22nd EURO Working Group on Transportation Meeting, EWGT 2019, 18-20 September 2019, Barcelona, Spain

Added value of a customized transit app for metropolitan bus trips

Carlos Romero[a]*, Andrés Monzón[b], Andrea Alonso[c], Raky Julio[a]

[a] TRANSyT - Transport Research Centre, Universidad Politécnica de Madrid, Calle Profesor Aranguren 3, 28040 Madrid, Spain
[b]Transport and Territory - Civil Engineering Department, Universidad Politécnica de Madrid, Calle Profesor Aranguren 3, 28040 Madrid, Spain
[c]Urban and Regional Planning- Architecture Department, Universidad Politécnica de Madrid, Avenida Juan de Herrera 4, 28040 Madrid, Spain

Abstract

Bus passengers require reliable and real-time information but the existing systems still do not fully satisfy their needs. Within the framework of the European project HARMONY, a transit app has been developed in Madrid Region to improve the information that passengers receive from metropolitan buses. It enables an option for passengers to send incidences to operators in real-time. A SWOT matrix has been built and a two-stage consultation to passengers has been carried out to know the current transit app market and to detect gaps in the users' needs, leading to the features to be implemented. None of the existing apps allow a bi-directional communication between operators and passengers. Survey results reveal that apps like Google Maps do not compete with specific transit apps that include real-time information because daily commuters require that specific information of their routes.

Peer-review under responsibility of the scientific committee of the 22nd Euro Working Group on Transportation Meeting

Keywords: Real-Time Information; Bus passengers; Transit app

1. Introduction

The current model of growth and suburbanization in European cities has created difficulties in the provision of public transport (Alonso, Monzón, & Cascajo, 2017). With this background, urban and metropolitan bus services emerge as a key role in the transportation network (dell'Olio, Ibeas, & Cecin, 2011). However, bus services have been perceived for a long time as a less reliable mode of transport in relation to route information, what can be pointed out as a loss of quality of service (Hensher, Stopher, & Bullock, 2003). The development of Real-Time Information (RTI) systems in the last years has contributed to enhance both urban bus operations and time reliability for transit users.

On the other hand, in the ICT era, citizens need to be continuously informed as they make decisions based on the information they receive. In this sense, smartphones and continuous access to Internet allow citizens to receive

* Corresponding author. Tel.: +34-910674225 .
E-mail address: carlos.romeromorales@upm.es

This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)
Peer-review under responsibility of the scientific committee of the 22nd Euro Working Group on Transportation Meeting.
10.1016/j.trpro.2020.03.126

information on a constant basis. The development of real-time information processes by public transport operators has enabled them to provide users basic information on their smartphones. Then users can handle the unreliability of transit services (Carrel, Halvorsen, & Walker, 2013). However, users increasingly require to receive specific information about each trip they are taking or are about to take. One option to produce and obtain RTI in an easy way is by using crowdsourced tools, where passengers are able to share information among them. Yet the willingness of transit users to share information is still low (Sarker et al., 2019). Another approach from the transit operator point of view is to deliver users a specific, customized transit app providing them information covering all the stages of the trip.

Regarding to the different types of information that may be relevant to passengers, it depends on their personal features (Esztergár-Kiss & Csiszár, 2012) and on each stage of the trip. Some information can be consulted with anticipation (i.e. planning an unusual trip) and some other is more valuable if obtained immediately. The RTI tools offers the latter, helping passengers to make decisions at the spot and reducing uncertainties throughout the stages of the trip. A wide set of studies about the use and perception of passengers' RTI tools are aimed at explaining the benefits of these tools and the main behavioural outcomes associated: wait time, travel time and transit use. These behavioural outcomes are reviewed by Brakewood & Watkins (2018). Being aware of the wait time at bus stops in real-time not only allows passengers to adjust their arrival at the stop to minimize the waiting time at stop but also reduces the wait time's uncertainty. Besides, in case a bus service suffers any inconvenience or an unexpected delay, these RTI tools may suggest passengers an alternative route. All this results in a potential increase of public transport share.

