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PUBLIC TRANSPORT INNOVATION: A CASE STUDY IN FRIULI-VENEZIA GIULIA

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Abstract

Road public transport is usually organized at spatial level based on traditional business models of fixed routes and scheduling, while innovative on-demand services are rarely provided over territories. On-demand public transport services (DRT – Demand Responsive Transport) represent a more flexible option and a significant opportunity for public transport companies to increase their ridership by diverting users from private cars, while serving the territory more effectively, especially in weak-demand areas. In the Friuli-Venezia Giulia region (Northeastern Italy), the Regional Public Transport Plan specifically identifies the so-called "third level services", consisting of flexible transport options like on-demand services. However, such services have never been designed and deployed in the Region yet. In this paper, the first ever on-demand service in the region – called SMARTBUS – is designed and tested to serve weak-demand, peripheral/rural areas, namely the Karst uplands. Eventually, policy recommendations are elaborated to support policymakers overcoming existing regulatory and operational barriers.

Keywords: public transport, Demand Responsive Transport, Friuli-Venezia Giulia.

1. Introduction

Road public transport is usually organized based on business models of fixed routes and scheduling as well as traditional vehicle sizes and types. At spatial level, it is designed focusing on the concept of "line". As a result, in peripheral and rural (weak-demand) areas, the provision of traditional public transport services is hardly perceived. Indeed, when the quality of the transport services – e.g., frequency – drops substantially, users would get a feeling of the nonexistence of public transport on the territory. At the same time, on-demand public transport services (DRT – Demand Responsive Transport) represent a significant opportunity for public transport companies to serve the territory – particularly weak-demand areas – more effectively, thus, increasing their ridership and diverting users from private cars. In this case, the overall business model rationale is turning upside down: instead of a "waiting for the bus" (traditional) approach, DRT adopts a "users calling for the bus" framework.
In Friuli-Venezia Giulia regional policies identify the so-called "third-level services". Third-level services consist of flexible transport options like on-demand services. More specifically, flexible services can be designed and developed in weak-demand areas – meaning, with less than 5.000 residents – to substitute or extend traditional fixed-route services (complementary services), usually in off-peak hours. The aim of flexible services is to increase the spatial accessibility at regional level, improve the

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public transport quality of services and optimize the overall public transport system over the territory. In fact, flexible services are associated to non-regular/low transport demand (random mobility) distributed over many dispersed origin-destinations, where traditional services turn out to be dramatically inefficient and ineffective.
Regional policies identify various categories of flexible public transport services – see Table 1.

Type of service	Description
A - Fixed route service	Routes are pre-defined and cannot be changed. Routes consist of a predefined sequence of stops. This category represents the type of flexible services which are more similar to traditional ones. Subcategories include: A.1: Services are operated only if/when requests are made. A.1: Schedule can slightly be changed according to users' requests.
B - Baseline routes with possible detours	Predefined routes are identified, and they can be slightly changed depending on users' requests. Changes can consist of limited detours on a predefined network. Timetables are provided within a predefined time period of service operations and availability. They can be modified – indeed, significantly – provided that the service is operated within the predefined time period.
C - Free routes connecting a predefined set of network nodes	These services can be further classified into: - "Zonal services": connecting major network (e.g., interchange stops) and peripheral predefined nodes (e.g., public transport stops). - "Area wide services": connecting peripheral nodes (e.g., public transport stops). In both cases, some service flexibility is allowed in terms of schedules and routes, however with some limitations: - Routes are specified according to a predefined network. - Schedule must be provided within a time period of service availability.
D - Free routes connecting any set of nodes	These services are similar to collective taxi's. They are completely flexible. However, some limitations are in place in terms of: - Routes: a predefined network must be used. - Schedule must be provided within a time period of service availability.

Table 1: Categories of flexible public transport services in Friuli-Venezia Giulia. Source: Piano Regionale del Trasporto Pubblico Locale – Regione Autonoma Friuli-Venezia Giulia.

