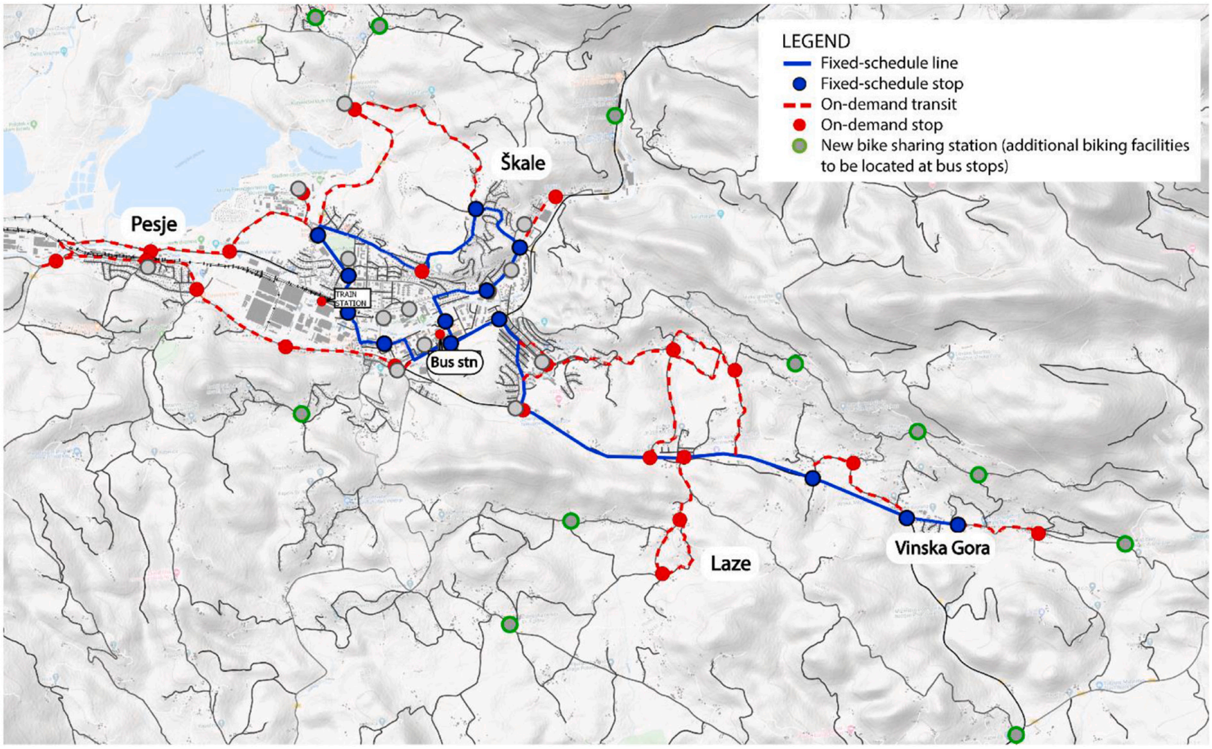

Fig. 5. First proposal of the new DRTS and e-BSS presented to the focus groups for review.

accounted for many of the issues that emerged in the first part of the focus groups. We showed participants the Velenje map and explained our draft proposal for serving the area, which features a fixed schedule "backbone" line, a number of on-demand stops to be served upon reservation, and an e-BSS that would be promoted alongside the DRTS (see Fig. 5). The use of the map enabled the participants to have a deeper understanding of the new system and to provide answers in a more systematic way.

Data analysis allowed us to identify four main themes: current mode choice, attitude towards buses, attitude towards cycling, and evaluation of the DRTS and e-BSS. Table 4 summarizes the main results.

3.1.1. Current mode choice

The focus groups pointed out noteworthy differences between citizens living in the urban center (Group 1) and in the suburban areas (Groups 2 and 3) of Velenje. Nearly 60% of the participants living in suburban areas owned at least two cars (70% for younger/working people vs. 50% for older/retired participants), whereas 80% of urban participants owned only one car. This difference is mainly explained by the poor accessibility and frequency of public transport in peripheral areas forcing respondents of these areas to choose a private car as their primary transportation mode. Long distances, flexibility, and shorter travel times were the reasons suburban citizens primarily travelled by car. Most of the respondents living in the urban area moved around the city center on foot or by personal bike. The short distance from their workplace to home was the main determinant of their choice.

3.1.2. Attitude towards buses

We observed differences between citizens in urban and peripheral areas in terms of their attitude towards using the bus. Respondents living in suburban areas stated that they would like to use their cars less and switch to using the bus, but the limitations of the existing system prevented this. They stressed their need to walk more than 1 km to reach the nearest bus station and complained about long waiting times at stations. They pointed out the low frequency of buses, the mismatch between bus schedules and working hours, and inefficient bus routes (to reach as many areas as possible, the routes are long and only go in one direction, thus lengthening the time it takes to reach the city center). One participant (a 45-year-old male) stated the following:

> There are only four buses a day, and they ride a not convenient route for me; they go in the opposite direction than what I need. They travel a longer route and take 20/25 min to get me to work. With my car I reach the workplace in only 4 min. Time matters.

Another woman (35 years old) complained "My working hours do not match with those of the bus, therefore I am forced to take the car." A retired woman claimed "I would take the bus to go downtown, but there are very few routes, and the risk is to wait too long to go home."

For the respondents living in urban areas, they forgo using the bus to move around the city center, preferring active mobility facilitated by the short distances. Unlike the people living in more peripheral areas, they were quite satisfied with the existing public transport in terms of frequency, daily coverage, and costs (buses are free of charge for Velenje residents).

3.1.3. Attitude towards cycling

The long distances from the city center and the hilly landscape of the suburban areas meant that most people living in such areas did not utilize bicycles to reach the city center. Other factors, such as travelling with a child or having a lot to carry, also decreased the likelihood of cycling. Younger people, however, stated that they made use of bikes, but only for recreational purposes. Replies such as, "I have a traditional bike, but I am not fit enough to cycle uphill for a round trip" or "I am too lazy to cycle" were common among older respondents.

Citizens in urban areas, on the other hand, proved more inclined to use bicycles because of the flat nature of the route and the shorter distances. Most of them, however, stated that they would only use bikes if the weather was nice.

3.1.4. Evaluation of the DRTS and e-BSS scheme

We asked respondents if they felt that the proposed system could overcome the issues previously mentioned and if they would be willing

Table 4
Main results of focus groups.

