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Examining Social and Safety Dimensions in Public Transport

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Abstract— Public transport plays a key role in urban mobility. However, its trustworthiness and usage have been reduced by factors such as perceived insecurity, rising incidents of gender-based violence, limited reporting avenues, and the impact of the COVID-19 pandemic. This decline in confidence for public transport has resulted in increased traffic congestion, heightened emissions, diminished social cohesion, and increased the lack of citizens to support it. To overcome these challenges, it is imperative to evaluate public transport services from the point of passengers and other various stakeholders. Therefore, an approach is necessary to engage public authorities and transport operators' involvement as well as passengers' empirically grounded insights into the quality of public transport services. This paper aims to present a comprehensive framework for the assessment of the social, safety and security dimensions of public transport. It adopts a comprehensive, multi-pronged, and multi-stakeholder methodology. Therefore, it gains invaluable insights into the performance of public transport services, empowering decision-makers to make well-informed choices regarding future enhancements and investments. Importantly, this framework emphasizes on the significance of social, safety and security elements as perceived by passengers, shedding light on their intrinsic value in public transport.

Index Terms— multi-stakeholders, public transport, social and security aspects, urban mobility

Introduction

Public transport (PT) provides affordable and convenient mobility options for individuals to travel to work, education, healthcare facilities, and other essential services, ensuring that everyone has equal opportunities for mobility and access. It promotes social equity by providing affordable transportation options for individuals from diverse socio-economic backgrounds and help alleviate traffic congestion by reducing the number of private vehicles on the road. The latter contributes to smoother traffic flow, shorter travel times, and improved air quality by reducing greenhouse gas emissions and other pollutants. In addition, global urban population is expected to increase from 4.2 billion in 2018 to 6.7 billion by 2050 [13], which means that approximately 68% of the world's population is expected to live in urban areas by that time. Therefore, effective operation of public transport is becoming essential as it enhances well-being and contributes to sustainable urban development.

Public transport is a vital aspect of urban mobility (UM), but its low perceived security, increased incidents of gender-based violence, limited reporting options, and the COVID-19 pandemic have decreased its trust and usage. This leads to increased traffic, emissions, limited social cohesion and reduced feedback from citizens in shaping future urban environments. To address these challenges, evaluating public transport services through the perspectives of passengers and other stakeholders is crucial. This will harness the power of the community and provide evidence-based understanding of the quality of public transport services from all stakeholders. This work aims to provide a comprehensive framework to evaluate the social and safety aspects of public transport.

The proposed framework offers a holistic approach to evaluating the social and security aspects of

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public transport. It considers multiple objectives and engages various stakeholders, ensuring a well-rounded assessment of the transportation system. It also recognizes that public transport plays a vital role in society, facilitating mobility, connectivity and access to essential services. By considering the diverse needs and perspectives of both the public and relevant entities, we aim to enhance the overall effectiveness, efficiency, and safety of public transport networks. Therefore, it is crucial to evaluate its performance not only from a technical standpoint but also through the lens of social impact and security considerations. By adopting a multi-objective and multi-stakeholder approach, our framework provides a comprehensive evaluation methodology that captures the complexity and interconnectedness of public transport systems.

Through the involvement of multiple stakeholders, including transport authorities, operators, community representatives, passengers, and security experts, the framework ensures that diverse perspectives are considered and integrated into the evaluation process. This collaborative approach enhances transparency, accountability, and informed decision-making, leading to the development of more effective policies, strategies, and improvements within the public transport sector. We envision a transportation system that not only meets the technical requirements but also fosters social cohesion, promotes accessibility and inclusivity, and prioritizes the safety and well-being of all users.

The remainder of this paper is organized as follows: Section 2 provides the research background presenting the aspects for evaluating the social and security aspects of public transport. The proposed framework is described and analyzed in Section 3 discussing the interaction among urban mobility components. Finally, in Section 4 experimental results are presented and in Section 5 conclusions are provided in an attempt to enhance the overall effectiveness, efficiency, and safety of public transport networks.

I. RESEARCH BACKGROUND

Public transport is a relatively secure place and only a small share of reported events is of criminal nature, while the vast majority concern public disorder and disturbance [4]. It is also considered as a very safe transit option presenting low crash risk compared to automotive occupants [16]. However, passengers often perceive PT as less secure, due to several groups of factors leading to personal fear. Such fear and risk perceptions are induced by several public transit attributes such as isolation in UM facilities (e.g. vehicles, stops) in which people are not surrounded by fellow passengers [5], traveling during night [17] or until the end of the line [26]. Another dimension inducing fear lays into public transportation modalities such as the access to vehicles or infrastructure [12], trip length and waiting time [5].