According to regional policies, the design and implementation of flexible services are left to ad hoc projects, including European ones, in which stakeholders should get involved. Smart on-demand services must be developed firstly as pilot actions. The timing and budget of the pilots should be estimated. Following good pilot results,

flexible services can be formally recognized and eventually included in regional plans. According to this framework, a pilot action to develop, design and implement an innovative on-demand service aiming at improving the accessibility of peripheral and rural areas around the Trieste areas cross-bordering with Slovenia has been carried out by the University of Venice along with Trieste Trasporti, the major local public transport company. An innovative solution – called "SMARTBUS" – has been designed, developed, and eventually deployed in selected areas.

2. The geographical context: an overview of the study area

The pilot study area (Figure 1) consists of the former province of Trieste, which is made up of 6 Municipalities, including Trieste, Muggia, San Dorligo della Valle, Monrupino, Sgonico, Duino-Aurisina. The territory is composed by a narrow land strip some 30 km long, which stretches between the Adriatic Sea and the Karst uplands (about 400 meters above the sea level), from the North-West (provinces of Gorizia, Monfalcone, Gulf of Panzano) to the South-East (Trieste), bordering Slovenia (coast) and the Gulf of Trieste (in the Adriatic Sea). The city of Trieste represents the central location and the hub connected with five "hinterland spokes" Municipalities.

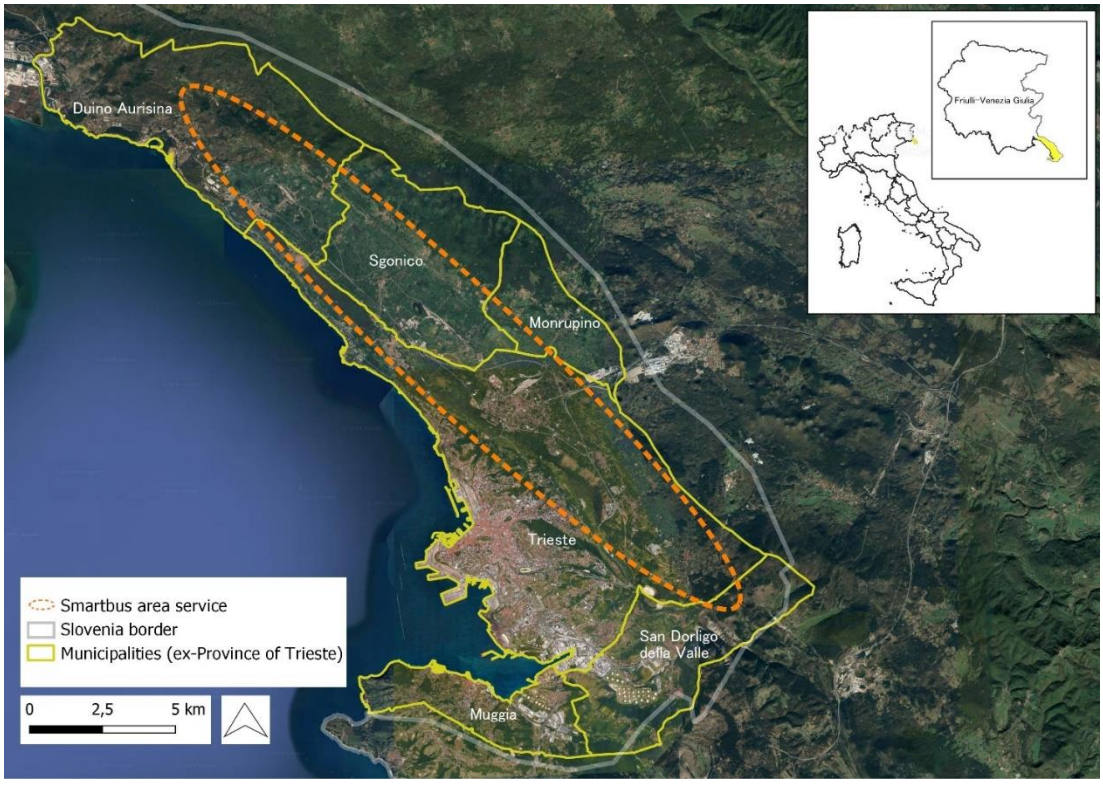

Figure 1: The pilot study area.
Source: this study.