Several studies are focused on measuring the impacts of a new RTI system in a certain bus service (Brakewood, Macfarlane, & Watkins, 2015; Tang & Thakuriah, 2012), and only a few of them have tried to perceive the passengers' preferences about media devices- both personal or in the infrastructure (Harmony & Gayah, 2017; Mulley et al., 2017) or analyze how a mobile transit app can channel feedback from passengers to transport authorities and operators (Barbeau, 2018). Therefore there are three gaps in the literature in this context: (i) to compare the passengers' perception on the main current mobile transit apps, (ii) to test a customized transit app and to compare it with other existing apps in order to find its added value and (iii) to analyze the performance and impacts of the bidirectional communication between passengers and transit operators.

The paper is composed of six chapters. Section 2 describes the methodology. Section 3 defines the case study and includes a screening of the current available RTI tools. Section 4 presents the customized tool. Finally, Section 5 exposes the results of the tool trial and Section 6 contains the conclusions and proposes further research.

2. Methodology

The need of customized information for public transport passengers requires to firstly define the specific target, including the location where the study is going to be performed and the main trends in mobility that happens there. Once the case study and the target have been set, a proper methodology of analysis and evaluation can be established. Then, the methodology of the research is divided in three stages: first, a market study to implement the tool is carried out using a SWOT analysis. Then, a double consultation to the potential users is conducted – before and after testing the tool. Finally, the results of the potential users' feedback are tested through a SWOT matrix in order to improve it and to find the real competitors of the deployed tool.

The process starts with a preliminary market study that may provide a first understanding of the developed tool, and the potential strategies to place a tool of that type in the market. The SWOT analysis is selected as it considers internal and external factors involved in an emerging product. The weakness, strengths, threats and opportunities of the tool developed in this project are analyzed in the context of other competing tools, leading to build the SWOT matrix. As mentioned before, this result is validated and improved in the last stage, with the involvement of the users.

The consultation to passengers allows to check if external factors are correctly defined and to analyze the current perceptions of users regarding similar or competing tools. This consultation is carried out through a survey campaign to users for a week, collecting information from daily commuting and weekend trips. The data collection procedure combines a face to face distribution and an online answering. This procedure has been validated in previous studies (Garcia-Martinez et al., 2016, Hernández, Monzon & de Oña, 2016). The questions provide information on their personal characteristics, mobility patterns and on the mobile transit apps and websites that they currently use to plan and check their trip and the traffic conditions. Regarding these tools, they are asked their opinion in a 1-to-5 Likert scale about aspects such as general perception, usefulness to know wait time and travel time, data reliability and missing features. It might have an age bias on mobility patterns since the users must answer the survey online, however it is expected this bias would have a small influence.

Next, the transit app is developed considering the opinions about missing features. Once the app is developed, it is tested to see if it meets the users' requirements. The consultation for the tool validation follows the same structure than the preliminary evaluation and permit to assess the internal factors of the SWOT matrix. The main difference between the two evaluations is that participants could use the developed mobile app, testing its capacity to improve their daily travels. Passengers who took part in the first survey campaign are eligible for the second assessment. After a week using the app, they must answer another survey to analyze the real utility of the app and its features. They are also asked whether they would keep on using this app and, if not, what other app they would use. The size of the sample considered for this beta testing is sometimes less than 20 (Papangelis et al., 2016). As it is expected a small sample in the second consultation, these results should not be considered as statistical significant.

The joint results of the preliminary analysis and the tool validation are checked with the results of the SWOT matrix. Besides, it allows to detect which current apps are offering similar or better solutions to the newly app.

