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Managing Urban Mobility during Big Events through Living Lab Approach

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Abstract: Urban transportation systems encounter distinctive challenges during planned major city events characterized by large gatherings that disrupt traffic patterns. The surge in private car usage for attending such events leads to a sudden increase in traffic, unauthorized parking, pollutant emissions, and risks to pedestrian safety in the vicinity of the event venue. This study delves into the challenges and advantages of employing Decision Support Systems (DSSs) to manage urban mobility during special urban events with the goal of reducing car dependency and promoting sustainable transportation options. The proposed methodology for designing and testing the DSS is based on the living lab principles of co-planning, co-implementing, co-monitoring, co-validating, and co-reviewing with engaged stakeholders. Moreover, testing of the DSS measures in real-world cases (i.e., during a football match at the San Siro Stadium and a concert at the Alcatraz music hall in the city of Milan, Italy) highlights the potential of the DSS in reducing the use of individual private cars in favor of shared mobility and micro-mobility solutions. As a result, the living lab has proven to be a valuable tool for interacting with stakeholders from the outset of brainstorming ideas for potential transport policies to their practical implementation, with the goal of bridging the gap between what decision-makers believe should be done, what transport operators can feasibly do, and what users desire and expect to be done. The insights presented in this paper contribute to the debate on leveraging technology to cultivate more efficient, resilient, and livable urban environments.

Keywords: quadruple helix; decision support systems (DSSs); parking policies; public transportation; shared mobility services

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1. Introduction

Urbanization and population growth have led to unprecedented challenges in managing urban mobility. The efficient movement of people within cities is crucial for economic productivity, social well-being, and environmental sustainability. Furthermore, the efficient operation of urban transportation systems faces unique challenges during planned special events that draw large crowds [1,2] and disrupt regular traffic patterns [3–5]. Events such as football matches, concerts, trade fairs, and other major gatherings not only enrich the cultural fabric of cities but also strain their mobility infrastructure, leading to congestion and associated problems (e.g., extended travel times, air pollution, decreased overall quality of life, etc.) [6–8].

The successful management of urban mobility during major events is a multifaceted endeavor that requires careful planning, dynamic decision-making, and innovative solutions [9]. Han et al. [10] and Lassacher et al. [11] have identified several policies that can help mitigate the impacts of peak mobility demand associated with major events, particularly controlling road closures, diverting private motorized traffic onto alternative routes, assisting travelers with real-time information systems, enhancing public transit services, managing pedestrian traffic, and implementing parking management measures. However, they also highlight how these policies can generate negative externalities for residents living in the vicinity of the event venue. For example, diverting traffic onto alternative routes can alleviate congestion near event venues, but it may increase traffic volumes in nearby residential areas. This can lead to noise pollution, reduced air quality, and safety concerns for residents. Moreover, enhancing public transit services encourages eventgoers to use public transportation, reducing the number of private vehicles on the road. However, crowded buses or trains can inconvenience residents who rely on public transit for their daily commutes.

One of the most promising tools to address the complexities of mobility management during such events is the deployment of Decision Support Systems (DSSs). These systems leverage modeling, data analytics, and optimization techniques to assist decision-makers in making informed choices with valuable insights and recommendations, enabling them to proactively manage traffic flow and mitigate congestion during large events [12,13]. Examples of models included in DSSs developed for urban travel demand management (including parking policies), public transport demand forecasting, traveler information, and assessment of accessibility and city logistics policies can be found in many existing research studies in the literature [14–18].

The dynamic nature of urban events introduces a multitude of challenges to the existing transportation infrastructure. Rapidly fluctuating demand, altered traffic patterns, and increased pedestrian movement can lead to gridlock, extended travel times, and frustration among commuters. By integrating DSSs into the mobility management framework, decision-makers can anticipate these challenges and implement strategies that proactively address congestion issues [19].

This study explores the challenges and benefits of using DSSs aimed at managing the urban mobility of people during planned large city events in order to reduce car dependency and foster the adoption of sustainable mobility solutions. Throughout this paper, real-world case studies that showcase the successful testing of DSSs during major events are examined and discussed.