Within the study area, pilot activities focus on the five Municipalities in the Karst uplands, namely Sgonico, Duino-Aurisina, Monrupino, San Dorligo della Valle and partially Trieste (District I and II).
The main objective of the Demand Responsive Transport (DRT) service is to improve the attractiveness of public transport through more efficient connections between the

peripheral area and the Municipality as well as between the small villages and the main centres of the peripheral area around Trieste on the Karst uplands. Traditionally, these areas are characterized by weak-demand and low frequency of public transport services.

3. A literature review on DRT/on-demand services

The interest and the popularity of the subject of DRT (Demand-Responsive-Transport) in scientific literature has grown over the last decade or so. As Deka *et al.* (2023) point out, while just 22 papers were published between 1973 and 2003 about DRT, 24 publications were published in 2020 itself. Deka *et al.* (2023) provide a rather extensive and up-to-date review on various on-demand services introduced worldwide, with the aim of getting a better understanding of the factors contributing to failures and successes of DRT schemes. By focusing on the case study of the Bus-on-Demand service in Dubai, the authors then discuss some policy implications.

An early review was performed by Higgins (1976), who discusses problems and challenges of DRT. He provides recommendations to policymakers, analysts, and transport planners.

With reference to Europe, Mageean and Nelson (2003) analyze the development of DRT relatively to various shortcomings of conventional public transport, particularly the lack of flexibility. Moreover, they stress the role of technology in fostering such a development.

Barrett *et al.* (2019) point out how more and more cities around the world are developing or running DRT schemes and projects, with the aim of replacing as well as complementing existing traditional public transport systems.

With respect to the UK evidence, Ryley *et al.* (2014) investigate the role of DRT as a system to provide more sustainable public transport. The authors identify several market segments of potential and effective development of DRT schemes to ensure financial sustainability. Additional evidence from England and Wales is provided by Johnson *et al.* (2009), who stress the role of DRT services with respect to geographical areas characterized by poor accessibility.

More recently, Schasché *et al.* (2022) investigate the conflict between expectations and users 'acceptance of DRT schemes by reviewing some 231 papers. In particular, the role of DRT in rural areas is critically analyzed and discussed based on the evidence of other publications (in particular, those of Alonso-Gonzalez *et al*., 2018; Mulley and Nelson, 2016; Ryley *et al.*, 2014; Velaga *et a*l., 2012; Vitale Brovarone and Cotella, 2020; Weckström *et al*., 2018). The authors point out that DRT services quite often show a lack of integration with existing public transport information and booking systems, especially in rural areas, while being poorly cost-effective (Avermann and Schlüter, 2019; Jittrapirom *et al*., 2019; Luiu *et al*., 2018; Nyga *et al*., 2020; Ryley *et al*., 2014; Sihvola *et al*., 2012).

Thao *et al.* (2023) discuss how DRT services should be specifically designed and operated when they are deployed in peri-urban territorial areas. They also provide some recommendations for future schemes to planners.

Overall, the literature review shows that there is the need to address additional case studies in various territories to improve our knowledge on an increasingly important transport system, while focusing on crucial elements, such as DRT overall performance in peripheral and rural areas, network design and users' acceptance. Our paper provides

on-the-field evidence of designing and deploying the first ever DRT service in Friuli-Venezia Giulia region.

