Passengers' Evaluation of the Integrated Transport Systems

Integrirani prijevozni sustavi – procjena putnika

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Summary

This paper presents the outcomes of the research focused on the passengers' subjective point of view on the Integrated Transport Systems (ITS) comparing with the separate non-integrated traffic lines. The research, within project realized in the Institute of Technology and Business in České Budějovice, was performed in several cities located in the central part of the EU where the establishing the ITS has been planned. The introductory parts of the paper contain the theoretical approaches of the given issue. Particularly, the issue of ITS such as, the review of performed ITS studies, information on the realized surveys and the draft of the used model are outlined in these parts. The used model includes two variants of the problem solving: ITS and individual bus. The surveyed criteria include: unproductive time, time of drive and travel fee.In the next two parts of the paper, the application of the model to real traffic conditions is presented and the outcomes of the research problem are emphasized.

KEY WORDS

Integrated Transport System
passenger
evaluation
survey
research
model

Sažetak

U ovom radu dati su rezultati istraživanja usmjerenog na subjektivni stav putnika o integriranim prijevoznim sustavima (ITS) u usporedbi s posebnim neintegriranim prijevoznim linijama. Istraživanje, u okviru projekta koji je provodio Institut tehnologije i poslovanja u Českim Budejovicama, je provedeno u nekoliko gradova u centralnom dijelu Europske zajednice, u kojima je planirano uvođenje ITS sustava. U uvodnom dijelu navedeni su teorijski pristupi temi rada. U drugim dijelovima rada govori se o samom ITS sustavu, dat je pregled obavljenih studija ITS, podatci o provedenim pregledima i nacrt modela koji je korišten.

KLJUČNE RIJEČI

Integrirani prijevozni sustav
putnik
procjena
pregled
istraživanje
model

INTRODUCTION

Individual car transport in cities causes a decrease in driving speed, irregularity of public transport services and, as a consequence for passengers, notable time delays, including productive and unproductive time. Given the congestions the accessibility to the destination places, mainly those that are placed in the centers of the towns, is jeopardized [1].

Other troubles regard: road infrastructure safety, the air pollution growth, traffic noise, global warming, etc. Building of new road infrastructure and transport devices requires major financial resources, covers big areas and outputs in the decreasing in space which could be placed to other purposes. Parked cars are often barrier for pedestrians, cyclists and the disabled people. Traffic contributes to urban sprawl and to the decentralization of towns as well. Due to these problems, towns have identified that the changes in people behaviors in the context of their travelling, towards less vehicle use and encourage them to travel with the utilization of public passenger means of transport, use more bikes and pedestrian travelling are the crucial issue for the reducing the problems[2].

This matter does not focus on completely eliminate individual car travelling; however, on its more rational utilization e.g. car travelling in case of a deficiency of opportunity to choose the more preferredmodes of transport, especially public passenger transport. Next option is the shared utilization of one car by a number of people, meaning carpooling or car-sharing systems [3].

The passengers' point of view and behaviors can be shaped using the concept of transport demand management. Transport demand management is aconception to the passengers´ carriages, oriented on the propagation of sustainable transport modes and the car use demand management. City residents can make a choice regarding the sustainable transport modes; however, simultaneously some cars confinements and good circumstances for implementation of the environmental friendly modes of transport need to be considered. These solutions and their powerful propagation can cause that public passenger transport and cycling, as well as pedestrian traffic, will be more competitive and more preferred than individual car transport.

And eventually, the integration of several modes of passenger transport and public transport systems that may occur at various levels and may include a lot of technical, technological and transport activities is one of the tools which allow for shaping the way of travelling. Indisputably, the application of the public transport systems integration may help to improve the travel conditions and especially lead to increasing the public passenger transport utilization [1], [3].

THE ISSUES OF INTEGRATED TRANSPORT SYSTEMS

The term ITS, "Integrated Transport System", covers the integration of individual modes of public transport into a single transport unit when using the uniform tariff and passengers handling system, and uniform carriage conditions of passengers with the integrated telematics, communication, controls and automation technologies that significantly contribute to improve the quality of public transport services [4].

The offer of more attractive carriage opportunities for passengers is the crucial advantage of ITS.

ITS include the latest technologies, infrastructure, and services as well as the operations, planning and control methods that are used for the carriages of passengers, and freight as well recently [5].

Speaking of the matter of the integrated transport systems within the public passenger transport, the issue of intermodality cannot be forgotten. It is understood as the passengers' utilization of various modes of transport in one travel. Passenger transport intermodality requires the integration of journeys and information, as well as coordination and service in intermodal terminal points and coordinating the timetables and ticket unification. Continuous travelling requires the suitable land utilization and urban planning. Improving the intermodality in passenger transport is the crucial aspect in the development of an efficient integrated transport system.