3. Screening of RTI tools' utilities for improving Public Transport in Madrid Region

3.1. Case study: North corridor of Madrid Region

The present study has taken place in the North corridor of Madrid Region, focusing on the mobility between Alcobendas and Plaza de Castilla, the main public transport hub in the north area of the city of Madrid. The interchange station of Plaza de Castilla has three Metro lines, 21 urban bus routes and 34 metropolitan bus routes that serve the northern Madrid Region. Plaza de Castilla holds more than 250,000 daily passengers in Public Transport – almost 50,000 were using metropolitan bus (CRTM, 2016)

Alcobendas is a municipality located about 15 km north of Madrid, with a population of 116,037 inhabitants and a density of 2,554 inhab/km2. It also contains several industrial estates and two important business parks. It is connected to Madrid by the A-1 motorway, in one of the most congested stretches in Spain. Regarding to public transport, the offer includes include 4 Metro stations, 2 suburban rail stations, 8 urban bus routes and 18 metropolitan bus routes.

The scope of the study only includes the bus routes belonging to a single bus operator, INTERBUS. This comprise 5 Alcobendas urban routes and 7 metropolitan bus routes that links Alcobendas with Madrid. The average demand of those routes in a working day sums up to 24,000 trips/day – 33% in urban routes and 67% in metropolitan routes.

3.2. SWOT analysis on current information tools

The initial market study considered the available tools in the location described above. It includes three global transit apps – Google Maps, Moovit, Citymapper –, one official app – Mi Transporte – and other non-official transit apps specific for the public transport system of Madrid. The main functionalities are analyzed as follows:

- Google Maps provides detailed information about geographical regions and sites around the world. Traffic and transit information is focused on its route planner. It offers the best route in public transport, by car, by bicycle or by walking. Regarding to the case study, Google Maps doesn't have information for the metropolitan bus routes.
- "Mi Transporte" is the PTA mobile app, and includes information of every public transport mode within the Madrid Region. The main feature is the wait time at the stops and stations in real time. However the estimated wait time is calculated from static timetables when bus RTI is unavailable. This app also displays on a map any transit service and includes alerts of planned events such as renovation works. The lack of a route planner is its main disadvantage.
- Citymapper and Moovit are two worldwide transit-oriented apps. In Madrid, these two apps integrate official public transit data from PTA, covering all the transit modes in Madrid Region, and their trip planners calculate routes including metropolitan buses.

Apart from the mentioned apps, some other transit apps designed for Madrid Region are taken into account since they have more than 100,000 downloads in the Google Play store. The combination of the characteristics of the current apps and the potential functionalities of the app under development leads to complete the SWOT matrix (Table 1).

Table 1. Preliminary SWOT matrix.

	Negative factors	Positive factors
Internal factors	The development of the tool is based on the integration of different types of data	Combines data on real time; inconveniences programmed in advance may also be included. Capacity to integrate official information (from transport operators and traffic managers) with unofficial information (passengers as data providers)
External factors	Competition with strong tools, with less types of data implemented but more users.	The tool captures specific and local conditions, and provides reliable and high quality data which is not considered by globalized tools

3.3. Consultation on available RTI tools

The preliminary consultation received 485 valid answers, and 81% of the surveyed passengers were habitual users of the considered metropolitan bus routes. They also were multimodal users, as 83% takes two or more transport modes in their daily trips. Regarding to the mobile transit apps' habits, they were asked about their frequency of use, being Google Maps (72% use it at least once a month) and Mi Transporte (46%) the most used. In the other hand Moovit, Citymapper and other non-official transit apps did not reach a 25% of usage. In order to compare the performance of the transport apps, the two most representative are selected: these are Google Maps and Mi Transporte.

Users' satisfaction on the different attributes analyzed are shown in Table 2. The number of answers for each app is different and shorter than the full sample as passengers only rated an app if used more than once a month. The main difference reported by users is that Mi Transporte performs much better than Google Maps in reducing wait times at bus stops. This result was predictable because Google Maps doesn't display RTI about the routes under study. Besides, passengers perceive that Mi Transporte also provides better information about routes and timetables. However, Google Maps gets better rates in the overall satisfaction.

