Methodology for qualitative assessment of the passenger information in public transportation systems

Stanislav Metelka[1], Waldemar Titov[2], Thomas Schlegel[2]
[1]Czech Technical University in Prague, Faculty of Transportation Sciences, Department of Logistics and Management of Transport, Horská 3, 128 03 Praha 2, Czech Republic
https://www.fd.cvut.cz/
metelsta@fd.cvut.cz
[2]Institute of Ubiquitous Mobility Systems, Karlsruhe University of Applied Sciences, Moltkestr. 30, 76131 Karlsruhe, Germany
http://iums.eu
iums@hs-karlsruhe.de

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1. Introduction

The modern means of information are today a component of the passenger information systems in the public transportation field. Various technologies make it easier for passengers to travel. The scoreboards at the stops save time, increase satisfaction and influence the behavior of the passenger (Dziekan et al., 2007). They are also easier and more convenient for the passengers (Grottenhuis et al. 2007). This paper explores what type of information the passengers actually prefer (Harmony et al., 2017).

Chapter 2 describes the methods used, such as analysis of public transport information systems. An own evaluation methodology is presented in this chapter. The analysis results for the selected systems in Berlin, Dresden, Prague and Karlsruhe are described in Chapter 3. In Chapter 4 results of the evaluation and passenger preferences are presented by a simultaneous Czech-German survey. Chapter 5 deals with suggestions expressed by the passengers themselves in the survey.

2. Used methods

2.1. Analysis of the information procedure

2.1.1. General

The analysis deals mainly with three different types of information. The first is information before the ride when the passenger is waiting at the stop. It researches which devices and which types of information are available to the passenger and how they reduce the entropy. The second is the information while traveling in the vehicle, where you can use various means of information. One of the most important topics discussed in the analysis is the use of the characteristics of the devices and the added value for the passenger. Finally, the private information process is analyzed with the smartphone app.

As an object of analysis, four major cities and their transport systems were selected. In order to better show the different information processes, the selected cities are far apart and represent different conditions. The federal capital Berlin has many opportunities to develop the system. By comparison, Prague, the capital of the Czech Republic, has a similarly polluted public transport system. The other two cities represent the two former German states - the state capital Dresden from the eastern part and Karlsruhe from the southwestern part of Germany.

2.1.2. Developed model passenger profiles and example scenarios

In order to better describe the various specific systems and their advantages and disadvantages, three fictive passengers have been developed. Each passenger has specific requirements and user conditions under which he uses the transport system. All of these persons have a personal restriction, or they are traveling during a breakdown. These models are the best way to demonstrate how the systems works under the specific conditions and how they can flexibly handle the different requirements. The normal operation of the information systems is described in the analysis without further example scenarios.

2.1.2.1. Individual restriction with the app

Cora Clausen (58 years old) lives in Schwäbisch Hall. She likes to travel and discover new things, places and people. With her job she can afford to go on trips often. Besides German, she speaks fluent English. Before each trip, she prepares thoroughly and downloads the respective smartphone app. Mostly, she travels alone, because she wants to be flexible. Several years ago, she suffered a disease and as a result, she moves slower. Nevertheless, she wants to experience everything herself.

Cora wants to travel from her hotel to the city center with some inevitable changes. Unfortunately, she injured her ankle yesterday. It is now difficult for them to climb the stairs and move faster than in a walking pace.

With this personality, it is demonstrated how the individual systems treat a foreign passenger without system knowledge, when he relies on the existing in this system information means while driving.

2.1.2.2. Barrier-free driving

Karl Müller (35 years old) is wheelchair user. A month ago, he found a new job to drive to once a week. He found the services for disabled people inadequate and therefore began to use public transport. To better know the system, he downloaded the app. After a month he has already learned how to behave on the stops and in the vehicle, so he does not have to ask for the help of other passengers.

Today the situation is different - Karl wants to drive to his new doctor but does not know if there are any barrier-free stops on his way. With this route, he has limited experience so he relies on the app, which should facilitate the journey.

This personality demonstrates the implications of the lack of app attitudes for disabled people and why it is important to specify the seemingly unimportant features such as barrier-free travel and barrier-free or disability accessibility in the app. Compared to the relatively subjective limitations of Cora Clausen, Karl Müller is objectively limited and for these passengers the context-specific information should also be available.

2.1.2.3. Irregularities, failures and detours

Angela Geller (15 years old) is a student who commutes by tram to school every day. Because she always uses the same route, she only knows its closest environment. If she drives in a different direction, she uses the app. She is open to modern technology and she always has her smartphone with her. The battery does not often last her at school for the whole day and she takes the charger with her.