4. The design of the SMARTBUS service

A straightforward methodological approach was adopted during the implementation and evaluation of pilot activities. Data was collected mainly through the Trieste Trasporti IT platform as well as face-to-face interviews with the Trieste Trasporti staff. Additional information came from meetings with relevant stakeholders. Some secondary sources were used as well, mostly consisting of relevant regional planning documents. In the following, the main features of the solution design that was developed and deployed are presented and discussed.

Network design, routing and scheduling

SMARTBUS operations are based on a specific public transport network design, which includes certain routing and scheduling features in the selected areas (Figure 2). Two interconnected sub-areas are identified to run the service covering the Western ("ADD West") as well as the Eastern ("ADD East) sections of the Karst uplands respectively. A major interchange hub is identified in the village of Prosecco.

The ADD West area includes the public transport network operated by Trieste Trasporti from Opicina to Sistiana, while the ADD East area includes the network from Opicina-Cattinara to the villages of Pesek and Grozzana. The Municipality of Muggia and San Dorligo della Valle are not included in the pilot activities and subsequently in the regular service operations. The village of Prosecco represents an interchange point (hub), where buses operating in the ADD West and ADD East areas meet every two hours, thus, allowing passengers on the Karst uplands to shift to the traditional public transport network directed to the city of Trieste.

The SMARTBUS routing and network design includes 68 stops in the Eastern areas and 199 stops in the Western ones.

The service is designed to exploit the existing stops and routes, while being operational only upon requests by users. The planning of the pilot project reflects the different mobility spatial patterns in the two areas: in fact, while the ADD West area is mostly characterized by connections from the Karst Municipalities and the city centre of Trieste, the vast majority of connections in the ADD East area turn out to be among the Karst villages (and with Slovenia as well). The villages of Prosecco, Opicina and Cattinara are conceived to play the role of main interchange hubs, thus, consolidating most of the traffic and allowing the interconnections with traditional bus services.