Moreover, personal fear is affected by potential deviant behaviors caused by groups of people, for example, young, drunk, or other surrounding social mixtures [24]. Women have been found to feel insecure in case the bus is not on-time, the service quality is low and relevant trip information is limited [20] as well as CCTV cameras have a lower effect on their feeling of security. Regarding elderly people, it has been shown that they do not deal only with accessibility or service quality issues to use PT, but also with the fear of crime [25].

Media exaggerated coverage of crashes or crime incidents in PT contribute to passenger fear [5], [16], however they also publish reports about the security perception of passengers raising the awareness of transport providers, local or national authorities and passengers. For instance, the Federal Public Service of Mobility and Transport in Belgium finds in its survey that one in three women fear the inappropriate behavior of fellow passengers and that is the reason for not using PT [7]. The same survey finds out that this is also the case for one in five men. The need for policymakers and PT to take measures is indicated by the aforementioned reports as well as innovative solutions are needed to tackle low security perception. Otherwise, fear creates a vicious cycle of distrust that undermines sustainable, multimodal and potential active mobility for the passengers.

Collecting data on security perception, feelings and opinions of passengers as well as road safety data in public transport is a difficult task, since the available information is fragmented to local circumstances or

groups of users. Such data are usually found in (inter)national surveys [2], [8], [16], studies commissioned by public transport providers [7], [14], opinion collection studies or scientific studies focused on specific target groups e.g. elders [19]. As shown above security perception can be affected by many environmental factors like darkness or transit attributes such as punctuality or service quality, however very crucial is the role of isolation. That is for example passengers being alone or feeling lonely and helpless during a trip [5]. This is not relevant only to perception, researchers argue that for a crime to occur there must be three elements: the presence of a motivated offender, a suitable target, and absence of capable guardians [10].

We, therefore, argue that for evaluating PT services we need to also consider the level of connectivity both among passengers and PTs or authorities. Note that the pandemic enhanced both the feeling and the actual isolation of passengers; they reduced the use of PT and increased personal car use [6], [23]. In addition, the increasing individualism in our society could be proven as a barrier to implement urban mobility policies for active and sustainable mobility. Public transport could use the available ICT tools both to strengthen the ties among passengers in PT infrastructure and people in urban public spaces. Connecting with other passengers could increase social cohesion in cities where individualism and the fast rhythms of life can distance people from their true nature of communicating. Public transport has mainly been focusing on affordable and safe means of transportation for everyone, however it could become more attractive by encouraging mutual support. Such behavior change could be achieved through passenger interaction towards an inclusive and connected passenger community. In this way, isolation could be reduced and subsequently both crime and deviant behaviors in PT, while both the feeling and the actual security would increase [10].

The human-centric public transport system we have been describing so far prioritizes passenger security, mutual support as well as accompanies the urban mobility services with feedback mechanisms. Currently, passengers have very limited tools to provide their invaluable feedback to providers or local authorities to improve the urban mobility environment. Crowdsourcing initiatives use the ICT technologies to bridge the gap between local authorities to enable citizens report local issues in their neighborhood [18]. For example, the SeeClickFix.com as well as other 311 solutions, systems that manage citizen requests, are becoming more and more popular. In addition, open-source organizations such as Fireware implement open data models to support communication of IoT sensors and devices thus enable the development of smart city solutions. Regarding public transport, such solutions can support both passengers who contribute their invaluable feedback as well as cities and transport providers who collect citizens' feedback and can extract knowledge and the ability to engage them by responding to their feedback.

Public transport has been helping all passengers to have access on safe and affordable mobility means. The increasing digitalization of transportation organizations combined with communication networks expansion such as 5G networks [21], the localization technologies growth and the availability of mobile phone devices enabled the development of numerous applications and services, among others in the mobility area. Urban mobility services include but are not limited to detailed mapping and localization, navigation, route planning and other. Improved mobility services consider multimodal transportation meaning when passengers unobtrusively can combine their mobility selection from public transport to bike or car sharing platforms, taxis, or other MaSS platforms [11]. Transport organizations enabled the creation of commercial and non-commercial applications by making available their own real-time data to the public through APIs [22]. Such mobility data may include timetable, trips, routes, arrivals, accessibility, information live feeds and other data often under the GTFS data model [1].