After class Angela travels home again. The tram operation is however influenced by sudden vehicle failure and route disturbance and some lines drive with diversions. That is also the case on Angela's line. Today she has forgotten the charger and cannot use the app because of a non-charged smartphone.

With this personality it is demonstrated how the system is capable of informing the passenger about the current situation with information only by means of public information. The example of a smartphone-dependent student shows that the elderly is not the sole group without (at least temporary) access to the transport apps.

2.2. Passenger survey

The first section is of the survey sortes subjects by gender (male, female) and age. The age group has been chosen to show the generational, occupational and probable differences in the technological affinity. Altogether there were 5 categories with the divisions of 15, 26, 40 and 65 years. The last question in this section deals with the passenger types. Above all, that is

- commuters who regularly drive on the same routes

- occasional drivers who only drive occasionally and on different routes

- special-purpose drivers who use public transport very low and in specific situations

- non-drivers.

If the participant selected the last option, he is be redirected to the last section, because the following questions about information procedures and means of information are hardly relevant for him because of his lack of experience. All questions in this section were multiple-choice questions with no ability to select multiple answers.

Section 2 deals with passenger preferences in the area of the information at the bus stop (i.e. before boarding). The questions asked were about

- additional information at the stop (e.g. public displays)

- current information about the next departures from the stop (real-time data)

- up-to-date information about delays, detours or failures.

Passengers should choose how important each type of information was to them. The types of questions allowed to connect the information types with the corresponding devices, although it does not depend on them. The scale in Table 2 was used. Again, all questions were multiple-choice questions with only one approved answer.

In the third section, the passengers answered how important they are to the types of information while driving (i.e. in the vehicle). Among the attempted information types belong

• Information about the route

• Information about transfer options at the following stops (displayed line number of the other lines)

• Current information about the departure times of the connections from the next stop (real-time data).)

This third section was organized similarly to section 2.

Section 4 deals with the preferred means of information for various types of information. The structure of the section was different from the previous one because it introduced the most modern means of information that are not yet known among the passengers. This is especially true for the SmartWindows (semi-transparent display instead of the normal window), but also for other dynamic vehicle displays.

The type of the questions is also different in the case of Section 4. The multiple-choice questions are enhanced by the ability to select multiple answers. I designed it that way, because there are many variants and it would be too much of a limitation to allow only one answer. In this section the scale from Table 3 is used.

The branch in the fifth section separates the subjects who do not have smartphones (redirected to the last section) from the smartphone owners who move to the sixth section. Here's how important the following features and functions of the app are for your app usage:

• graphic representation and clarity

• current departure times with incorporated data about delays

• Forecasting the feasibility of the transfers

• individual settings (e.g. mobility restrictions)

• Point-to-Poit connection search directly from the card

In this section, the scale had to be adjusted from. Adapted options in Section 4 so that it could better reflect the specific features of the app. All questions here are multiple-choice questions and allow only one answer. At the end of the section is a question of separation, whether the passengers have already used the official smartphone app for the connection search (PID lítačka / KVV.mobil).

The penultimate section 7 contains two types of questions - a multiple-choice question with only one allowed choice and two voluntary open questions. With the obligatory question, the passenger evaluates the corresponding Prague or Karlsruhe App of Table 4 and with two remaining questions he can write which he describes aspects as negative and what he lacks in the app.

In the last section, which is common to all types of passengers, I ask them which improvements would convince them to use public transport more often. Here was once again possible to select multiple answers to the multiple-choice question:

• Public displays

• Scoreboards at stops

• improvement of existing ones

2.3. Evaluation and passenger preferences

This paper uses its own quality assessment methodology. The basis for this is the German-Czech survey, which deals with passenger preferences in the field of public transport information. Passengers were asked how important the various types of information are to them. The survey and the methodology consist of three parts: information before the journey (at the stop), during the journey (in the vehicle) and personalized information (smartphone app). At the end of the survey, the participants were asked what new information tools can convince them to travel more often by public transport. The latest public transport information trends such as Public Displays and SmartWindows were also available in the survey.

The answers were collected at two different institutions simultaneously. The first respondents were the students and staff of the Faculty of Transportation Sciences of the Czech Technical University in Prague (ČVUT v Praze Fakulta dopravní) and their relatives, the second were the students and academic staff of Karlsruhe University of Technology and Economics, Faculty of Information Management and Media. The dual survey enabled to make a comparison of the preferences, demands, opinions and future expectations of the Czech and German passengers.