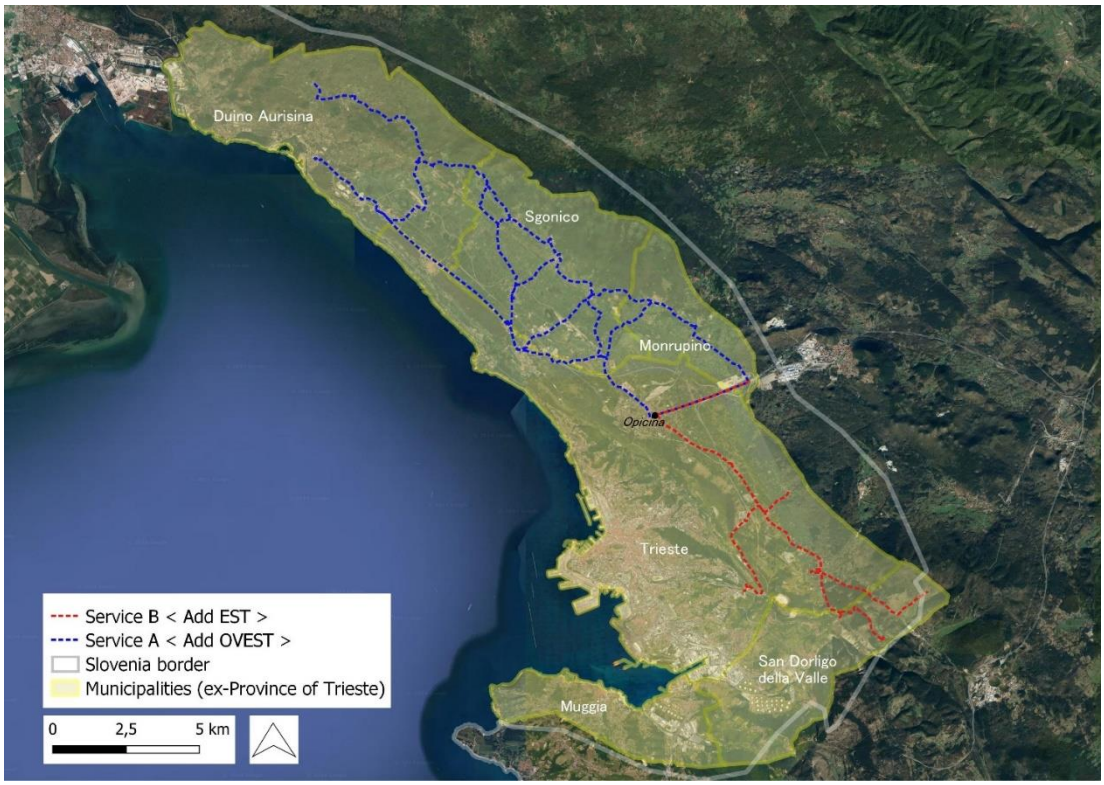

Figure 2: The SMARTBUS transport network spatial design. Source: this study.

Equipment: IT platform features and type of vehicles

The selection of the most suitable IT solutions was carried out through public procedures specifying some IT requirements, namely:

- A free cartographic support, to be easily integrated with the Trieste Trasporti cartographic system.
- A monitoring system.
- Service booking channels (such as an app for smartphones and tablets, a web site and a call centre).
- A user-friendly driver interface, providing real time data and information.

As for the vehicles employed in the operations of the on-demand service, traditional 10.5 meters long buses were employed, which were already belonging to the Trieste Trasporti fleet. The buses were rebranded with the project colours and logos.

Human resources training

Each driver was expected to go through a one-day training programme to get used to the operating system, tablet features and overall smart solution operational features, including driver's behaviour towards users.

Authorisation procedures

Trieste Trasporti represents the local public transport company, which is subject to regional legislation. According to the Regional Public Transport Plan, Trieste Trasporti and the Friuli-Venezia Giulia Region signed a Service Agreement to regulate

the provision of public transport services at local area. Based on that, the proposal of an additional public transport service must be agreed between the two bodies and Trieste Trasporti should be officially authorised by the Region to carry out a new on-demand service. Moreover, procedures for DRT services specifically were not in place, since no previous experience existed in the region. Eventually, testing activities were approved by the Region.

The booking system

The booking system of the SMARTBUS was developed based on the selected IT platform. In particularly, it can be accessed either through the Trieste Trasporti website or a dedicated call centre (which was made operational in a later stage of the pilot). Booking can be made by users up to 2 hours prior departure. Confirmation is received 10 minutes after the request, displaying stop and departure time. Some additional booking choices about departure time are also provided. The booking system delivers routing and scheduling programmes according to requests.

Ticketing and pricing policy

Following pilot activities, the SMARTBUS service was provided initially for free to all users. Afterwards, a fare of 2 €/run was introduced. The service remained free for annual subscribers. Users can access the service by buying tickets or by using prepaid cards (coupons of 2-6 €). Alternatively, they can use the SMARTBUS mobile app (smart ticketing).

5. Pilot activities' main results

SMARTBUS trials were carried out for some six months, and a thorough performance assessment of the smart service was then undertaken. Main results are discussed below.

Performance - qualitative indicators: users' satisfaction

Although high users' satisfaction was reported during pilot activities, an ad hoc online questionnaire for users was not developed. A survey on university students was carried out – since the University of Trieste represents a major generation and attraction transport node and it is located close to the Karst uplands – to assess the smart solution and its probable development to include a night schedule.

Performance - quantitative indicators: transport demand & supply analysis and assessment

Several performance indicators (KPIs) were identified to assess both demand and supply features of the provision of the SMARTBUS service during the trial period. As for the demand assessment, the results are the following:

- Number of passengers using the service: 1,761.
- Number of requests: 2,234.
- Number of requests from the Eastern Area: 60%.
- Number of requests from the Western Area: 40%.
- % of fulfilled requests (trips): 78%.
- % of partially fulfilled requests (trips): none. All the requests were totally fulfilled.
- % of not fulfilled trips: 22%.