Table 2. Mean values for every feature of Google Maps and Mi Transporte app.

	Google Maps (n=351)	"Mi Transporte" CRTM app (n=223)
Check routes and timetables	3.6	3.9
Reduce wait time at the bus stop	2.5	3.6
Save total travel time	3.5	3.4
Ease of use	4.3	4.1
Reliability on data	3.8	3.4
Global satisfaction	3.9	3.4

4. The customized transit app: HARMONY

The HARMONY project is a CEF action by Indra and the Universidad Politécnica de Madrid, with the aim of improving the Multimodal Information Services and Systems in European urban areas. A pilot has been carried out in the North corridor of the Madrid Region, including three use cases: urban traffic monitoring, public transport fleet management and transit information provision to passengers. (Alfonso et al., 2018). In order to cope with the last use case, a customized transit app for users has been developed.

At the end of the previous consultation, passengers were told that a customized transit app was under development and they were requested to rate their interest on several features. These features are included in the Table 3. Users declared to be completely interested in checking routes and timetables, estimating travel time and receiving real time information from the bus operator. On the contrary, passengers appear to be less keen on sending information to the bus operator, thus it may reduce the effectivity of the tool.

Table 3. Potential new features of HARMONY app: users' interest.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Check routes and timetables	87%	7%	4%	0%	2%
Estimate travel time	81%	11%	4%	1%	3%
Receive RTI from bus operator	81%	9%	6%	1%	3%
Send RTI to bus operator	69%	14%	10%	3%	5%
Know the environmental impact of the trip	41%	19%	20%	8%	11%

These outputs were contemplated in the final deployment of the app. The app allows to do the following actions:

- Check waiting times at bus stop in real time, introducing its stop number or scanning the QR code at bus stops.
- Display the routes in a map. An example of this function is shown in Figure 1a.
- Show the expected time of arrival for a given route, stop and date. This apply not only for the next bus but for future services, not necessary for the present day. An example of those functions is shown in Figure 1b.
- Look for near stops, if the GPS mobile function is activated.

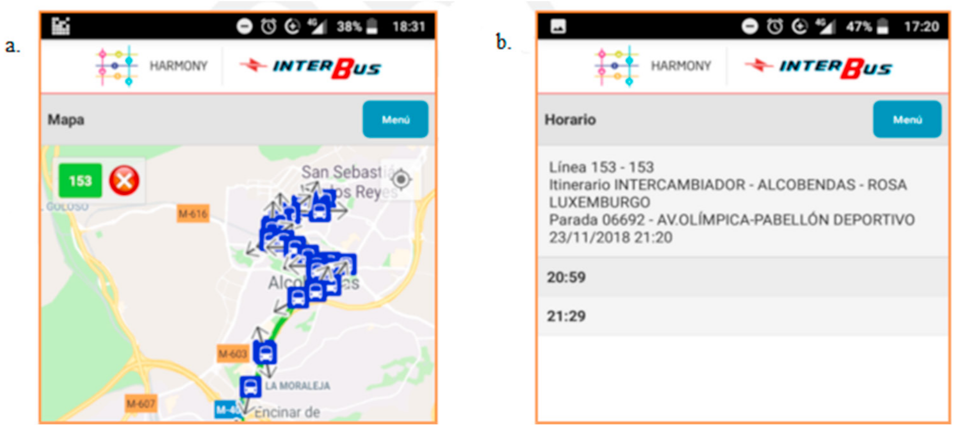

Fig. 1. (a) Screenshot of routes' display (b) Screenshot of the incident reporting menu.