The two survey versions differ significantly in the number of answers. The German survey was filled by 42 people and the Czech by 368 people. Of course, since the conditions in these two cities are heavily influenced by the existing state, the importance of each parameter is determined by both surveys according to the formula (1). The survey used a semantic scale that fully responds to a numerical scale shown in Table 1.

$$W_n = \frac{N_{m,PRG}}{N_m} * W_{n,PRG} + \frac{N_{m,KA}}{N_m} * W_{n,KA} \quad (1)$$

W_n .... Weight of the parameter n
$W_{n,PRG}$ .... Mean value of the rating of the parameter n from Karlsruhe survey
$W_{n,KA}$ .... Mean value of the rating of the parameter n from Prague survey
N_m .... Total number of responses in the part m over the whole survey
$N_{m,PRG}$ .... Total number of responses in the part m for Prague
$N_{m,KA}$ .... Total number of responses in the part m for Karlsruhe

The assessment methodology consists of three categories above and is calculated according to formula (2). In each category each traffic system gets points according to formulas (3) to (5). The quality level Q_n describes the Table 2.

$$B_s = B_{Sto} + B_{Veh} + B_{App} \tag{2}$$

$$B_{Sto} = \frac{Q_{Addinf}*W_{Addinf}+Q_{Dep,Sto}*W_{Dep,Sto}+Q_{Opinf}*W_{opinf}}{W_{Addinf}+W_{Dep,Sto}+W_{Oppinf}} \tag{3}$$

$$B_{Veh} = \frac{Q_{Rou}*W_{Rou}+Q_{Con}*W_{Con}+Q_{Dep,Veh}*W_{Dep,Veh}}{W_{Rou}+W_{Con}+W_{Dep,Veh}} \tag{4}$$

$$B_{App} = \frac{Q_{Int}*W_{Int}+Q_{Del}*W_{Del}+Q_{Prog}*W_{Prog}+Q_{Set}*W_{Set}+Q_{Point}*W_{Point}}{W_{Int}+W_{Del}+W_{Prog}+W_{Point}+W_{Set}} \tag{5}$$

B_s .... Overall rating of the transport information system s
B_{Sto} .... Rating of the parameter Information at the stop
B_{Veh} .... Rating of the parameter Information in the vehicle
B_{App} .... Rating of the parameter App for smartphone
Q_{Addinf}, W_{Addinf} .... Quality level / weight of the parameter Additional information at the stop
$Q_{Dep,Sto}$, $W_{Dep,Sto}$ .... Quality level / weight of the parameter Real-time departures at the stop
Q_{Opinf}, W_{Opinf} .... Quality level / weight of the parameter Operation problems information
Q_{Rou}, W_{Rou} .... Quality level / weight of the parameter Route progress information
Q_{Con}, W_{Con} .... Quality level / weight of the parameter Connection possibilities in the vehicle
$Q_{Dep,Veh}$, $W_{Dep,Veh}$ .... Quality level / weight of the parameter Real-time departures of the connecting lines from the next stop
Q_{Int}, W_{Int} .... Quality level / weight of the parameter Interface and friendliness to the customers
Q_{Del}, W_{Del} .... Quality level / weight of the parameter Departure times with current delays
Q_{Prog}, W_{Prog} .... Quality level / weight of the parameter Prognose of the connections
Q_{Set}, W_{Set} .... Quality level / weight of the parameter Individual settings for a mobility restriction
Q_{Point}, W_{Point} .... Quality level / weight of the parameter Point-to-Point-Search

Table 1. The scale of the former semantic parameters

W_n	1	2	3	4	5
Description	not interested	not very important	good but not fundamental	Influences my decision in favor of public transport	fundamental

Table 2. Quality levels Q_n and their meanings

Q_n	0	1	2	3	4
Description	not available	poor	average	good	very good

Each sub-parameter is assigned a quality level. These levels represent the actual implementation quality of this parameter in every public transport system in practice. The determination of the assigned quality level is made according to the results of the analysis, which is an important component of the final methodology.

The maximum score in each rating category is 4 points and therefore the passenger information system can get from 0 to 12 points. The selected method (sum of the weighted mean) shown by the formulas (2) to (5) has significant advantages. It allows an independent general comparison between individual public transport systems, although the initial weights were determined by only two surveys. The weighted average eliminates too sharp local differences within the categories and prevents the situation that too low score unrealistically affects the whole category and therefore only one extreme value significantly shifts the score. For example, missing individual restriction settings is a significant problem for the disabled. However, this group is rather small compared to the others and therefore the quality level 0 should not unduly lower the whole score. The used method avoids these cases.

3. Quality assessment of the information procedure

For the passenger information systems to be evaluated, the weights from the survey had first to be determined. The weights W_n calculated according to the formula (1) and the assigned quality level according to the analysis results are shown in Table 3. The score of the individual systems using the evaluation methodology can be found in Table 4.