	Group 1 (Urban area)	Group 2 (Suburban area)	Group 3 (Suburban area)
Number of participants	10	10	10
Current transportation choice			
Which mode of transport do you use most often to go to the city center?	Walking, bike	Car	Car
What are the main determinants of your choice?	Short distance	Long distance, flexibility, shorter travel time	Long distance, flexibility, shorter travel time
Attitude towards buses			
Why don't you use the bus?	With short distances, cycling or walking becomes faster	Infrequent, longer travel time, unavailable for commuting to work, but would like to avoid using the car	Infrequent, longer travel time
Attitude towards cycling			
Do you have a bike?	Yes: 6	Yes: 5	Yes: 2
Do you usually ride a bike to go to the city center? Why?	Yes: 6	Yes: 2 Obstacles: Long distances, uphill roads, luggage	Yes: 0 Obstacles: Long distances; uphill roads
Evaluation of the DRTS and e-BSS			
Are you interested in this service? Why or why not?	Yes: 6 Issues: not needed	Yes: 8 Issues: none	Yes: 10 Issues: more interested in using the bus than biking
Would you be willing to pay a ticket for this new service?	Yes: 10	Yes: 10	Yes: 10
If so, how much would you be willing to pay?	~1.0 €	~1.6 €	~1.5 €
Is 30-min notice enough time to book the bus service?	Yes: 10	Yes: 10	Yes: 10
Booking and payment would be done via app. Would this be acceptable?	Yes: 9	Yes: 8	Yes: 2

to switch to this new system. We also investigated affordable tickets, expected booking time, reservation and payment methods, and whether they agreed that this type of service could improve the level of transport service, especially in less-served suburban areas. We used the collected information and suggestions to better define the design and policy-making of the DRTS.

Overall, we recorded a positive perception of the new transport service, which we feel is even more significant given the pandemic period in which the interviews were conducted. As for the DRTS system, there was enthusiasm, especially among participants living in the suburbs. They stated that if such a service guaranteed that there would be bus stops located closer to their homes and destinations as well as more frequent buses during working hours, they would consider the use of public transit as their primary daily travel mode. This implies that DRTS is a promising transit service in this area.

The e-BSS, in contrast, was deemed useful, but less so for daily trips:

> I would not ride a bike, even an e-bike, to get the city center or to reach the nearest bus stop. I often carry bags; I play sax, and I often carry it with me, so it would be inconvenient for me to ride a bike. It would be different to use this service on weekends. In that case, yes, I would gladly take the bike. (23-year-old female).

> The area where I live is not flat, then the distance from the center is relevant … using the bike at my age and in these conditions (up and down) is not the best! But the electric bike could be a great solution. I could consider it, but only to have fun during a sunny day. (63-year-old female).
> Great the possibility to rent the electric bike and not have to buy it. You take it only when you need it, and if you shop and have bags with you, you go back by bus. I think it's a good idea. It is also a way of doing some physical exercise. (45-year-old female).

The discussion with participants also generated topics that the moderator had not anticipated, such as environmental aspects. Some participants were particularly aware of environmental issues and wanted to contribute to environmental protection in some way, such as by leaving their car at home. Thus, they were happy with the proposal and hoped it would be implemented.

Regarding the economic aspects, even though the existing public transport is free of charge, all of the respondents from the suburban areas claimed that they would be willing to pay for a ticket if the new service guaranteed more flexibility in terms of transit times and coverage. Most of the respondents, in fact, seemed to be well-aware of the costs incurred from operating a car (fuel economy, parking fees, maintenance, etc.) and were therefore willing to consider the trade-off with the new system. People in urban areas were also willing to pay a ticket, but on average at a lower price with respect to those in suburban areas. Many citizens suggested keeping the price low and considering the same fare for on-demand bus and e-bike sharing services.

The reservation requirement was not negatively perceived by respondents as a barrier that would restrict flexible travel. Younger respondents were enthusiastic about the app as a reservation tool but at the same time expressed doubts about the effective accessibility of such technology for older people or for people who are reluctant towards new technologies. For such users, they suggested also allowing phone reservations. We registered the same attitude among older respondents.

3.2. The combination of DRTS and e-BSS

As previously mentioned, on-demand services can provide transit to more users at lower costs by efficiently employing economic resources in terms of vehicles, staff, and fuel, thus improving services without a significant cost increase (Rahimi, Amirgholy, & Gonzales, 2018). Depending on the characteristics of the areas to be served, the elements of flexibility can vary and may include scheduling, type of operations, type of vehicle, and area of operations (OECD & ITF, 2015). Based on the features of the operations, four settings in particular were identified by Nocera and Tsakarestos (2004): line operation (one to one), band operation (few to one), sector operation (many to one), and area operation (many to many; Fig. 6). A Geographic Information System-based analysis of current public transport operations and the distribution of households in the Velenje area, together with some productive dialogue with the Municipality of Velenje, allowed us to identify the most relevant corridors and areas for public transport. These and other

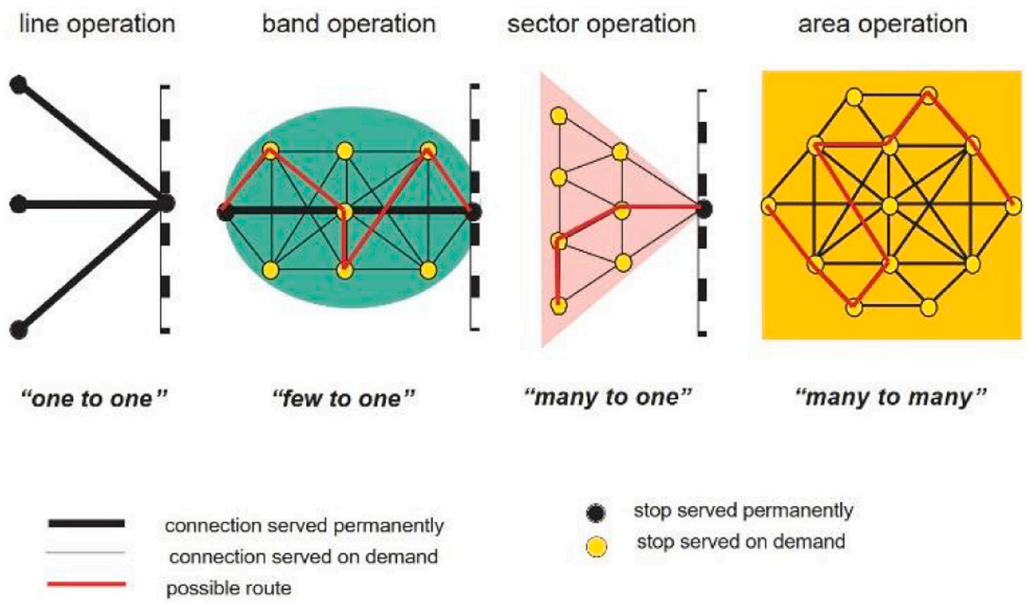

Fig. 6. A mix of band and sector operations was chosen from among various possibilities for application in Velenje (Source: Nocera & Tsakarestos, 2004).