In particular, this paper describes the methodological approach and the collaborative process that, within a living lab established as part of the TRIBUTE project ("inTegRated and Innovative actions for sustainaBle Urban mobiliTy upgrade") [20] of the Interreg ADRION programme (i.e., a European transnational programme that invests in regional innovation systems, sustainable transport, and mobility) [21], led to the design and experimentation of a DSS in the city of Milan, Italy. Therefore, this paper intends to contribute to the literature by presenting the research results stemming from the on-field implementation of a pilot action as well as providing planning guidelines for decision makers to decide, together with engaged stakeholders, the measures for promoting sustainable forms of mobility that could be implemented when planned large city events occur. Lastly, this paper aims to demonstrate how participatory methods involving stakeholders of diverse backgrounds can streamline decision-making processes regarding the implementation of transport policies by narrowing the gap between what planners and policymakers believe should be done, what transport operators can feasibly provide, and what users are willing to do to alter their travel behaviors.

After this brief introduction, the methodological approach based on the principles of living labs proposed in this paper for the design and development of the DSS and the testing of mobility measures in real urban environments is described in Section 2. In Section 3, the results of ex ante simulations using the analytical tools of the DSS and on-field experimentation are presented. Finally, in Section 4, the research outcomes are discussed, and conclusions are drawn.

2. Materials and Methods

The design, development, and testing of a DSS for the city of Milan which aims at supporting the identification and implementation of appropriate measures to stimulate the use of sustainable transportation modes for reaching the venues of planned city events were carried out within a living lab. According to Menny et al. [22], the living lab approach "offer opportunities to foster sustainability in cities. They are sites to design, test and learn from innovation in real time". By using this methodology, stakeholders are acknowledged as co-creators within the decision-making process of planning and implementing urban transport policy and actions [23–25].

The flow chart diagram in Figure 1 schematically represents the three phases of the project described in this paper and how the living lab supported the design, development, and testing of the DSS.

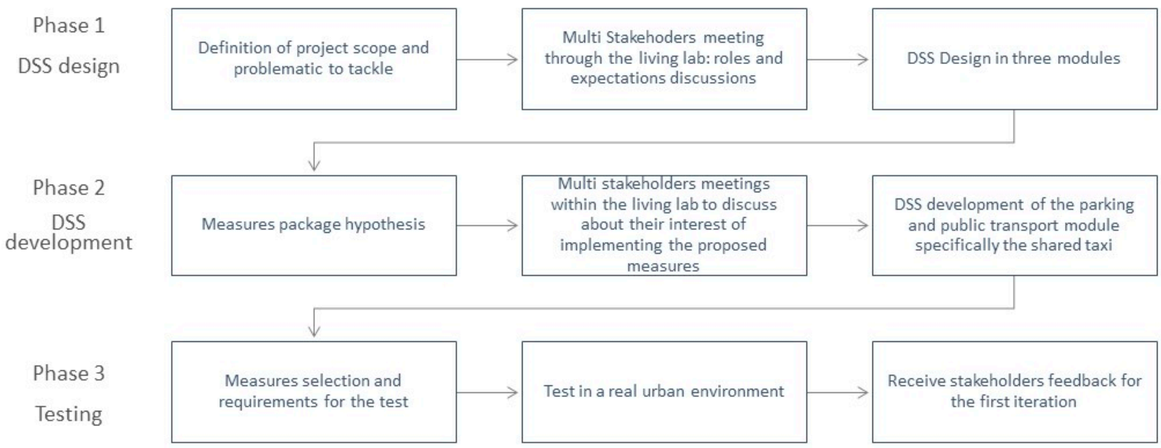

Figure 1. Flow chart diagram of the adopted methodological approach.

The design phase of the project commenced with the definition of the project scope and the identification of key stakeholders essential for achieving the proposed objective. It was crucial to understand the roles of involved stakeholders and their expectations concerning their participation in the project. After these initial steps were completed, the potential modules of the DSS were conceptualized to facilitate the planning of a comprehensive array of measures, encompassing diverse alternative transportation modes for reaching the venues of planned city events. The envisaged modules included public transport, active mobility, and parking management. In particular, the public transport module was designed to enhance the accessibility and attractiveness of public transit systems within the urban area. The active mobility module supports actions on sustainable human-powered transportation modes, such as walking and cycling. Lastly, the parking management module addresses challenges related to parking locations and availability for car-pooling and chauffeur vehicles, touristic coaches, bikes, and e-scooters.

Subsequently, in the second phase, a series of measures were outlined in relation to the hypothesized modules of the DSS. Stakeholders were actively engaged in various meetings where different measures were proposed and collectively chosen for implementation. The aim of this measure package was to offer stakeholders a wide spectrum of options, enabling alternative mobility solutions for individuals (other than their private vehicle) for reaching the venues of the events.