Table 3. Quality levels and the respective weights for all the assessed parameters

n	Addinf	Dep, Sto	Oppinf	Rou	Con	Dep, Veh	Int	Del	Prog	Set	Point
$Q_{n,B}$	1	4	3	2	4	0	4	4	4	3	3
Q_{nDD}	1	3	3	3	4	4	3	3	2	4	4
$Q_{n,PRG}$	2	1	1	2	1	0	2	0	0	2	0
$Q_{n\cdot KA}$	1	3	3	2	1	0	1	0	0	0	2
$W_{n,PRG}$	2,61	3,85	4,16	3,63	3,34	3,33	3,76	4,30	3,80	3,16	3,24
$W_{n,KA}$	2,52	4,48	4,57	3,52	3,90	3,74	4,00	4,56	4,22	3,32	3,10
W_n	2,60	3,92	4,20	3,61	3,40	3,38	3,79	4,32	3,84	3,18	3,23

The hypothesis for greater demands of the Karlsruhe passengers has been confirmed, although it does not apply to every parameter. The lowest importance was given to the parameter “Additional information at the stop (points of interest, weather, advertisements, connection search)”, which has a very low quality level in both cities. In the category of the real-time departure times at the bus stop, the people of Karlsruhe take their stops as a matter of course, but the people from Prague, who are not used to it, have lower demand. Nevertheless, the passengers in both cities strongly want to get current operational information at the bus stop. Compared to the real-time departures parameter at the stop, the demand for the parameter delays in the app is relatively the same in both cities, although the real-time app delays are absent in the case of Prague.

For the individual parameters, the information types are more important for men and for the age group 16-26. If the introduction of this parameter helps the passenger with less knowledge of the system, it is also important for the groups of "occasional driver" and "special-case-only driver".

Table 4. Assessment of the selected public transport information systems in Berlin, Dresden, Prague and Karlsruhe (maximum 4 points per category, 12 points in total)

n	Stop	Vehicle	App	Total score
Bn,B	2,88	2,00	3,65	8,54
Bn,DD	2,51	3,65	3,14	9,31
Bn,PRG	1,24	1,02	0,76	3,02
Bn,KA	2,51	1,02	0,56	4,09

The most important features of the successful information system are good processing of real-time data and a good smartphone app. If Berlin had even better vehicle information with departure times, it could have got the highest score with the best app. The opposite is Karlsruhe, that despite an average result in other categories received only 4 points. The problem with Karlsruhe is the app, which has virtually no settings. Only 3 points for Prague documented that without real-time data, the passenger information system in the 21st century is not competitive and that a dense transport offer must also be supported by the sufficient passenger information systems.

4. Passengers´ preferences and their suggestions for improvement

Regarding the information means, the Prague passengers are more conservative with the alternative SmartWindows having a bigger share (33 %) only in the category of news and POI, i. e. information unrelated to the journey itself. In contrast, the results of this technology were much better in Karlsruhe, which may be caused predominantly by the better knowledge of SmartWindows and their features among the Karlsruhe test subjects. Although both groups prefer the LCD panels or their own smartphones, the trend towards SmartWindows is to be spotted by a group of travelers who express their willingness to visualize personal data on the public screens. The detailed information contains the Table 5.

Tabelle 5. Bevorzugte Informationsmittel für verschiedene Informationsarten

	Personal information		Connections		Route progress information		Operational information		News, POI	
City	PRG	KA	PRG	KA	PRG	KA	PRG	KA	PRG	KA
Personal smartphone	74%	67%	62%	57%	47%	52%	58%	62%	54%	24%
LCD screen	59%	71%	69%	76%	81%	69%	69%	74%	37%	40%
SmartWindow	22%	33%	22%	26%	20%	48%	23%	45%	34%	67%
Audio announcement	21%	19%	15%	14%	25%	7%	48%	71%	4%	0%

The participants were also asked which positive changes in passenger information systems would convince them to use public transport more often. The results confirm that the passengers want to solve the current problems and limitations of the systems and do not tend to find the introduction of new information means as important as it is often anticipated.

5. Conclusion

The developed methodology is general and can be used for further comparison of some public transport information systems in major cities. The only condition that needs to be fulfilled is a thorough analysis of the current state of affairs that deals with the information categories mentioned above and is also of interest to passenger minorities. Although the compared cities were all the European ones, the methodology with the preceding priority survey may be applied

This research has some limitations. The sample used for the comparison between Prague and Karlsruhe does not reflect the age and gender distribution. Since most of the data was collected at a university, the participants are predominantly male students with a high degree of technical affinity. The number of subjects in Karlsruhe is not statistically sufficient for some comparisons. Nevertheless, it has also been possible to reflect the ideas of older passengers from Prague.

For future research, it is recommended that you interview comparable and better distributed subjects. Nevertheless, these data can be used for further comparison in the context of a before-after study during the test use of the new information tools such as SmartWindows.

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