- Number of additional users: estimates show that some 75% of users were subscribers, thus, some 25% could be considered as additional users (440 over the testing period).
- Number of fulfilled requests from disabled users: 3.

Additional indicators were analysed and elaborated to assess some supply-side (output) features of the SMARTBUS service. Results are the following:

- 14.739 km travelled.
- 750 runs.
- 19.65 km/run.
- 2.35 passengers/run.
- 0.12 passengers-km.
- Number of vehicles employed: 2.

Stakeholders involved

Several meetings were organised with relevant stakeholders of the territory during the pilot activities in order to get feedback and recommendations to possibly improve the characteristics of the proposed innovative solution. In particular, the following stakeholders were involved:

- Area Science Park, a major scientific and technological park, and Elettra Sincrotone, an international research centre. They both locate in the periphery of Trieste. They were of utmost importance for the pilot project, since they represent major generation and attraction transport nodes.
- Some municipalities in peripheral and rural areas, including Monrupino, Duino-Aurisina, Sgonico.
- Citizens' associations.
- Institutions in the Karst uplands.

Meetings with Area Science Park and Elettra Sincrotone representatives were organized first to effectively communicate and promote the new public transport service and its characteristics to some of the largest organizations generating and attracting a significant proportion of users. At the same time, although the DRT service focuses primarily on weak-demand areas, representatives reported the need to identify and include additional large centres in the design of the innovative service to ensure its economic sustainability, such as – for instance – the university. However, even if the university is indeed located in a rather peripheral area – with respect to the city centre – it is nevertheless already included in the main urban public transport network. At the same time, meetings were useful to promote the development of an additional DRT service for students in the form of a "night service". Moreover, representatives highlight the need to ensure enough transport capacity according to prominent scheduling needs by employees.

Representatives of the Karst municipalities stressed the need to foster and improve the communication efforts by the public transport company to users (potential inertia in users' behaviours was envisaged) as well as to carefully designed the service to ensure effective connections to the city centre. Locations and scheduling performance of main interchange hubs were discussed. Similar feedback was collected by other institutions in the Karst region.

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SMARTBUS: feeding the new public transport policies at regional level

Following pilot activities, SMARTBUS was officially launched as a regular service (Figure 3). It was deployed by the local public transport company - Trieste Trasporti (Figures 4) - operating daily (holidays included) from 8:30 AM to 9:30 PM. Booking systems include both the company' website and the call centres. According to the pilot activities, two buses were employed on the existing routes and stops: one operating in the western part of the Karst uplands (between Opicina and Borgo San Mauro) and the other one in the eastern part (between Opicina, Cattinara and Draga Sant'Elia).
However, following the regulatory reform of the public transport system at regional level – for which a new regional public transport company (TPL FVG) has been established, which unifies the previous four local public transport companies - the overall development of flexible public transport services is currently under revision in order to cope with a broader regional spatial context, and the SMARTBUS service has been temporarily halted. Possible strategies include the redesign of flexible services in the Trieste area (including a night service, for instance) as well as the extension of DRT services in other regional areas characterized by weak transport demand.

Figure 3: SMARTBUS institutional kick-off at the premise of the Regione Friuli-Venezia Giulia.
Source: this study.

Figure 4: pictures of the SMARTBUS service operations.
Source: this study.

6. Conclusions and Policy recommendations

Some lessons can be learnt from pilot activities and specific barriers and drivers ultimately arising should be discussed.

Drivers and benefits

Some major drivers and benefits can be identified fostering the development and deployment of the innovative public transport solution, namely:

- A strong political and technical will by relevant stakeholders were in place to gain experience and build expertise from innovation solutions in the field of public transport.
- Pilot activities led to the actual introduction and deployment of DRT solutions at regional level for the first time ever, with the view of extending such innovative solutions to other regional areas.
- An "innovation ecosystem" for public transport supported by a new IT platform to test innovative solutions was built.
- A high users' satisfaction was recorded.