In the third phase, after proposing this measure package to stakeholders from various sectors, the specific measures garnering interest from particular stakeholders were selected for implementation. The measures that were chosen by stakeholders and received endorsement by the public administration were ultimately tested in real urban environments on 22 and 26 October 2022, respectively, during a football match and a concert, as part of the third phase of the project. Finally, stakeholders were engaged in a feedback session aimed at gathering insights that could inform the initial iteration of the testing phase, so that such input would then be integrated into a future testing phase.

In the following paragraphs, the main materials and methods are described in more detail.

2.1. Living Lab as a Collaborative Process with Stakeholders

Living labs are often associated with the quadruple helix approach [26] due to their role in fostering collaboration and innovation among academia (universities and research institutions), industry (businesses and corporations), government (public policy and regulatory bodies), and civil society (citizens and non-governmental organizations). This approach aims to bring diverse perspectives and voices in order to foster more comprehensive and responsible innovation outcomes that not only drive economic growth but also address pressing social and environmental challenges. Therefore, living labs serve as practical examples of how the quadruple helix approach can be implemented in real-world settings to promote collaboration, inclusivity, and responsiveness in decision-making processes. Adhering to such an approach, where individuals and organizations from different sectors convene, discuss, and cooperate to mutually exchange novel ideas and subsequently implement and verify them, the living lab of the city of Milan organized eleven meetings with heterogeneous stakeholders within the timeframe of the project. The key stakeholders have been identified as outlined in the EU-MACS living labs guidelines [27], "quadruple helix stakeholder engagement is a central factor in living labs. It brings together stakeholders from public institutions (at the level of cities, regions & local, regional, national & European policy), private organizations (start-ups, SMEs, corporations), as well as academia (researchers, universities, research institutes) and citizens".

The living lab adopted this approach throughout all the phases of design, development, and testing of the DSS, respectively, following the principles of co-planning, co-implementing and co-monitoring, and co-validating and co-reviewing of the project.

The stakeholders were involved in multistakeholder meetings to enhance and find potential synergies among stakeholders, which could facilitate the implementation process. The stakeholders were grouped into two meetings during the first phase of the project. Additionally, three meetings were conducted with stakeholders to discuss and deliberate on the proposed measure package and to gauge their interest in the measures' implementation process and potential roles. Lastly, the rest of the meetings focused on the testing phase. Precisely, six meetings were held with stakeholders to coordinate all the necessary components for testing the selected measures during two events and to subsequently discuss the outcomes. Table 1 provides details of the living lab's meetings, including the dates, participating stakeholder types, main discussion points, and the corresponding project phase.

Table 1. Living lab meetings with stakeholders.

Date	Type of Stakeholder	Main Discussion Points	Phase
December 2021	Sharing mobility, taxi, and carpooling operators	Roles and experiences they have had during big events and potential interest in participating in the project	Phase 1
April 2022	Sharing mobility and carpooling companies	Key points to be considered when designing the presented measures during big events	Phase 2
April 2022	Rental car with driver company	Roles and experiences they have had during big events and potential interest in participating in the project	Phase 1
May 2022	Taxi and cyclability stakeholders	Feedback on the selected measures and recommendations, for instance, about an exclusive lane for taxis to access and leave the stadium	Phase 2
June 2022	Representatives of the public transport companies	Measures related to public transport and opinions regarding the proposed express lines' buses arriving in the proximity of the stadium	Phase 2

Table 1. *Cont.*

Date	Type of Stakeholder	Main Discussion Points	Phase
October 2022	Sharing mobility, taxi, and carpooling operators	Definition of all the operational phases of the two tests of the DSS, i.e., the event held on 22 October (football match) and the event held on 26 October (concert), 2022	Phase 3
October 2022	Bike-sharing operators and public transport operators	Operational details of the definition of the measure regarding micro-mobility and carpooling	Phase 3
October 2022	Local police	Operational details discussion with local police concerning the test on Alcatraz (i.e., the concert venue)	Phase 3
October 2022	Sharing mobility and carpooling operators	Operational details of the testing phase	Phase 3
October 2022	Taxi operators	Arrangement of the shared taxi system and spatial definition of the area where the groups would be organized	Phase 3
November 2022	Sharing mobility, taxi, and carpooling operators	Feedback from participating operators about the two tests of the project	Phase 3

2.2. Identified Measures and Selection Process

The proposed package of measures that could be implemented during large city events aims at decreasing the private vehicle modal share while encouraging more sustainable means of transportation. The following table (Table 2) presents the measures that were discussed with stakeholders to assess their level of interest in implementing specific actions within the domains of active mobility, public transportation, and parking management.