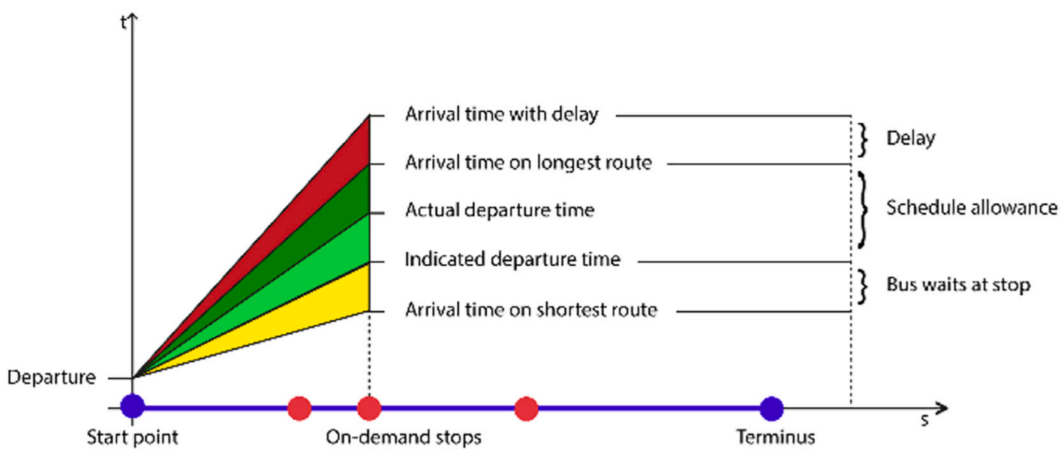

Fig. 7. Building a schedule for a band-operation DRTS (Source: Nocera & Tsakarestos, 2004).

relevant settlements that are currently isolated will be included in the new DRTS and e-BSS. A band type semi-flexible DRTS setting[4] was selected among various possibilities as the most suitable for serving the area. This setting features a fixed schedule "backbone" line together with a limited number of on-demand stops served on reservation. A second sector-type DRT line would also be introduced to serve selected areas and connect them to the train station. To enhance system accessibility, the improvement of the BSS and an increased number of available e-bikes is promoted alongside the DRTS.

Fig. 7 intuitively shows the functioning of a DRT band-operation bus line, showing how the schedule may adjust for some intermediate stops to allow for efficient and reliable service in all situations, independently from the bus taking detours to serve on-demand stops or not. At selected intermediate stops, the schedule provides allowance for waiting in case the bus is requested to perform the longest route, thus allowing it to continue onwards within a given schedule allowance. This reduces the effectiveness of the service by lowering its commercial speed. However, it also cuts down on time fluctuations (which are generally not well-tolerated among customers), thus making up for some possible accumulated delay.

As mentioned above, a semi-flexible DRTS was introduced for Velenje. The draft discussed in the focus groups included two bus routes (to be operated by the existing fleet; see Fig. 8), an extended BSS (compatible with the existing system; Fig. 8), and suggested a growth of the role played by buses and train stations as modal interchange hubs.

During the early stages of the proposal development, a reduced bus coverage was considered, to be flanked by the additional provision of a collective taxi service to reach residents who live in rural communities and are unable to cycle. This option, however, was later scrapped due to excessive costs and low interest expressed by the municipality and key stakeholders, who stated their preference for a "proper" bus system.[5]

[4] Semi-flexible operating policies are defined by Errico, Carinic, Malucelli, and Nonato (2013) as transit services combining on-demand service adjustment capabilities and schedules characteristic of conventional transit. Such services have been seldomly discussed in the literature compared to fully flexible transit options. However, scheduled demand-responsive connectors used as feeders to schedule public transport lines have been found to perform well when dealing with band or sector operations because they are nearby or connected to a scheduled transit corridor (Li & Quadrifoglio, 2010; Qiu, Shen, Zhang, & An, 2015).

[5] Despite a great variability in numbers, subsidies per passenger journey are often significantly higher in the case of collective taxis if compared to those for

Fig. 8. A shared e-bike and local bus in Velenje; these are the backbone of the proposed integrated system Reprinted from Municipality of Velenje, 2020.

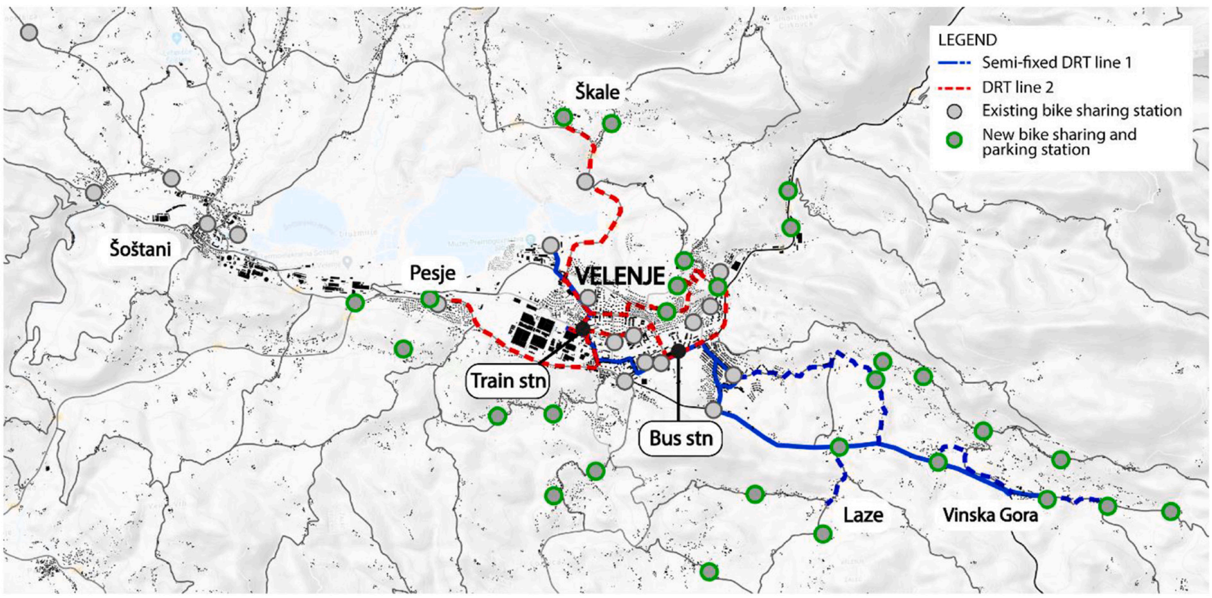

Fig. 9. Connections between bus routes 1 (blue) and 2 (red) and bike sharing and parking facilities in the Velenje area. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