One way to improve at the same time the provision of transit information to passengers and the bus fleet management consists in establishing multilateral communication channels to exchange information between passengers and transit operators. To allow that, the HARMONY app includes a feature for users to inform the bus operator about incidents in bus services. This feature is integrated with the existing Operation Assistant System (OAS) of the bus company. In order to avoid incompatibilities between the app and the OAS, this feature contains the same items that the current OAS. These features are the following ones:

- Element. There are four available elements: general, route, stop and itinerary. The division of route and service has been done since some bus routes may do a specific itinerary few times a day.
- Cause. Passengers can point out the reason of the incident among a set of options. That includes technical issues, accidents, medical emergencies, police intervention…
- Effect. Passengers may also indicate the consequence of the incident, including different options such as significant delays or canceled service.
- Period of validity. Passengers are also required to suggest the number of days this notice will be shown in the OAS.
- Text. Finally, a brief text is required to add useful details, such as the route number or the bus stop affected.

The notification is shown in the initial screen in case it is active.

5. Impacts of HARMONY app

After the development of HARMONY app, a trial test was carried out with the aim of validating its performance, especially the communication between passengers and operators. Besides, it would be possible to check if passengers take different decisions based on the notifications they receive in the app from operators.

Testers were picked from among the participants in the previous survey. Finally, 17 passengers agreed to test the HARMONY app and answer a second survey. Since this sample is small and might be unrepresentative of the initial sample, some individual attributes (age and gender distribution) and some perception of information received (mean satisfaction with apps) of both groups are selected and compared. These attributes are represented in Table 4, finding that age distribution and satisfaction with apps seems quite similar between both groups. In consequence, the results of this validation phase are not statistically significant but may provide an interesting insight.

Table 4. Comparison of key attributes between the initial sample and the app testers

Attribute		Initial sample (n=485)	App testers (n=17)
Age	< 25 years	31%	35%
	25 – 65 years	67%	65%
Gender	Male	43%	24%
	Female	57%	76%
Mean satisfaction with apps	Google Maps	3.9	3.8
	Mi Transporte	3.4	3.3

5.1. Satisfaction with HARMONY

The ratings of the HARMONY's features under evaluation (Table 5) are positive, particularly on checking routes and timetables. However, it is surprising that the worst rate is achieved at reliability on data, despite the data is gathered directly from the bus control system. Besides, two items related to the bi-directional communication between operators and passengers are also rated: users receiving RTI information from bus operators in the app and users sending notices to the bus operators. The notices sent to operators are also estimated as real-time because passengers send that notices during the trip.

Table 5. Mean values for every feature of HARMONY app.

	HARMONY app (n=17)
Check routes and timetables	4.4
Reduce waiting time at the bus stop	3.8
Save total travel time	3.2
Ease of use	3.9
Reliability on data	3.2
Receive RTI from bus operator	3.5
Send RTI to bus operator	3.7
Global satisfaction	3.7

When comparing the results shown in Tables 2 and 5, HARMONY app achieves better results than Google Maps and Mi Transporte in static information about routes and timetables and reducing wait time at the stop. On the contrary, it has technical issues to improve on the user experience to compete with Google Maps. HARMONY's data reliability is undervalued – probably as expectations on an official app are often elevated. Globally, HARMONY tool performs better than Mi Transporte, but worse than Google Maps. Two possible explanations emerge from that: first, Google Maps is easier to use, so passengers' experience may weigh way more than expected on satisfaction with the app, and last, Google Maps allows to plan trips on car, by walking or by public transport, and this function is not included in the beta version of the HARMONY app.

5.2. HARMONY app: analysis of incidents and notifications

One of the expected added values of the developed app is the implemented bi-directional communication between operators and passengers, allowing both of them inform each other about incidents on real-time. The procedure for passengers to send and receive these information is explained in Section 4. In the validation survey, passengers were required to point out the number of incidents suffered and the notification received during the trial week (Table 6). The total amount of incidents suffered by passengers was 72, but they only received 13 notifications, so the ratio is 1 notification read every 5,5 incidents suffered. It must be remarked that one notification from operators may be read by several passengers, maximizing the impact of one notification uploaded by operators.