Urban mobility services except from localization and trip selection come down to management services, meaning ways to manage the booking and make the payment of the offered service. Native transport providers' applications as well as third party services usually offer various options for buying a ticket. Booking management and paying utilities are a crucial part of an offered service, thus

transport providers need to offer easy and up-to-date options to passengers. Urban mobility contains by default environment, space and moving people, however this notion is nowadays limited since people need to be able to access various mobility services that are on-demand, energy-efficient, environment-efficient, making our living in the urban centers more livable [9]. Public transport infrastructure and services can lead the mobility of the future cities by integrating efficiently with third party mobility services considering also the environmental efficiency. For instance, passengers need to be able to quantify their environmental and energy footprint of their mobility choices, promoting active mobility. Raising awareness among passengers about their personal and collective activity can lead to real behavior change and improvement. We, thus, argue that such features are important for the urban mobility services of the future.

II. ASSESSMENT FRAMEWORK

The proposed assessment framework (Fig. 1) consists of several components that enable its successful implementation for the evaluation of UM by considering passengers' behavior, transport service providers and the public authorities' group of stakeholders. It follows a 5-steps assessment, and its output is based on both quantitative and qualitative data. The basic components involve (i) Stakeholders. They are the main users of the public transport i.e., passengers, public authorities and transport service providers; (ii) Objectives. Each stakeholder group is linked to an indicator to reveal the stakeholder interest to assess the offered public transport services. These are linked to stakeholders to present the objectives of each stakeholder category.; (iii) Criteria. There are several criteria for each of the predefined objectives that could be quantified by proper KPIs.; and (iv) Key Performance Indicators (KPIs). The different criteria set the basis to develop the corresponding KPIs that support monitoring and assessing the performance of the offered public transport services. A KPI may concerns one or more stakeholders referring to their objectives and priorities.

Following fig. 1, Step 1 refers to the identification of UM components, including key influencing factors and services of UM activities. In fact, in this step, the UM scene is set and the interaction among the components is presented in fig. 2.

Figure 1: Assessment Framework

The main stakeholders involve (i) passengers, who are the main users of the framework; (ii) public transport providers, including also security service providers and MaaS providers; and (iii) public authorities i.e., Municipalities, Regional and local Authorities.

Figure 2: Interaction among urban UM components

An initial list of key influencing factors has been determined based on the objectives of the relevant stakeholders i.e., (i) to enhance the security feeling of passengers, (ii) to increase passengers' connectivity and communication while allowing them to select with whom to be connected, (iii) to enable passengers to report their experiences and provide feedback about the UM services, (iv) to enable cities receiving and managing geo-analytics on users' feedback as well as evaluating digitization of reporting, (v) to provide detailed information about the means of transport and mobility routes, and (vi) to allow public authorities to quantify environmental benefit of improved UM services [15].

Determining the "proper services" for safe, secure and efficient PT in urban areas and assessing their performance are critical processes that depend on multiple priorities and objectives of the different stakeholder groups. The latter are reviewed and

evaluated in an attempt to determine the "proper services" of relevant tools that ensure the commitment of the relevant stakeholders. More specific objectives that could be quantified by proper KPIs are developed to monitor and assess the performance of the proposed services in a systematic way in order to achieve synergies among public and private sector. Within the evaluation stage, performance measurements are utilized to properly revise the services based on the results derived from the KPIs supporting decision making regarding urban PT planning.

More specifically, passengers need higher security in UM and are interested in receiving high quality services for their movements allowing communication among users and increasing users' connectivity. In addition, passengers are interested in communicating and receiving comments and information from other users of the PT. As such, higher connectivity of passengers is one of their main requirements. On the other hand, the main priorities and challenges of the public transport providers are to enable users to report giving feedback and to enhance the feeling of safety and security to their users offering improved services. The public authorities aim to increase the means of reporting in order to allow residents to give their feedback and inform them about problems.

The aforementioned objectives address three main impact areas that assess UM i.e. (i) security, (ii) connectivity and (iii) reporting. Measuring the performance of the current UM services using proper KPIs evaluates their impact assessment supporting decision making regarding their improvement. The KPIs evaluate comprehensively the performance of the applied measures and policies, quantify the criteria of the different stakeholders for promoting efficient UM and they also provide practical guidance to stakeholders for assessing impacts of UM related to sustainability and safety of an urban area [3]. Table 1 summarizes the common criteria of the different stakeholders for improving UM linked to the aforementioned impact areas as well as the relevant indicators.