For these reasons, the proposed DRTS has been expanded to virtually any location reachable by bus within the municipality of Velenje, thus providing a sensible increase in public transport offering. Another reason of concern while defining the new transit system for Velenje was the substitution of the Yellow line with an on-demand service. It is interesting to stress that the change arising with the demand shifting from buses to other modes might not be fully absorbed by active transport (Coutinho et al., 2020). However, in this particular situation, this might not be the case for one should also consider that the Yellow line provides a useful yet inefficient service for those unable or unwilling to walk or cycle within the urban core. As explained in section 2 and as made evident by the focus groups' outcomes ("it is faster to walk [than to use the yellow line, ed]"), the Yellow line mostly serves inelastic demand. Moreover, Velenje's city center is not an easily drivable area due to the many restrictions enforced. For these reasons, we believe that our proposed DRT and e-BSS could solve the issue presented by Coutinho et al. for it aims at satisfying the inelastic demand that needs a PT service and it attracts new users currently relying on walking or driving to parking facilities and then walking the last mile.

The architecture of the proposed DRTS for the Velenje area is reported in Fig. 9, which shows the new bus lines (in blue and red) and their relation to new and existing bike sharing and bike parking facilities (grey with green and black borders, respectively). Fig. 10 details the location of the bus stops and numbers them according to the schedule proposals reported in Tables 4 and 5.

The "backbone" line 1, represented in blue, would run on weekdays every 30 min from 6:00 to 20:00. It would operate as a fixed-schedule line with a limited number of on-demand diversions (band operations) and would perform 29 daily departures. Diversions are designed to serve on-demand rural communities, often located uphill, thus easing access and regress to PT service while keeping costs and trip time low. The line would link the stadium (stop 1), where a parking lot is located, with the train station and the Gorenje factory (stop 4), the main bus station (stop 7), and some of the most inhabited suburbs of the city (Laze, Bevče, Pirešica, Vinska Gora, and Prelska). Line 2, shown in red, would operate as an on-demand feeder to line 1 along the red line. It would start at the train station (stop 4) and offer a 60-min headway between 6:00 and 19:00, with peak-time reinforcements. Its scheduled departures, performed only if requested, would guarantee a quick interchange with line 1 at the train or bus stations. The line links Velenje city center with Škale (stops 29 and 30) and Pesje (stops 32 and 33) before ending at the Velenje-Pesje train station.

The details of the DRTS operations are reported in Tables 5 and 6. Both lines would be operated according to a repetitive, easy-to-remember schedule. Line 1 is 9.1 km one way (excluding on-demand diversions) and takes 23 min. Including layovers, two vehicles would be

(*footnote continued*)
public transport. The balance between subsidy and fare revenue is at times also worse for collective taxi systems. The UK Government statistical office (2020) declared a net subsidy per passenger trip of £0.628 in 2018/19, in line with values shown in the last decade, for rural PT services in England. A different government study (UK Commission for Integrated Transport, 2008), instead, shows that collective taxi services in the UK and in mainland Europe require a subsidy per passenger journey between £1 and £7, rising over £10 in smaller systems.

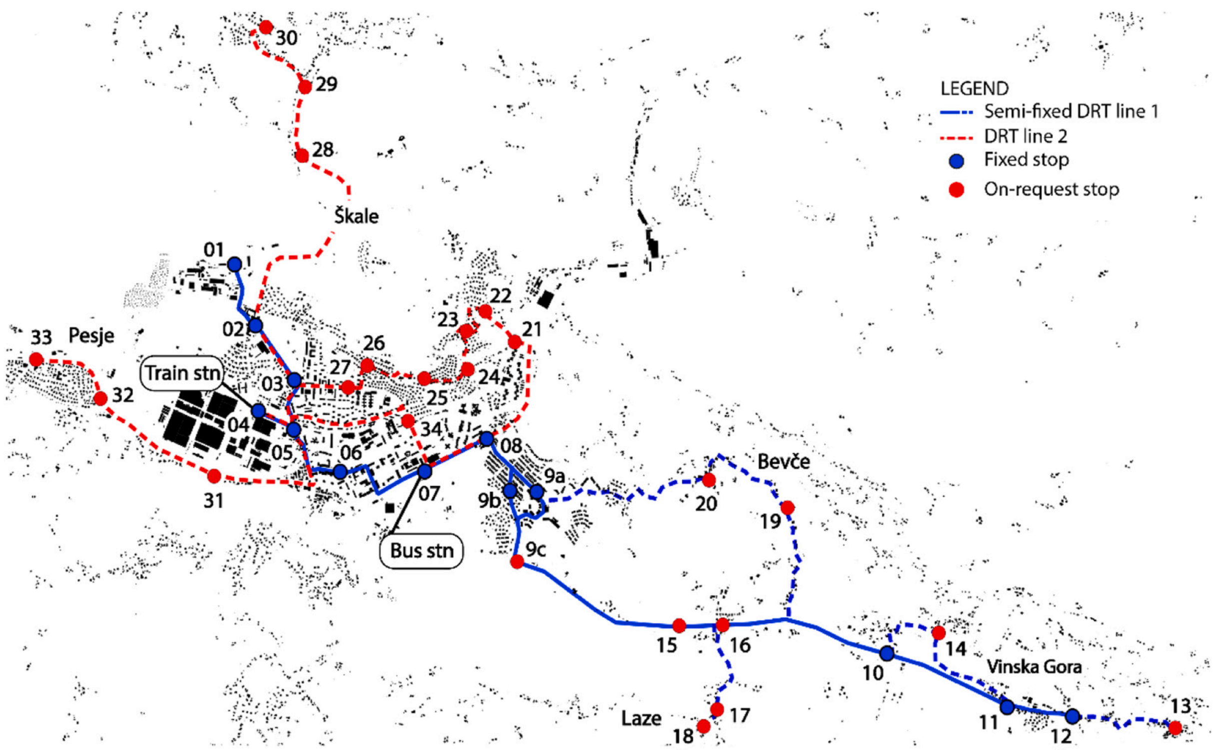

Fig. 10. Details and numbers of new fixed (blue) and optional (red) bus stops. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 5
Itinerary and stops on DRT lines 1 and 2.