Table 6. Incidents suffered by passengers and notifications received in the app during the trial.

	Delays at bus stops	Vehicle issues	Traffic accidents	Other incidents
Incidents suffered	51	11	6	4
Notifications received	13	0	0	0

Besides, the information shown in the app was useful in the route choice. In fact, reports from passengers indicate that 12% of them changed his/her route at least once during the trial week due to the information gotten from the app, even though the passengers are daily commuters of the routes under study. It must be remarked that this result is not statistically significant but reinforces the idea that RTI affects the route choice.

5.3. Adoption of HARMONY

The last step of the analysis seeks to confirm whether a customized app like HARMONY has a market niche in metropolitan bus routes. In order to get this insight, participants in the trial were asked if they would like to keep on using the HARMONY app to consult information about their metropolitan bus trips. They were given three options – “yes”, “maybe” and “no”. A total amount of 53% of testers declared their will to use the HARMONY app after the trial and 41% of testers said that maybe will continue using it. Furthermore, those who stated that won’t adopt or weren’t unsure on adopting the app were required to indicate which app would replace HARMONY. Only 25% of them would utilize Mi Transporte instead, another 25% would utilize Citymapper or Moovit, and the other 50% would prefer another transit app.

Hence, the most remarkable result about the transit app choice is that no participant in the validation survey would rather use Google Maps than HARMONY app, since the global satisfaction with Google Maps is higher than HARMONY app. This output suggests that despite these differences in global satisfaction, Google Maps may be not the main rival of the proposed customized app because the information provided to passengers is different. More specifically, the lack of RTI about metropolitan buses is a handicap that HARMONY solves effectively.

6. Conclusions

This paper has analyzed the current information about public transport that bus passengers receive in North corridor of Madrid Region and how to facilitate passengers’ decisions by providing specific RTI of metropolitan bus routes and allowing a two-ways communication between passenger and operators. An initial analysis proves that no current transit app meets all the information required by the multimodal commuters in the case study. Then a new transit app has been developed, HARMONY, and it has been tested to see if it fulfils the commuter’s needs.

Main results seem to indicate that it may be useful to offer users two levels of information. The first level corresponds to general information allowing the passenger to choose mode of transport and route. This level has value for non-regular passengers and it is currently covered by apps like Google Maps. On the other hand, the second level seeks to provide specific information for regular users on specific lines and routes. That includes the estimation of travel times, RTI about incidents and the possibility for users to report incidents to operators, thus enhancing a two-ways communication. HARMONY clearly fits into this second level.

This study also aimed to estimate the performance and impacts of a bidirectional communication between passengers and transit operators. It appears that during the validation phase, although users have received few real-time notifications compared to the incidents suffered, these notifications have had some effect on route choice. In fact, 12% of passengers changed his/her route at least once because of the notification received.

The outputs of this study open two branches for future research: (i) to carry out a more in-depth examination on the differences of the two levels of transit information and (ii) to propose and analyze strategies to encourage passengers to actively inform the operators and which reasons keep operators from sending incident notifications to passengers, since this communication seems to have positive effects on passengers.

Acknowledgements

The HARMONY project, exp. n. INEA/CEF/TRAN/M2014/1036707, is cofinanced by the INEA, under the CEF-TRANSPORT SECTOR programme, in the multi-annual 2014 CEF-Transport call. The authors also gratefully acknowledge the support of the Fundación Agustín de Betancourt.