Table I: Objectives, Criteria and KPIs of Stakeholders

Objectives	**Criteria**	**Key Performance Indicators (KPIs)**
O1: Enhance **Safety & Security**	Level of security feeling	Passengers' security (Likert scale)
		Number of reports for certain stops
		Passengers' trust (trust score and/or Likert scale)
O2: Enhance **Connectivity**	Level of connection	Number of connect requests
	Level of invitation selection	Usage of filtering features (Y/N)
O3: Offer **Reporting** Services	Level of passengers' reporting	Number of reports
	Categorization of reports	Number of categories
		Level of categorization (Likert

		scale)
O4: Offer improved **Mobility** Services (e.g., route planning, navigation, etc.)	Available information about routes	Live feed information (Y/N) UM open data available (Y/N)
O5: Offer improved **Management** Services	Operational Costs incurred	Ticket management acquisition (Y/N)
O6: Support **Environmental Efficiency**	GHG emissions	CO2 (equivalent)

Measuring the performance of the current UM services using proper KPIs evaluates their impact assessment supporting decision making regarding urban PT. The KPIs evaluate comprehensively the performance of different applied services, quantify the criteria of different stakeholders for promoting secure and sustainable UM and they also provide practical guidance to stakeholders for assessing impacts of UM related to sustainability and security of an urban area. The proposed KPIs are established to assess the different criteria of the relevant stakeholders associated with their objectives. The next step includes the establishment of weights to the indicators in an attempt to provide accurate and efficient assessment of the different objectives.

I. RESULTS

A survey is conducted using the proposed framework and representatives of public authorities, transport service providers, research institutes and universities evaluated the importance of each KPI based on their perspective. An online questionnaire developed and fig. 3 depicts the established weights of each objective based on the derived results. The stakeholders identified “safety & security services” and “mobility services” as the main objectives that appeared the higher interest with a share of 23% and “management services” follow with 18%. “Environmental efficiency services” appear a limited interest of the stakeholders with 15% and similarly, the “connectivity services” with 12%. Finally, “other reporting services” is the least willing service with only 9%.

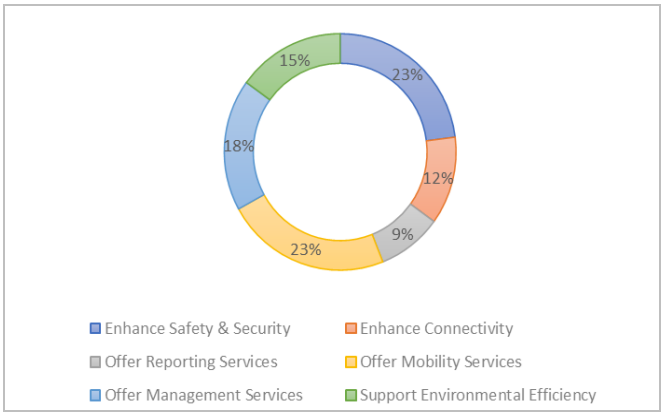

Figure 3: Established Weights of Objectives

Correspondingly, the established weights of each KPI are presented in the figures below (fig. 4, fig. 5, fig. 6, fig. 7, fig. 8 and fig. 9). Regarding the objective for enhancing safety and security, the most promising KPI is the feeling of passengers' security with 45%. The responders also established the higher weight in the number of connect requests for the objective of enhancing connectivity. Based on the survey, the number of reports achieved a very high weight (50%) for the objective of offering reporting services. Similarly, the available UM open data is very important, with a weight of 80%, for the objective of offering improved mobility services. Finally, the ticket management acquisition and the CO2 are the only KPIs for the objectives of offering improved management services and supporting environmental efficiency, correspondingly.