LINE 1 (blue)			LINE 2 (red)		
km	Stop no.	Time	km	Stop no.	Time
0	1-Stadium	00:00	0	4-Train stn	00:00
0.5	2	00:01	0.6	3	00:01
1	3	00:02	1.1	2	00:02
1.6	4-Train stn	00:04	2.8	28	00:05
1.9	5	00:05	3.3	29	00:06
2.4	6	00:07	4	30-Škale	00:07
3.2	7-Bus stn	00:08	4.7	29	00:08
3.7	8	00:10	5.2	28	00:10
4.2	9A/9B	00:11	6.9	2	00:12
1.3	20	00:12	7.4	3	00:13
2.1	19	00:14	8	4-Train stn	00:15
3.7	10	00:19	1.3	34	00:19
0.7	9C	00:12	1.7	7-Bus stn	00:25
2	15	00:13	2.2	8	00:26
2.3	16	00:14	3	21	00:27
3.5	10	00:19	3.3	22	00:28
2.9	17	00:15	3.7	23	00:29
3.1	18	00:16	4.1	24-City center	00:30
5.2	10	00:19	4.4	25	00:31
7.7	10	00:19	4.9	26	00:33
0.6	14	00:19	5.2	27	00:35
1.4	11	00:20	6.1	4-Train stn	00:40
8.6	11	00:20	0.3	5	00:41
9.1	12	00:21	1.5	31	00:43
0.8	13	00:23	2.4	32	00:45
Return trip identical			3.1	33-Pesje	00:48
			3.8	32	00:51
			4.7	31	00:53
			5.9	5	00:56
			6.2	4-Train stn	00:58

Table 6
Schedules for DRT lines 1 and 2.

Timetable Line 1 (blue)			Timetable Line 2 (red)		
Stop no.	Bus 1	Bus 2	Stop no.	Bus 1	Bus 2
1-Stadium *departure*	xx:10	xx:40	Inbound line 1	xx:00	Peak only
4-Train station	xx:15	xx:45	4-Station *departure*	xx:00	
7-Bus station	xx:20	xx:50	30-Škale	xx:07	
10	xx:29	xx:59	4-Train station	xx:15	xx:45
12-Arrival	xx:33	xx:03	Outbound line 1	xx:15	xx:45
12-Departure	xx:40	xx:10	Inbound line 1	xx:25	xx:55
10	xx:43	xx:13	7-Bus station	xx:25	xx:55
7-Bus station	xx:55	xx:25	24-City center	xx:30	xx:00
4-Train station	xx:00	xx:30	4-Train station	xx:40	xx:10
1-Stadium *arrival*	xx:05	xx:35	Outbound line 1	xx:45	xx:15
First: 6:10 from terminal stops			Inbound line 1	xx:30	–
Last: 20:10 from terminal stops			33-Pesje	xx:48	–
			4-Station *arrival*	xx:58	–
			Outbound line 1	xx:15	–
			First: 6:00 from terminal stop		
			Last: 19:00 from terminal stop		

needed to guarantee a 30-minute headway. Line 2 is comprised of three different subsections—one serving Škale (8 km long), one serving Pesje (6.2 km long), and a loop serving the Velenje city center and bus station (6.1 km long)—all of which would be operated on demand only and would terminate at the train station. One vehicle could guarantee a 60-minute headway on all sections, as shown in Table 5. Stops of both lines have been chosen in full accordance with the Municipality of Velenje, and existing stops (when present) have been maintained and reassigned to the new system. Moreover, as mentioned already, a GIS-based analysis has allowed to identify the distribution of households and population in the area.

Reservations would be made by phone or using a web application, with expected pickup times of a few minutes. The use of recent, real-time operations technological innovations would contribute to making FTS a more inclusive, reliable, and attractive format compared to the current service (Dimitrakopoulos, Uden, & Varlamis, 2020; Mohamed, Rye, & Fonzone, 2019). Current Information Communication Technologies allow for real-time scheduling, which is managed by on-board devices for the operator's needs and via web applications for users' needs (e.g., reservations, information, and payment), in line with other recent FTS experiments (Gross-Fengels & Fromhold-Eisebith, 2018).

A BSS was recently developed in Velenje as part of the European project known as Chestnut (Municipality of Velenje, 2020c). The system has since been expanded and now offers 57 bikes distributed among 12 stations in Velenje (including three e-bikes; see Fig. 7) and 25 bikes among five stations in the nearby town of Šoštanj (Municipality of Velenje, 2020d). Since both the implementation and maintenance phases have been fully funded by EU funds, the existing BSS should not be included among current costs for public and shared mobility (BICY, 2020). This paper proposes a reinforcement of the BSS outside the city's main core for use as a feeder to both bus lines, with a specific focus on the modal interchange between both shared and private bikes and the fixed-operations buses of line 1. The integration of DRT and bike sharing is, to the authors' knowledge, an innovative solution in rural contexts, and literature on the topic is not very extensive. However, benefits from "hardware" and "software" integration between multiple transport modes, which contribute to the mobility as a service concept, have been significant in a variety of studies as highlighted in Ambrosino, Nelson, Boero, and Pettinelli (2016). The expansion of Velenje's BSS would include the provision of 28 additional docking stations, six of which would be located at bus stops, and 96 e-bikes. Despite increasing investments and maintenance costs, the choice of e-bikes as a complement to the existing BSS is necessary due to the hilly geography of the area.[6] The weather in Velenje is known to be mild, with cold but dry winters compared to Ljubljana and to the Slovenian average (Weatherbase, 2020).[7] The valley surrounding the city is sometimes advertised as the "valley of the sun". The literature has demonstrated that even with typical North-European weather, the use of e-bikes is consistent (Fyhri & Beate Sundfør, 2020; Sun, Feng, Kemperman, & Spahn, 2020); the favorable climate in Velenje has aided the success of the existing BSS and encouraged future expansions, such as the one proposed in this paper.

Stations located in proximity to bus stops would be similar than existing ones, with eight to 10 docks, a standard rotation of five e-bikes, and racks for safe storage of personal bikes, per European guidelines (OBIS-IEE, 2011). Stations located in rural settlements would be smaller, with an endowment of three e-bikes and five docks, in an effort to contain costs while enhancing the accessibility of the DRTS via BSS or private bike. Fig. 7 shows existing (grey with black border) and new (grey with green border) BSS locations. Moreover, a digital tool will be made available for desktop and mobile use. The tool will manage all aspects related to service registration, bookings, payments, and information for both the BSS and the DRTS. Access to services will be granted by phone for users not acquainted with web technology.

An additional or alternative measure to the development of the e-BSS would be the provision of financial incentives to support private citizens in the purchase of their own (e)-bike. This measure was however not included in this paper as, unlike the expansion of the BSS, it is not a structural solution and it is also not fundable through EU funds. The Municipality of Velenje acknowledged that the possibility of obtaining regional/national funds for this policy is scant under the current regional and national administrations, and that they had no political interest in such a solution. Indeed, the outcomes of a plan of this sort are uncertain and, more importantly, it does not provide the city with BSS infrastructure.