In line with the quadruple helix approach, citizens were actively engaged in this phase through a survey. Involving citizens through participatory methods ensures that their perspectives, needs, and preferences are considered when making decisions, including the selection of measures. This approach fosters inclusivity, transparency, and citizen-centric values in the decision-making process.

The measures were discussed and presented to the general public through a mobility survey conducted before a concert in Milan on 26 June 2022. A total of 215 individuals participated in the survey, providing insights into their potential willingness to adopt alternative modes of transportation for reaching a large city event.

Regarding the carpooling measure, 47% of respondents expressed interest in utilizing carpooling, and among those who arrived at the event by car, 46% showed an inclination toward using carpooling in the future. In more detail, 66% of the attendants who drove to the venue event were in pairs, indicating an opportunity to promote carpooling and increase average car occupancy.

Concerning the shared taxi measure, taxis were used by 2% of the survey participants, while 54% of respondents who commuted from within the city of Milan expressed their interest in using shared taxis. Furthermore, 47% of individuals who used private cars to reach the event demonstrated interest in shared taxis, rating their interest as 4 on a scale from 1 to 5.

Regarding shared mobility measures, more than 2% of surveyed attendees had used shared mobility options, whereas 46% indicated a strong interest in adopting shared mobility modes, provided there was a rental option that allowed them to keep the vehicle until the event's conclusion without paying for unused time.

Table 2. Measures description and framework.

DSS Module	Measure	Brief Description
Active mobility	Bicycle and e-scooter group routes	Routes or itineraries that enhance road safety by supporting the use of bicycles and e-scooters to reach the venue of the event. The routes can be implemented as temporary bike paths guarded by the police
	Pedestrian group routes	Pedestrian pathways leading to the venue of the event to increase walkability. The routes can be implemented as temporary walking paths guarded by the police
Public transport	Public transport enhancement	PT attractiveness improvement with the enhancement of the subway and/or the surface services
	Implementation of express bus lines	Express bus lines between key points of the city and the event venue, ensuring frequent service to enable easy access and return for event attendees
	Support the shared taxi service	Taxi-sharing systems among three to four individuals traveling in the same direction, offering a 60% discounted fare
Parking management	Support the use of carpooling	Free dedicated parking spaces for carpooling users near the event venue, with the aim of increasing the occupancy of the vehicles
	Parking areas dedicated to bikes and e-scooters	Temporary dedicated and guarded spaces for individuals using bicycles or e-scooters to reach the event
	Parking areas dedicated to touristic coaches	Dedicated parking areas for touristic buses near the event venue
	Parking areas dedicated to rental cars with drivers	Dedicated parking areas for rental cars with drivers near the event venue

In relation to the proposed measure involving organized group routes for bicycles and e-scooters to reach the event, 56% of respondents expressed a strong interest, whereas 61% of survey participants indicated their interest in participating in an organized walking procession to reach the event.

The survey demonstrated a widespread inclination toward sustainable and alternative mobility modes if these were available, even among those who utilized cars to travel to the venue event.

Finally, in line with the top-down bottom-up approach of the living lab, the process of selecting measures concluded with the identification of measures deemed most interesting by both stakeholders and the local administration governing the area. In addition, the DSS was used to model "to be" scenarios and simulate, ex ante, the effectiveness of the selected measures, specifically, shared taxi systems and dedicated parking areas for micro-mobility and carpooling vehicles.

Table 3 shows the measures for which there is stakeholders and public administration interest in implementation (highlighted in green), the measures already in place or considered not cost-effective by key stakeholders (highlighted in grey), and the measures that stakeholders or the public administration are not interested in implementing (highlighted in yellow).

Table 3. Classification of measure by interest in implementation: measures for which there is stakeholders and public administration interest in implementation (highlighted in green), measures already in place or considered not cost-effective by key stakeholders (highlighted in grey), measures that stakeholders or the public administration are not interested in implementing (highlighted in yellow).