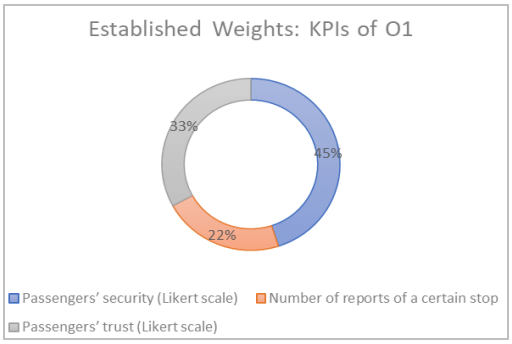

Figure 4: Established Weights of KPIs for the O1

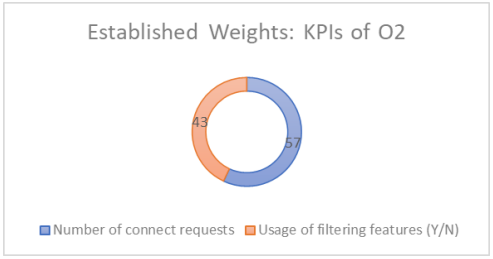

Figure 5: Established Weights of KPIs for the O2

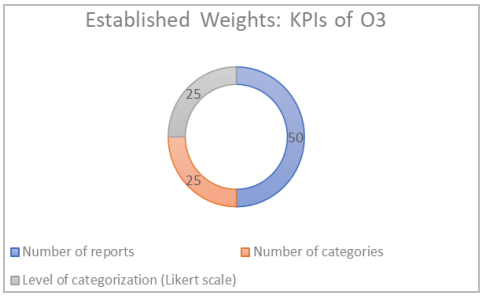

Figure 6: Established Weights of KPIs for the O3

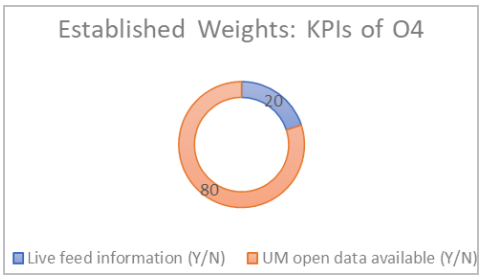

Figure 7: Established Weights of KPIs for the O4

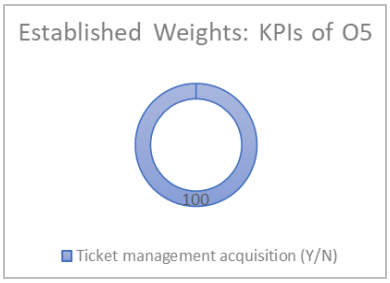

Figure 8: Established Weights of KPIs for the O5

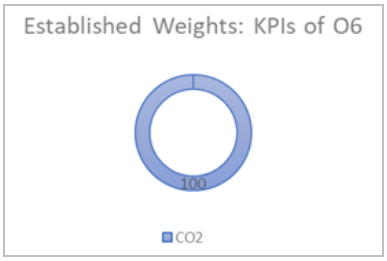

Figure 9: Established Weights of KPIs for the O6

This approach would allow for a comprehensive and systematic assessment of the quality and impact of different urban mobility services on the users and the environment. The level of service and satisfaction could be estimated by using the defined objectives and KPIs by weighting their importance according to these results. In other words, by using the weighted objectives and KPIs, the stakeholders can compare and prioritize the most suitable and sustainable options for enhancing urban mobility and addressing the challenges and opportunities in this domain. Therefore, potential services could be evaluated to determine their significance in urban mobility and improved decision making could be achieved.

Conclusions

The proposed assessment framework follows a comprehensive, multi-objective and multi-stakeholder approach to evaluating public transport services in a modern city. It is flexible and adaptable to different contexts and scenarios of public transport services and can provide robust and reliable results. This unified approach ensures a detailed assessment of the different aspects of

public transport services and considers all relevant stakeholders. The derived KPIs are designed to address the needs and goals of both the private and public sectors. The interconnected components of the assessment framework streamline the evaluation process for different users and guide them towards a comprehensive understanding of their satisfaction. The assessment framework considers multiple dimensions of the service quality i.e., accessibility, reliability, comfort, safety, and others.

The final outcomes of the evaluation process provide valuable insights into the users' perception of the public transport services, enabling decision-makers to identify areas for improvement and make informed decisions about future investments and upgrades. The framework also serves as a tool for fostering dialogue between stakeholders, promoting collaboration and co-creation of solutions to enhance the quality and performance of public transport services. They provide significant understandings into the quality and performance of public transport services, enabling decision makers to make meaningful observations by identifying the value of safety and security aspects according also to passengers.

References

[1] A. Antrim, and S. J. Barbeau, "The many uses of GTFS data–opening the door to transit and multimodal applications," Location-Aware Information Systems Laboratory at the University of South Florida, 4, 2013.

[2] R. Bamzar, "Safety in Stockholm's underground stations: the importance of environmental attributes and context," In Trafiken i stadsförnyelsen-förtätning som mantra eller lösning?, Stockholm, Sweden, 12-13 April, 2011.

[3] F. Bruzzone, F. Cavallaro and S. Nocera, "The effects of high-speed rail on accessibility and equity: evidence from the Turin-Lyon case-study," Socio-Economic Planning Sciences, 85, 101379, 2023.