The combination of semi-flexible DRTS and e-BSS would increase the number of daily connections in Velenje's settlements. In particular, residents of Škale and Pesje would benefit from a maximum of 14 daily rides compared to the current four and eight, respectively. Residents of settlements located to the east of Velenje, currently served by the green and orange lines, would benefit from a maximum of 29 daily rides compared to the existing four. *E*-bikes and personal bike storage at bus stops would allow residents of rural communities to access the DRTS, thus increasing the potential user base. The integrated strategy as a whole is expected to generate a modal shift at the expense of private motorized transport (Cass & Faulconbridge, 2016) by expanding the number of potential users thanks to better coverage (both spatial and temporal, introducing peak time services and modal integration), thus allowing for a reduction in external costs generated by mobility in the area. The diverse elements of the proposed integrated strategy—the new, semi-flexible DRT; the expansion of the BSS with the provision of 96 e-bikes and 28 additional stations; and the development of a digital tool to manage the system—were subject to a cost analysis, which was compared with the current public transport and bike sharing offer. The cost analysis is reported in the following section.

3.3. Cost analysis

As discussed in the previous sections, the new transport system would prove particularly useful for satisfying Velenje citizens' mobility needs. The project, however, must be economically feasible in order for the municipality to implement it. This section aims to verify whether the proposed transport system is economically advantageous compared to the existing one. For this purpose, we considered all the costs related to the implementation of a DRTS, an e-BSS, and their integration.

According to Rahimi et al. (2018), the costs for operating a bus public transport system typically include capital costs for vehicle purchases as well as variable operational costs related to fleet size (e.g., taxes, registration costs, and vehicle insurance), vehicle hours travelled (e.g., total wages, fringe costs, and overhead costs), and vehicle miles travelled (e.g., fuel, tires, and body repair). The total operating costs are usually shown in terms of operational hours and kilometers. The Municipality of Velenje awarded the public transport contract to a local contractor and currently pays an annual service contribution of €348,731, which covers an average annual distance equal to 272,480 km; thus, the service has an all-inclusive cost of 1.28 €/km, of which 53% goes to operating costs and 47% to drivers' wages (Municipality of Velenje, 2020).

The proposed integrated system would optimize the overall routes by both lowering the minimum number of vehicles required to meet the demand without violating the time window constraint (thus decreasing the number of drivers) and by reducing the overall annual distance travelled. The latter varies between 137,228 km if no citizens reserve the on-demand bus service, and therefore the bus does not deviate from the main route, and 226,200 km if all of the on-demand stops must be served, thus considering both detour and line-haul travels. Consequently, considering the current cost per km, the annual costs for operating the bus service range between €175,652 and €289,536. A Monte Carlo algorithm allowed us to use the process of repeated random sampling to make numerical estimations of such parameter. We thus estimated an annual distance travelled of 177,516 km and an annual cost for operating the integrated system equal to €227,220.

An e-BSS is both a flexible addition/complement and an alternative to the public transport system. This system thus represents an opportunity for public transport operators to increase the attractiveness of their services because bikes can be used independently of timetables. The main costs to implement such a service from an operational point of view can be divided into two categories: infrastructure and start of the

[6] *E*-bikes have proven to be particularly useful when trip distances are important and when vulnerabilities—both in terms of the lay of the urban land (for example in the case of hilly streets) and individual physical conditions (for example, when considering people with health difficulties and physical impairments)—make traditional bicycles unsuitable. An e-bike reduces the effort required while saving travel time. Thus, an e-BSS can enhance connectivity for cities that are not bike friendly and have underdeveloped public transportation systems (Ji, Cherry, Han, & Jordan, 2014; Langford, Cherry, Yoon, Worley, & Smith, 2013).

[7] Ljubljiana experiences 186 days of precipitation per year, compared to 124 days in Velenje.

service as well as operating costs. The costs of implementing large-scale systems (solar or grid-powered stations) would vary from €2500–3000 per bicycle (OBIS-IEE, 2011), depending on the system configuration. This range includes both the hardware (bicycles, stations, workshop, etc.) and software (system back end and customer interfaces). The operating costs would be between €1500–2500[8] per bicycle per year, though this would vary according to the size of the system and the usage rates. The greater the bicycle usage, the greater the maintenance costs, customer support needs, and redistribution interventions. Hence, the cost per bicycle would increase. Overall, the total cost for implementing such a service is estimated at €288,600 (purchase of e-bikes and stalls) and €144,000/year (maintenance).

The integration between the DRT and e-BSS with the existing BSS is an important aspect that should be taken into consideration. Such an integration must take place on three levels: integration of information for facilitating intermodality, physical integration in order to integrate the BSS with public transport during peak hours or in areas where public transport cannot satisfy all mobility requests, and integration of technological methods of access to services and tariffs. To this aim, we propose e-bike sharing stations located near bus stops and outside the city center for use in combination with public transport.

Regarding access and rates, taking into account the suggestions collected during the focus groups, we propose a fully integrated fare and ticketing system. Such a change would allow citizens to use public transport and rent bikes/e-bikes for bike sharing with a single card or take advantage of special discounts, such as a single daily rate or a special discount for using bike sharing and other mobility services. These integrations would inevitably rely on mobile technology and thus require management software and an app. However, this would enhance public transport use and facilitate operational planning.

Among the most significant ITS applications for the modernization and rationalization of the public transport sector are the AVL/AVM systems for real-time tracking and localization of vehicles; user information systems for providing real-time waiting time at stops and/or on personal devices (smartphones/tablets); and multimodal and multicarrier platforms for mobile payments (based on microchip smartcards, contactless smartcards, short message service, mobile apps, near-field communication, the internet, etc.). The overall costs of implementing such software would depend on its complexity. We estimate that it would cost €40,000, of which €20,000 would be used to equip each bus with an AVL/AVM system for real-time tracking and localization of vehicles, and the other €20,000 would go to the trip planning and the payment app (Osservatorio Nazionale sulle Politiche del Trasporto Pubblico Locale, 2015). The advantages derived from the application of ITS will be significant both for citizens (in terms of the regularity and reliability of the improved service) as well as for the services company and programmers. The mere extension of the AVL/AVM system to the entire circulating fleet could lead to relevant savings in terms of the regularity of the vehicles, fuel savings, optimization of the use of vehicles, and driver shifts.

As summarized in Table 7, considering the overall costs of the individual systems and their integration, we estimate an initial investment equal to €328,600 and an annual operating cost equal to €371,220 (the latter only €22,500 higher than the costs of the current system).

Although the new system requires an initial investment and annual operating costs that are overall higher than the annual contribution currently paid by the municipality, we believe that the public will find it attractive and economically advantageous for at least three reasons. Firstly, the new system would allow for a reduction in social costs by promoting a modal shift from private transport to bicycles and/or public transport. This would contribute not only to lower urban air and noise pollution but also increase citizens' well-being through the use of

Table 7
Cost analysis.