DSS Module	Measure	Interest in Implementation
Active mobility	Bicycle and e-scooter group routes	No interest has been shown by stakeholders or the public administration in implementing them
	Pedestrian group routes	No interest has been shown by stakeholders or the public administration in implementing them
Public transport	Public transport enhancement	Enhancement actions already in place
	Implementation of express bus lines	Classified as not cost-effective by key stakeholders
	Support the shared taxi service	Interest has been shown by both stakeholders and the public administration in implementing them
Parking management	Support the use of carpooling	Interest has been shown by both stakeholders and the public administration in implementing them
	Parking areas dedicated to bikes and e-scooters	Interest has been shown by both stakeholders and the public administration in implementing them
	Parking areas dedicated to touristic coaches	No interest has been shown by stakeholders or the public administration in implementing them
	Parking areas dedicated to rental cars with drivers	No interest has been shown by stakeholders or the public administration in implementing them

2.3. DSS Modules and Analytical Tools

The development of the DSS modules was linked to the selected measures. Therefore, the analytical tools of the DSS allowed for modeling and simulating, in advance, the measures to be implemented to incentivize carpooling solutions, size the dedicated parking areas for e-scooters and bikes, and promote the usage of shared taxis.

Particularly, for carpooling solutions to be effective, an adequate critical mass of users is required to ensure that both those seeking a ride find a driver and drivers offering rides find passengers. To assess the necessary critical mass for supporting carpooling, the probability of a passenger finding a ride was estimated as a function of the number of available rides. The list of offered rides was generated by randomly selecting origins and setting the destination at the event location. Each passenger could find a ride among the offered options if at least one of the drivers could adjust their route to accommodate the passenger's origin within a predefined threshold time. The percentage of passengers finding a ride relative to the number of trips offered represents the probability of finding a match as a function of the number of rides offered.

Regarding the dedicated parking areas for e-scooters and bikes, the measure was supported by a DSS module which is based on an extension of the AMAT Parking Tool [28]. This tool analyzes all departures and arrivals in the municipality of Milan based on the origin–destination matrix, adjusting parking availability (i.e., freeing or occupying a parking space) for each departure or arrival. The probabilistic model simulates users' choice behavior considering factors such as the type of parking space (free, paid, residential, unregulated, etc.), and distance to the destination. The Parking Tool facilitates the assessment of drivers' behavior in response to supply changes (e.g., reducing/increasing parking availability in an area) and addresses critical issues arising from extraordinary planned events that escalate parking demand.

Furthermore, to evaluate the shared taxi service's performance concerning user satisfaction (i.e., quality of service) and the efficiency indicators, the DSS employs an integer linear model. This model optimizes taxi routes, ensuring that all users are served while adhering to taxi capacity constraints and minimizing total cab travel distance from the event venue. Users' requested trips were simulated by setting the trip origin at the event location and randomly selecting destinations. The optimal routes obtained allow us to estimate each user's travel time, taxi ride duration, and distance traveled.

3. Results

Firstly, this section provides a description of the outcomes stemming from the use of the DSS prior to the testing phase. In fact, it outlines the results obtained from DSS simulations and their instrumental role in streamlining the execution of the selected measures during two events: a football match on 22 October and a concert on 26 October, both held in 2022 in the city of Milan. Secondly, this section showcases the application of the shared taxi and carpooling measures in real urban environments. Conversely, the measure concerning dedicated parking areas to micro-mobility, despite being implemented during the testing phase, did not exert any notable impact on event-level mobility due to its limited scale, and thus, it is not reported.

3.1. Evidence from the Modeling of Measures Using the DSS

Based on simulations using the DSS, it was found that implementing a shared taxi system would lead to a reduction in the number of rides and distance traveled, although serving the same number of passengers and slightly increasing the travel time with a detour time of just 6 min on average (refer to Table 4). Figure 2 illustrates an example of the DSS user interface regarding the grouped ride requests with the San Siro Stadium as the event venue of the football match.

Table 4. Simulation results of the DSS shared taxi tool.

Taxi Type	Number of Rides	Average Travel Time (Minutes)	Total Distance Traveled (Kilometers)	Detour Time (Minutes)
Individual Taxi	12	23	104.4	0
Shared taxi	4	37	56.6	6