Barriers and corrective actions

Several barriers leading to potential further improvements and corrective actions at a later stage can be identified from overall outcomes. They mostly consist of the need to improve some "flexibility" features of the on-demand service by addressing some currently existing constraints, in particular:

- The need to improve the operational synchronisation of the service at interchange nodes. SMARTBUS was designed to be a "feeder" service in selected peripheral and rural areas, thus, its operations must be further enhanced by optimising the management of passenger flows at interchange hubs. In doing so, some features of mobility patterns (e.g., the role of internal vs radial flows) should be further considered in the future.
- The need to optimise the size (and overall technical characteristics) of the vehicles employed. Pilot activities and subsequent regular services were performed by employing traditional buses (10.5 meters long). However, more options must be

considered in the future to optimise the performance, including mini-buses, minivans and electric options (to increase also the capillarity of the service).

- Additional opportunity would consist of the design of a broader governance framework encompassing the integration (by means of ad hoc agreements) with taxies and car rental with driver (NCC) companies.
- The need to move on with such further opportunities and governance schemes is also supported by some performance indicators (reported in this paper), which clearly show that passengers' choices and preferences should be optimised by employing smaller vehicles – which seems to be the ultimate goal when serving peripheral and rural (e.g., weak-demand) areas.
- The need to further promote communicational efforts. There is the need to change users' overall attitude (a kind of "cultural" corrective action) toward public transport, going from a supply-driven ("waiting for the bus") to a demand-driven ("calling the bus") approach. Despite remarkable communication efforts made during the pilot activities, inertia is still in place by users. Additional communication efforts should be made to highlight opportunities and benefits of "flexible" solutions.
- The need to address the overall financial sustainability of proposed flexible solutions. Although reported KPIs are mostly in line with other EU and non-EU experiences in peripheral and rural areas (both in absolute terms and depending upon population size), the SMARTBUS service turns out to be rather expensive (which is in turn something in line with other international experiences). Other similar initiatives show ticket revenues accounting for some 20% to 70% of overall costs (thus, a rather broad range).
- Importantly, financial sustainability should lead to the development of broader governance schemes. In fact, many similar initiatives at EU and non-EU level show that the overall financial burden of on-demand services are taken not only by public transport companies, but also by relevant organisations benefiting from an improvement in accessibility in peripheral and rural areas. They include, for instance, both economic activities (shops, restaurants, banks, etc.) and municipalities. Quite often, relevant stakeholders promote associations to support on-demand services1. Some estimates show that such associations can cover up to 50% of overall costs of the on-demand service.
- At the same time, it should be noted that such broader governance schemes face some constraints within the current regulatory framework in the selected areas. In fact, public transport services (of any type) are provided by the public transport company based on a regional public tender. Thus, rooms to include additional stakeholders in the operations cannot currently be proposed. As such, there is the need in the future to address such regulatory issues as well.
- The opportunity to address further potential markets. Based on pilot outcomes and stakeholder meetings, some further opportunities were envisaged, including the provision of the SMARTBUS services to university students. In fact, the University of Trieste is located close to the selected peripheral areas, and it represents a concrete opportunity to further develop the service. Moreover, night/evening extensions – targeting mainly students – would be beneficial for the

[1] And usually, users pay an annual fee to the association.

service as well. Currently, some of these opportunities (such as an extended "night bus" service) are already under development. At the same time, it should be noted that that no specific transport demand study was carried out to identify users 'categories. In fact, only existing transport demand data by the public transport company was employed for pilot activities. Users mostly consist of workers, students and elderly users using public transport primarily to move to the city centre. Indeed, this is the reason why much attention in the design of the DRT service was put on the location and operational characteristics of the major interchange hubs. Moreover, the provision of a call center was eventually provided to allow elderly users to access the DRT service. At the same time, ad hoc transport studies are recommended to improve the knowledge of transport demand in the area. In particular, cross-border potential transport demand (e.g., users to/from Slovenia) should be carefully analysed.