Condition	DRTS only		e-BSS only		DRTS + e-BSS		Current transport system
	Initial costs (€)	Annual operating costs (€)	Initial costs (€)	Annual operating costs (€)	Initial costs (€)	Annual operating costs (€)	Annual total costs (€)
A) Bus with no on-demand requests	–	175,652	–	–	–	175,652	–
B) Bus serving all on-demand stops	–	289,536	–	–	–	289,536	–
C) Most likely estimate for DRTS	–	227,220	–	–	–	227,220	–
D) e-BSS	–	–	288,600	144,000	288,600	144,000	–
E) Software + app	40,000	–	–	–	40,000	–	–
Overall costs of conditions C, D, and E	40,000	227,220	288,600	144,000	328,600	371,220	348,731

[8] http://mobility-workspace.eu/wp-content/uploads/OBIS_Handbook_IT.pdf

active transportation modes. The latter is both a direct effect given by new users of bike sharing and an indirect effect given by the greater diffusion of cycling that the presence of bike sharing typically induces. Additionally, the presence of personal bike stands alongside those dedicated to bike sharing (which are monitored) reduces the risk of theft of individuals' personal bikes. In this sense, the bike sharing could contribute to bicycle marketing by giving it a positive and smart aspect and, more generally, to the development of an advanced and attractive image of the city that does not undervalue equity considerations.

Secondly, the integration of bike sharing with DRTS and the existing transport services (in terms of registration, payments, and unique smart cards for accessing services) would allow users to combine multiple modes of transport and thus contribute to making travel more convenient and efficient. For this reason, we expect an increase in the demand for such a system with respect to the existing one (equal to 35,000 passengers per month). However, even if the demand remained unchanged with respect to the current system, if the service required a fee (an integrated ticket) equal to €1 per ride, the municipality could obtain an annual revenue of €420,000, which would completely recover the initial investment in just one year. If the municipality instead chose to institute the new service free of charge (no registration and/or use fees), it could cover the annual imbalance with respect to the status quo by relying on advertising contracts, sponsorships (for the entire service or for individual components, stations, and/or bicycles), or revenue generated by parking charges or congestion charges.

Thirdly, the proposed system might help reducing the marginalization processes that typically characterize rural areas (Daniels & Mulley, 2012; Vitale Brovarone & Cotella, 2020). The low density and the peculiar geomorphological characteristics of such areas, generally combined with considerable distances from the city center where basic services and work and leisure opportunities are located, make these territories highly car-dependent. Thus, the poor transit quality of Velenje's surroundings definitely leads to reduced mobility of those who, due to age, economic, or cultural barriers, have no permanent access to a car. The proposed system, by providing a widespread and equitable mobility offer (not only to the elderly, but also to young people), might help not only to increase active mobility, alleviate congestion, and reduce environmental impacts, but also to counteract transport-related social exclusion. The resulting improved accessibility will thus contribute to a sustainable development of Velenje.

4. Discussion

In this paper, we analyzed an unattractive and uncoordinated transit system in a Slovenian town and proposed a new system organization based on the combination of a semi-flexible DRT and an e-BSS in order to solve an evident performance problem and promote the local population's use of public transport.

This combined service would incorporate coordinated schedules for an easy-to-remember headway and to provide users with real-time information. The purpose is to minimize waiting times and operating costs while introducing a series of elements capable of increasing the perceived quality and thus shifting demand shares from private transport (Chakrabarti, 2017). In any pilot project that is based on the identification of the mobility needs of the populations concerned and on shortcomings in the current transport offer, the aim is to offer a system of transport services that can meet demand needs at an adequate level of service with minimal social cost for the community (Liu & Xu, 2018). In such cases, the trial phase should be followed by regular assessments in order to correctly calibrate significant parameters.

Our results demonstrate that the proposed system would provide better quality service for the transit customers in Velenje while using approximately the same amount of financial resources for its operation. Compared to the existing bus system, the proposed combined DRT and e-BSS provides all-day service to a wider percentage of the local population, thus enhancing social inclusion and empowering those who are currently unable to reach the city center and train and bus stations autonomously. Contextually, this system may also enable the local municipality to generate resources to cover the up-front costs through the introduction of low-price tickets and seasonal tickets. Evidence from the focus group survey demonstrated a moderate consensus among the sample of possible customers, who expressed a substantial willingness to pay for a DRT service that offers a high level of satisfaction.

Other results demonstrated the possibility of actually cutting down some external costs due to reductions in car use. Some relevant gains were also apparent in the variation in the customers' average travel time: the performance of the integrated DRTS and e-BSS would be supported by the application of an ITS solution for conveying information to customers.

In interpreting these results, we have made some conservative assumptions to bolster our argument. First of all, the discussion of the results has not included any possible increase in travel demand, even though it seems legitimate to expect a customer gain due to the increased attractiveness of the transit supply. This, in turn, can generate positive effects related to (possible) consistently higher revenues, which could be the object of a specific assessment. The same holds true for the analysis of travel times: by its refinement, it could also be possible to see some positive time gains and consequent financial savings.

Another aspect to consider is the possibility to improve the level of customer satisfaction through specific actions, such as the creation of dedicated interchange facilities. In our proposal, we have tried to contain the expense figures and hence did not consider such a possibility in an earlier phase. However, because the proposed system is based on the train and bus stations, this lays the groundwork for further integrations in the future. Furthermore, we did not consider the option of covering the initial infrastructural costs through revenues not already available to the municipality (e.g., those possibly deriving from the acquisition of a future EU-funded project, outstanding state loans, or contributions by foundations). However, the involvement of other key stakeholders could also bring advantages to the integrated system project.

The methodology presented here is generalizable to other similar contexts, which is a significant advantage and a relevant benefit for policy purposes. Future research could involve the use of optimization models to improve operational efficiency of the transport service (Iliopoulou & Kepaptsoglou, 2019; Verma, Kumari, Tahlyan, & Hosapujari, 2017; Wei et al., 2017) or to tackle service and energy costs more specifically (Batarce & Galilea, 2018; Brown, 2018; Cavallaro, Danielis, Nocera, & Rotaris, 2018; Tong, Hendrickson, Biehler, Jaramillo, & Seki, 2017). Future work could also examine additional customer-oriented smart services because interconnected transit solutions foster the possibility of offering further specific services to organizations and transit users (Nocera, Fabio, & Cavallaro, 2020). Finally, some heuristic meta-strategies could be used to improve the design of the bus routes (Bräysy, Dullaert, & Nakari, 2009; Suman & Bolia, 2019).