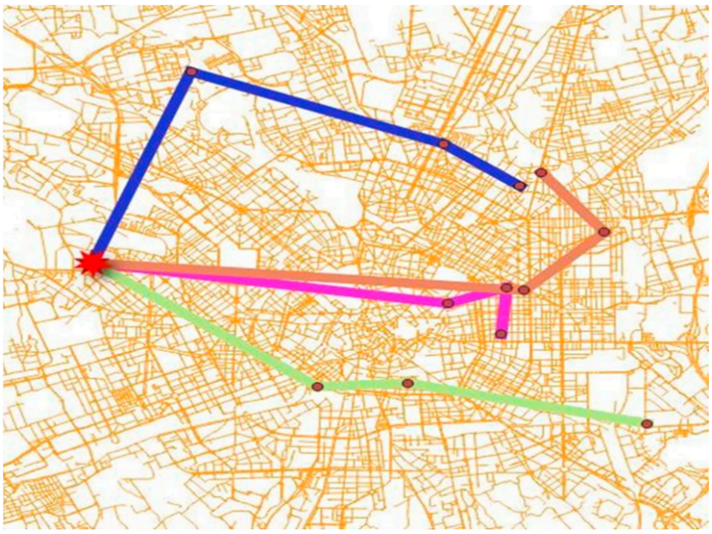

Figure 2. Example of the DSS user interface regarding the generated shared taxi tours (each color indicates a different tour).

With regard to the measure for promoting carpooling solutions, the analytical tools of the DSS revealed that employing 20 dedicated carpooling parking spaces can generate a quantity of offered trips that would ensure users with a 50% chance of finding a carpooling ride to the event venue. The following figure (Figure 3) presents the graphical representation of the analysis.

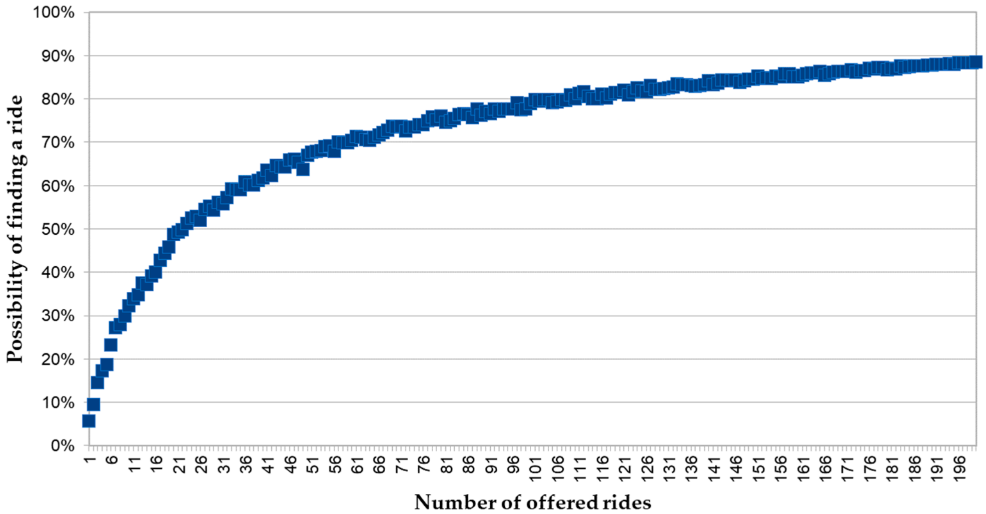

Figure 3. Relationship between the number of offered rides and the likelihood of finding a ride.

3.2. Testing of Measures in Real Urban Environments

The implementation of the selected three measures was conducted in two real urban environments in the city of Milan—at the San Siro Stadium during the football match Milan–Monza on 22 October 2022 and at the Alcatraz music hall during the concert of Muse on 26 October 2022. The testing phase had the participation of the following shared mobility operators: Bikemi, Bird, Bolt, Dott, Helbiz, Lime, Ridemovi, Tier Mobility, and Voi. Whereas the taxi operators were: Taxiblu 024040 and RadioTaxi 028585. Lastly, the carpooling operator that participated was Bepooler.

By way of example, Figure 4a shows the locations of the pick-up points (highlighted in purple) for the shared taxi system at Axum Square near the San Siro Stadium. These spaces were obtained by using a no parking zone procedure that was officialized by the local police. Figure 4b shows the taxi operators forming the collective rides.