References

Alfonso, J., Menéndez García, J. M., Perales, D., Castiñeira, R., & Gil, M. (2018). The HARMONY project – Study for the harmonization of data in the public transport network and road network. Proceedings of 7th Transport Research Arena TRA 2018. https://doi.org/http://doi.org/10.5281/zenodo.1485705

Alonso, A., Monzón, A., & Cascajo, R. (2017). Measuring Negative Synergies of Urban Sprawl and Economic Crisis over Public Transport Efficiency. International Regional Science Review, 16001761668736. https://doi.org/10.1177/0160017616687361

Barbeau, S. J. (2018). Closing the Loop: Improving Transit through Crowdsourced Information. Transportation Research Record, 311. https://doi.org/10.1177/0361198118791388

Brakewood, C., Macfarlane, G. S., & Watkins, K. (2015). The impact of real-time information on bus ridership in New York City. Transportation Research Part C: Emerging Technologies, 53, 59–75. https://doi.org/10.1016/j.trc.2015.01.021

Brakewood, C., & Watkins, K. (2018). A literature review of the passenger benefits of real-time transit information. Transport Reviews, pp. 1–30. https://doi.org/10.1080/01441647.2018.1472147

Carrel, A., Halvorsen, A., & Walker, J. (2013). Passengers' Perception of and Behavioral Adaptation to Unreliability in Public Transportation. Transportation Research Record: Journal of the Transportation Research Board, 2351, 153–162. https://doi.org/10.3141/2351-17

CRTM. (2016). Annual Report 2016. Madrid. Retrieved from https://www.crtm.es/media/579711/annual_report.pdf

dell'Olio, L., Ibeas, A., & Cecin, P. (2011). The quality of service desired by public transport users. Transport Policy, 18(1), 217–227. https://doi.org/10.1016/J.TRANPOL.2010.08.005

Esztergár-Kiss D. & Csiszár Cs. (2012) Analysis of multimodal journey planners using a multi-criteria evaluation method, 19th ITS World Congress, Vienna, Austria, 22.10.2012-26.10.2012., Paper EU-00662

Garcia-Martinez, A., Cascajo, R., Jara-Diaz, S. R., Chowdhury, S., & Monzon, A. (2018). Transfer penalties in multimodal public transport networks. Transportation Research Part A: Policy and Practice, 114, 52–66. https://doi.org/10.1016/j.tra.2018.01.016

Harmony, X. J., & Gayah, V. V. (2017). Evaluation of Real-Time Transit Information Systems: An information demand and supply approach. International Journal of Transportation Science and Technology, 6(1), 86–98. https://doi.org/10.1016/j.ijtst.2017.05.003

Hensher, D. A., Stopher, P., & Bullock, P. (2003). Service quality—developing a service quality index in the provision of commercial bus contracts. Transportation Research Part A: Policy and Practice, 37(6), 499–517. https://doi.org/10.1016/S0965-8564(02)00075-7

Hernandez, S., Monzon, A., & de Oña, R. (2016). Urban transport interchanges: A methodology for evaluating perceived quality. Transportation Research Part A: Policy and Practice, 84, 31–43. https://doi.org/10.1016/j.tra.2015.08.008

Mulley, C., Clifton, G. T., Balbontin, C., & Ma, L. (2017). Information for travelling: Awareness and usage of the various sources of information available to public transport users in NSW. Transportation Research Part A: Policy and Practice, 101(May), 111–132. https://doi.org/10.1016/j.tra.2017.05.007

Papangelis, K., Nelson, J. D., Sripada, S., & Beecroft, M. (2016). The effects of mobile real-time information on rural passengers. Transportation Planning and Technology, 39(1), 97–114. https://doi.org/10.1080/03081060.2015.1108085

Sarker, R. I., Kaplan, S., Anderson, M. K., Haustein, S., Mailer, M., & Timmermans, H. J. P. (2019). Obtaining transit information from users of a collaborative transit app: Platform-based and individual-related motivators. Transportation Research Part C: Emerging Technologies, 102(September 2018), 173–188. https://doi.org/10.1016/j.trc.2019.03.011

Tang, L., & Thakuriah, P. V. (2012). Ridership effects of real-time bus information system: A case study in the City of Chicago. Transportation Research Part C: Emerging Technologies, 22, 146–161. https://doi.org/10.1016/j.trc.2012.01.001