5. Conclusions

Sustainable mobility practices can be fostered through the promotion and diffusion of the right technologies as well as by offering combinations of transportation modes that are favorable to the population. Ad-hoc measures aimed at increasing the availability and quality of public transport services can rebalance the preferred mode of transport in favor of sustainable transportation and reduce the number of vehicles on the road (Lah, 2019). The goal is to create a mobility system that strengthens the competitiveness of the territories through high quality services while also ensuring a more effective use of resources. Among the key issues is the better integration of modal networks through increasingly connected systems and multimodal connection platforms for passengers. Successful, environmentally friendly solutions include smart mobility (Lyons, 2018), carpooling and carsharing (Bulteau, Feuillet, & Dantan, 2019), enhancement of local transport (McTigue, Rye, & Monios, 2020), integrated planning of transport modes (Holz-Rau & Scheiner, 2019), apps and systems for infomobility (Catalano & Migliore, 2014), the construction of new cycle paths (Mayakuntla & Verma, 2018), toll and pricing policies (Cavallaro, Giaretta, & Nocera, 2018), and electric mobility (Lemme, Arruda, & Bahiense, 2019).

In this context, any pilot projects that foster integrated planning into this process would have particular value. In this paper, we described the integration of an e-BSS and a DRTS to solve the issue of low demand for public transport in the Slovenian town of Velenje. In general terms, placing a pilot action in real contexts means involving local stakeholders and policymakers from the very first stages of planning. Additionally, the plan must consider how differences in infrastructure, geography, orography, settlement and urban planning, and travel demand (including non-systematic mobility) may influence the definition of the key aspects of the system. In the case of system combinations, a main transport system along the primary routes must coexist with one or more adduction systems supporting it (Le Pira, Ignaccolo, Inturri, Pluchino, & Rapisarda, 2016).

Our results show that with funding levels comparable to the existing conventional bus system, a combination of DRTS and e-BSS could be set up to offer broader service hours to a greater share of municipal citizens. Unlike most literature on the topic, in this paper, we developed and evaluated a preliminary cost analysis of this fundable system and concluded that even if there was no increase in users and no application of fares, the Municipality of Velenje would be able to finance the proposed system with its own resources or by participation in EU-funded sustainable mobility projects. The proposed integrated mobility system presented here would not optimally solve transport issues in Velenje's suburban areas; however, it would increase the number of settlements with daily and frequent access to the train and bus stations and to public functions downtown, thus allowing citizens to access public transit and sharing services independently and to choose them for their daily commute. Thus, the proposed system would allow for more equitable distribution of opportunities and accessibility throughout the municipality, making a small step towards transport universality.

People and authorities of the 21st century tend to take for granted freedom of movement. However, awareness is growing regarding the environmental and social costs of travelling as well as the need for fair, inclusive, and accessible transport systems. Some concerns about individual responsibilities for containing primary pollution are also emerging at both the local level (Zhou & Lin, 2019) and on a global scale as more people are now conscious of and concerned by climate change (Nocera, Ruiz-Alarcón Quintero, & Cavallaro, 2018; Nocera & Tonin, 2014; Nocera, Tonin, & Cavallaro, 2015). To some extent, the ongoing coronavirus disease 2019 (COVID-19) crisis has shown that individual behavior can be substantially modified and travel substituted through technological innovations. In many cases, however, there is still no substitute for direct contact, which requires physical displacement and the subsequent creation of certain social costs. However, these costs can be contained through the provision of efficient and low-impact transport systems. The provision of such services must be a central consideration in order to guarantee sustainable future development. However, considering the complexity of modal split mechanisms, striving for an efficient and low impact service may not be sufficient to reduce the negative effects of the mobility system as a whole.

Authors statement

This research has been developed under the common responsibility of all authors.

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Appendix A. Participant demographics

Table A1
Demographics of the focus groups.

Demographics	Group 1 (urban area)	Group 2 (suburban area)	Group 3 (suburban area)
Gender			
Male	50%	70%	40%
Female	50%	30%	60%
Age (years)			
< 25	20%	40%	10%
25–44	60%	50%	20%
45–70	20%	10%	70%
Number of cars in household			
0	0%	0%	0%
1	80%	30%	50%
2 or more	20%	70%	50%
Household structure			
One-person	0%	0%	20%
Multi-person, no children	30%	30%	70%
Multi-person, with children	70%	70%	10%
Position in labor market			
Employed full time	70%	60%	30%
Employed part time	0%	0%	0%
Student	30%	40%	0%
Unemployed	0%	0%	10%
Retired	0%	0%	60%
Highest education level			
Post Graduate	0%	0%	0%
Master	20%	20%	0%
Bachelor	50%	40%	20%

(*continued on next page*)

Table A1 (*continued*)

Demographics	Group 1 (urban area)	Group 2 (suburban area)	Group 3 (suburban area)
High school diploma	30%	40%	60%
Professional degree	0%	0%	20%
Junior high school license	0%	0%	0%
Annual household income			
< €30,000	30%	20%	20%
€30,000–50,000	70%	70%	70%
€50,001–70,000	0%	10%	10%
€70,001–100,000	0%	0%	0%
> €100,000	0%	0%	0%

Appendix B. Focus group topic guide

Introduction (5 min):

- Welcome and thank the participants.
- Introduce yourself and provide a brief description of the research.
- Review the ground rules: everyone's ideas are important, and everyone will be given an opportunity to speak. There are no right or wrong answers; even negative comments are useful in gaining insight about the topic under discussion.
- Remind everyone that the session will be recorded.
- Remind everyone that the whole process is confidential: anonymity will be kept; all the audio recordings and transcriptions will be used solely for research purposes.
- Provide the researchers' contact details.
- Ask if there are any initial questions before the focus group starts.

Ice breaker (2–3 min):

- Ask everybody to introduce themselves:
  - First name
  - Occupation

Discuss the existing public transport in Velenje (20 min):

- *Which mode of transport do you use most often to go to the city center? Which are the main determinants of your choice?*
- *Why do you (or do not) use public transport?*
  - Let people share their thoughts and experiences.
- *Do you have a bike? Do you usually ride a bike to go to the city center? Why?*
  - Let people share their thoughts and experiences.

Introduce a scenario-type approach in which the focus group participants are presented the DRTS + e-BSS (15 min):

- Explain that this is our draft scheme based on previous contacts with the municipality and on the literature.
- *Are you interested in this service? Why or why not?*
- *Would you be willing to pay a ticket for this new service? If so, how much would you be willing to pay?*
- *Is 30-min notice enough time to book the bus service?*
- *Booking and payment would be done* via *app. Would this be acceptable?*

Sum up the meeting (5 min):

- Thank all the focus group participants for their time and effort.
- Remind them that the use of all information collected will be confidential.
- Ask the participants whether they would like to receive a follow up (to be generally informed about the conclusions of the study).

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