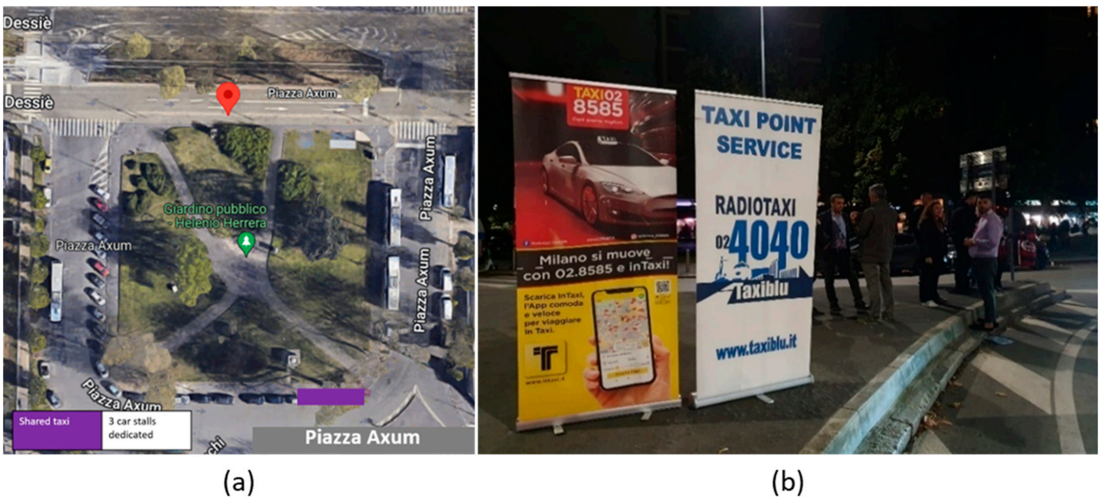

Figure 4. Example of shared taxi pick-up points at Axum Square (San Siro Stadium). Location (**a**) and actual photo (**b**) of the pick-up points.

As an example of the carpooling incentivizing measures, Figure 5 shows the location of the dedicated parking spaces (highlighted in blue) for the cars that offered a ride in carpooling. This area was temporarily implemented in Via Bernina 18 near the Alcatraz music hall. It was located 270 m (3 min walking distance) away from the concert venue and it had the capacity to accommodate 20 vehicles. Users interested in offering carpooling rides were encouraged by the provision of a dedicated, guarded, and free parking space for the whole duration of the event. Users had to publish the trip 24 h prior to the event so that there would have been enough time to communicate the license plates to the local police, enabling free entry into the restricted traffic zone.

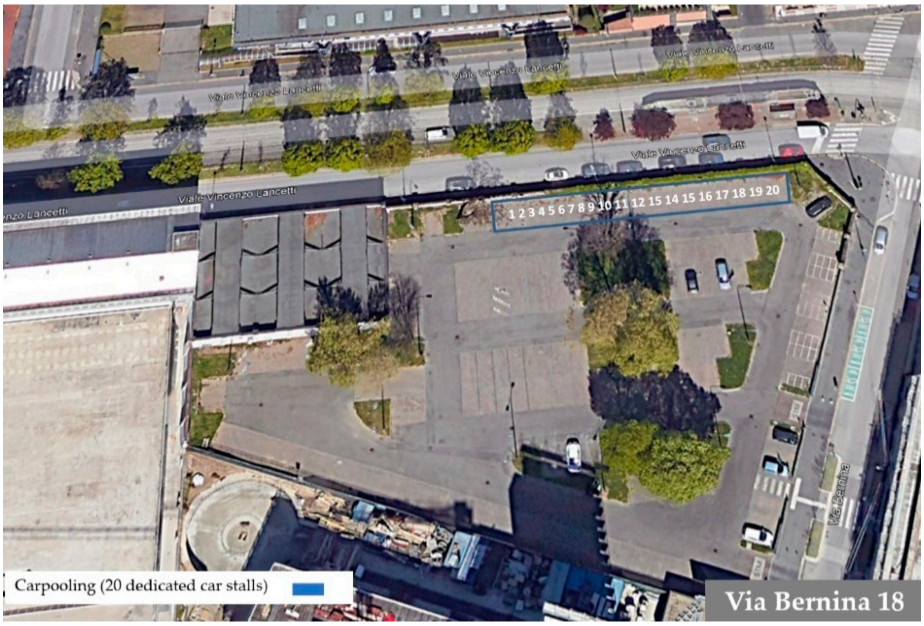

Figure 5. Dedicated car stalls for the carpooling users.

Finally, Figure 6 showcases one of the two designated areas where shared mobility vehicles were positioned in proximity to the San Siro Stadium. Specifically, 192 e-scooters and 96 bikes were stationed. This area is usually for parking vehicles used by the police, and it was temporarily repurposed for the event.

Figure 6. Micro-mobility-dedicated parking areas for bike and e-scooter sharing.