- The need to optimise (and revise) the overall network design. In fact, pilot activities were performed by considering SMARTBUS as a complementary solution with respect to existing services in the selected areas. A possible major revision of the role of the SMARTBUS as a – at least – prominent choice for users in the areas should be considered. Consequent positive impacts on users' demand would follow.
- Finally, there is the need to further enhance cross-border synergies. Although the approval of innovative cross-border solutions between Italy and Slovenia relies upon international agreements, which currently significantly restrict such opportunities, nevertheless operational synergies coming out from SMARTBUS were in place – for instance, cross-border users can directly access the service – e.g., at major interchange hubs – and Arriva, a major shareholder of Trieste Trasporti, operates also some cross-border services.
- The pilot action highlights the existing constraints related to the bilateral agreements involving cross-border countries, especially in terms of "cabotage" and type of vehicles. Cabotage restrictions do not allow passengers to board and alight in the same country. Such a constraint leads to the need of doubling the services (given that national mobility cannot be served by cross-border services), thus worsening any economic and financial performance. Also, regulation does not allow any change in the type of vehicles employed on cross-border services (for example, urban busses are prohibited). A strong recommendation towards a simplification of international regulations (even updating existing bilateral Agreements) may arise.

Policy recommendations

Following pilot outcomes and the identification of a number of barriers, the following policy recommendations can be suggested for the future:

- There is the need to promote a revision of current regional plans and overall legislation to allow for the support of additional stakeholders in peripheral and rural areas in the development of innovative solutions by local public transport companies so as to ensure financial viability – which still represents a critical issue EU-wide. Broader governance schemes should be promoted to involve all relevant stakeholders interested in improving accessibility of peripheral and rural areas.

- Similar needs arise about revising regulation at regional level to allow for an integration and coordination between public transport companies and other mobility operators – including taxies and chauffeurs – when providing flexible transport services in peripheral and rural areas. Remarkably, such revisions – which are needed to overcome existing constraints deriving from tendering procedures dealing with the assignment of public transport services at regional level - would shape broader governance schemes, where the public sector could play a more pro-active role in fostering innovation in the field of mobility.
- An overall revision and indeed simplification of international regulation is required to enhance cross-border mobility operations, since cross-border public transport services – albeit showing good operational synergies - are currently hindered by a variety of legislative constraints (in particular, cabotage restrictions leading to a duplication in the provision of mobility services).
- Significant communication efforts should be further promoted to change users' attitude towards innovative solutions in the field of public transport in peripheral and rural areas – going from a "waiting for the bus" to "calling the bus" paradigm. Despite remarkable communicational efforts already in place, users still show inertia to benefit from "flexible" mobility solutions.
- The development and implementation of best-in-class "IT ecosystems" by relevant stakeholders should crucially be promoted to foster innovation in the public transport sector and ensure replicability at wider territorial level, since they represent a strategic asset.
- On-demand/flexible public transport services should be carefully designed to optimise overall performance. In particular, issues such as users' targeted categories, vehicles size, operational integration, coordination and synchronisation with traditional public transport networks should be addressed to optimise technical performance.

In summary, some strategic goals to develop and actually implemented ("busses on the road") innovative solutions in the field of public transport in Friuli-Venezia Giulia – with a view to cross-border mobility – were achieved. Thanks to the pilot project, a significant shift of innovation boundaries in the selected region were realized, thus, paving the way for additional developments. Pilot outcomes represent then the basis for a radical change in the attitudes towards innovation in the field at regional and cross-border level. As such, pilot activities were an opportunity to drive such a change. However, some limitations and barriers are still in place, both from an operational, financial and regulatory perspective, and they must be addressed to further improve innovative solutions at regional level, both in other weak-demand and urban areas.

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