[4] V. Ceccato, A. Uittenbogaard and R. Bamzar, "Security in Stockholm's underground stations: The importance of environmental attributes and context," Security journal, 26, 33-59, 2013.

[5] C. Concern, "People's Perceptions of Personal Security and Their Concerns about Crime on Public Transport: Literature Review," The Department, 2002.

[6] Continental, "The 2020 Mobility Study," https://www.continental.com/en/press/studies-publications/continental-mobility-studies/mobility-study-2020/, 2020.

[7] DeMorgen, "FPS Report. One in three women avoids trains and buses for fear of fellow passengers," https://www.demorgen.be/nieuws/een-op-de-drie-vrouwen-mijdt-trein-en-bus-uit-angst-voor-medepassagiers~bd89ab6d/, 2020.

[8] DeMorgen, "European Agency for Fundamental Rights Survey. Eight out of ten young European women avoid public spaces out of fear," https://www.demorgen.be/nieuws/acht-op-de-tien-jonge-europese-vrouwen-mijden-openbare-ruimtesuitschrik~b7c890f3/?utm_source=link&utm_medium=app&utm_campaign=shared%20content&utm_content=free, 2021.

[9] EIT UM, "STRATEGIC AGENDA 2021 – 2027. EIT Urban Mobility - Mobility for more liveable urban spaces," https://www.eiturbanmobility.eu/wp-content/uploads/2021/04/210329_SA_EIT-UM-branded_Final-published.pdf, 2021.

[10] M. Felson and R.V. Clarke, "Opportunity makes the thief," Police research series, paper, 98(1-36), 10, 1998.

[11] P. Georgakis, A. Almohammad, E. Bothos, B. Magoutas, K. Arnaoutaki and G. Mentzas, "MultiModal route planning in mobility as a service," In IEEE/WIC/ACM International Conference on Web Intelligence-Companion Volume (pp. 283-291), October, 2019.

[12] B. A. Hamilton, "Personal security in public transport travel–Problems issues and solution. Land Transport New Zealand Research Report," 2007.

[13] R. Hannah and R. Max, "Urbanization," Published online at OurWorldInData.org. Retrieved from:

https://ourworldindata.org/urbanization, 2018.

[14] L. Hempel, J. Meier, H. Rau, C. Steltner and D. Vedder, "Subjektive Sicherheit im Öffentlichen Personennahverkehr. Test und Evaluation ausgewählter Maßnahmen," Gemeinsamer Abschlussbericht, 2011.

[15] H. Inac and E. Oztemel, "An assessment framework for the transformation of mobility 4.0 in smart cities," Systems, 10(1), 1, 2021.

[16] T. Litman, "A new transit safety narrative," Journal of Public Transportation, 17(4), 114-135, 2014.

[17] L. J.Loewen, G. D. Steel and P. Suedfeld, "Perceived safety from crime in the urban environment," Journal of Environmental Psychology, 13(4), 323–331, 1993.

[18] I. Mergel, "Distributed democracy: Seeclickfix. com for crowdsourced issue reporting," Com for Crowdsourced Issue Reporting, January 27, 2012.

[19] J. Noble, "Fear of crime in public transport," Deviance et Societe, 39(3), 343-364, 2015.

[20] R. Sham, N. Samsudin and K. Rahman, "Managing public transport service operation in reducing travel fear factor," Procedia-Social and Behavioral Sciences, 101, 338-344, 2013.

[21] K. Shafique, B. A. Khawaja, F. Sabir, S. Qazi and M. Mustaqim, "Internet of things (IoT) for next-generation smart systems: A review of current challenges, future trends and prospects for emerging 5G-IoT scenarios," IEEE Access, 8, 23022-23040, 2020.

[22] M. Stone and E. Aravopoulou, "Improving journeys by opening data: the case of Transport for London (TfL)," The Bottom Line, 31(1), 2-15, 2018.

[23] D. Tarasi, T. Daras, S. Tournaki and T. Tsoutsos, "Transportation in the Mediterranean during the COVID-19 pandemic era," Global transitions, 3, 55-71, 2021.

[24] M. Tulloch, "The meaning of age differences in the fear of crime," British journal of criminology, 40(3), 451-467, 2000.

[25] R. C. P. Wong, W. Y. Szeto, L. Yang, Y. C. Li and S. C. Wong, "Public transport policy measures for improving elderly mobility," Transport policy, 63, 73-79, 2018.

[26] R. Zauberman, "Surveys on victimisation and insecurity in Europe," The Routledge Handbook of European Criminology, 74, 2013.