4. Discussion and Conclusions

During planned major city events such as those related to football matches, concerts, fashion, or other domains, the city of Milan experiences significant peaks in demand and private vehicle usage, which adds strain to the transportation network. Concerning venues with high-attendance events, a strategy is in place to address these surges in demand. In line with what was already found by Tempelmeier et al. [3] and Fernando [6], we received confirmation through our case study that the prevalent use of private cars to attend an event results in an abrupt surge in traffic within the vicinity of the event venue, with ripple effects on traffic congestion spreading even further [29]. This impact includes issues like unauthorized parking and air quality concerns that particularly affect the local residents surrounding the event's influence area, as also highlighted by Han et al. [10] in previous research. Additionally, on a broader scale, the dominance of private vehicles when attending large events escalates pollutant emissions and safety risks for pedestrians in the vicinity of the venue.

The importance of this paper lies in its ability to bridge the gap between research and practical application in the realm of urban mobility management. By showing that the integration of a Decision Support System within a living lab presents a promising avenue for enhancing transport policy development, this paper can provide invaluable guidelines and policy recommendations for decision-makers and transport planners. Firstly, active involvement of stakeholders and citizens in decision-making processes is needed. Seeking their input on policy priorities and potential solutions not only empowers transport operators and citizens but also ensures that policies are rooted in the real needs and preferences of the community. The formulation of measures to be communicated to the stakeholders and the general public was a collaborative and enriching process, involving all relevant parties during both the planning and implementation phases. During this process, synergies were identified among different stakeholders that could be further exploited in future testing. An example is the concept of establishing common "super sharing" spaces where various sharing mobility modes could be situated. This arrangement would offer users a comprehensive array of choices in proximity to the event venue, while also amplifying communication and promotional efforts. Secondly, living labs can serve as testbeds for innovative approaches, such as promoting shared mobility services. Policymakers should actively promote these sustainable modes of transportation through infrastructure investments, supportive regulations, and incentives. Nevertheless, policies developed within living labs should not remain isolated experiments. The scalability of successful policies to broader urban contexts needs to be assessed. Consideration should be given to how these policies can be adapted to different cities and regions, taking into account local characteristics and needs. Moreover, knowledge sharing and collaboration between different living labs should be promoted. Networks can facilitate the exchange of best practices, lessons learned, and policy insights. This fosters a collective learning environment and accelerates policy innovation. Lastly, with the integration of DSS, data become a cornerstone of decision-making. Clear guidelines and standards for data collection, sharing, and storage within living labs are essential. By doing so, it becomes possible to monitor and evaluate the effectiveness of policies, with the aim of making them dynamic and adaptive. In fact, by establishing mechanisms for continuous feedback, the iterative approach allows policies to evolve based on data-driven insights. The ability to adjust policies in response to changing circumstances ensures that they remain relevant and effective over time.

However, despite the evident benefits, the application of the proposed DSS is not exempt from challenges. The stakeholders' engagement process within the living lab posed challenges regarding actively engaging all key stakeholders before the definition of the measures that would have been implemented. This fact is due to the nature of the collaborative process in which the measures are chosen together with stakeholders. The need for seamless coordination among various stakeholders presents difficulties that require careful consideration. In the Milan case study, the level of participation from mobility operators was perceived as positive. All major sharing mobility operators offering e-scooters and bike-sharing participated, as well as two prominent taxi operators and a carpooling service.

For future tests, improvements could be centered around event selection, contingent on the level of cooperation achieved with the event organizer, which is crucial to establishing direct contact with event attendees. This approach would ensure that communication campaigns directly target event attendees, increasing the likelihood of reaching the intended audience who would be notified in advance about the availability of alternative mobility options to reach the event. It was also noted that selecting areas for dedicated parking for shared micro-mobility and carpooling should involve on-site visits with the operators. This would unveil potential challenges or issues before initiating contact with local authorities to request permission to occupy public spaces.

In conclusion, the design, development, and testing of Decision Support Systems within a living lab of a municipality presents an innovative and practical solution for mitigating congestion and enhancing urban mobility during planned major urban events. As cities continue to host a diverse array of events, such as cultural festivals, sports matches, international conferences, and music concerts, the insights presented in this paper contribute to the ongoing debate on harnessing technology to create more efficient, resilient, and livable urban environments.

The living lab and the quadruple helix approach were demonstrated to be valuable instruments for interacting with stakeholders while concurrently fostering governance over potential project measures. Stakeholders' engagement from the inception of brainstorming ideas for conceivable measures to their eventual implementation allows us to design and develop measures in the most efficient manner.

Finally, the outcomes achieved during the testing phase will be incorporated into an iterative approach to the entire planning and implementation process. In so doing, the feedback received from stakeholders will be integrated to enhance and maximize the achieved results thus far for future testing.

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