INTEGRATED URBAN TRANSPORT SYSTEM

Integration is a consolidation, combining, creation of a whole from parts or merger. Integration may occur at various levels and may includea lot of aspects and activities. There is no general accepted definition of integrated urban transport system and it is differently understood by many authors.

The authors offered the different variantdefinitions of integration of transport systems for different towns. One of the definitions is: the design rules for effective integrated public transport systems as well as discussed different types of transport integration [6].

The most popular definitions are: the organizational process, in which the elements of public transport system (network and infrastructure, fares and ticketing, information and marketing, etc.) served by different operators, who use different transport modes, interact more efficiently and closely. This results in general improvement in travel conditions and quality of service; or the way in which the individual elements of public transport are embedded in the chain of movement [1].

Generally, urban transport is to provide attractive chain of services in the relationship "door to door" through the integration of [1]:

- different means of public transport,
- public and individual transport,
- transport policy with other policies concerning the spatial planning or investments in infrastructure.

The integration of urban public transport may go on at various levels [1]:

- Infrastructure integration consists of a defined combination of aspects that create the integrity of a transport network. This applies to all such aspects as: placement of bus stops, stations and interchange terminals for comfortable and rapidchangeof a mode of transport. Therefore,integration is generallyinfluenced by: tram/trolley/bus tracks, stops for different means of public transport, stairs, elevators, pavements, underpasses and intersections.
- Transport integration includes all levels of the transport infrastructure serving urban, suburban or regionaltraffic. It includes the integration of means/modes of transport, through the organization of transport, which helps toensure the continuity of a journey in the shortest possible time. The most generally used instrument for theorganizational integration is the coordination of timetables, which involves their adjusting one to another insuch a way that minimizes time losses regarding the needs to change the modes of transport.
- Tariff integration, just like organizational integration, it includes all levels of transport infrastructure serving urban, suburban or regional traffic. It involves the organization of journeys through different modes oftransport to ensure the best financial conditions of the journeys for passengers when changing the means of transport (regardless of the operator).
- Information System integration includes all levels of transport network that serve urban, suburban or regional traffic as well. It consists in providing the no-stress travelling for the passengers throughout the individual transport systems. The integrated passenger Information System means that passenger information is shared among the whole passenger travelling regardless of a transport operator or a mode of transport. The various sources of information on the public passenger transport for end users could be distinguished: information provided at passengers´ service places, cellphones, Internet and at bus/trolley/tram stops and train stations. Information in real time is an additional convenient element for passengers, since it allows the passengers bigger flexibility of travelling to better respond to delays and/or malfunctions in the infrastructure.
- Spatial integration includes specific spatial development of urban forms with the existing transport infrastructure. Suitable land utilization and the development of transport infrastructure are to be ensured by the synchronization of the land planning and its management with traffic planning.

THE REVIEW OF INTEGRATED TRANSPORT SYSTEM STUDIES

In recent years, research within the different projects with the purpose of integration of individual modes of public transport into the ITS has been performed in EU countries.

At the end of last century, studies about ITS applications were mainly focused on urban public transport. Then, the topic has developed to include all modes of transport and levels, for both passengers and goods, and to take into account the material flow, i.e. the handling and storage of physical entities, and the information flow, which takes place at the different business levels and may support the decision-making process. ITS availability has led to new issues and new management instruments, encouraging sector research on new themes, such as real time congestion control or dynamic navigation. These issues have been solved by several experts through specific models [4], [7].

Over the last 15 years, there have been the interesting activitiesfocused on the improving the performances of transport systems, in order to achieve a wide range of objectives, such as congestion and security control, the enhancement of the efficiency and effectiveness of transport systems, the interaction between different mobility components.

There exist many ITS studies in literature. A lot of them have provided an accurate analysis of ITS and proposed a classification based on the concepts of Intelligent infrastructure vehicles and on their integration. The European Commission has defined a unified ITS architecture by organizing them into eight functional categories: traffic and mobility management systems; intermodal integration in public transport systems; user information systems; public transport management systems; fleet and freight management systems; automatic payment systems; advanced control vehicle systems for safe transport; emergencies and accidents management systems. There are many more or less specialized scientific and technical reports on ITS as well [5], [6] - [9].

REALIZED SURVEYS WITHIN THE GIVEN ISSUE

The preferred criterion questionnaire surveys among cities have been used within the issues passengers' subjective point of view (evaluation) on the Integrated Transport Systems. First, the route of the public transport service under planning is described. A brief description of two options of public passenger transport, an individual transport vehicle (bus) and the ITS (combination of urban trolley, suburban bus and regional train) is provided.

The two modes of transport run in mixed traffic. The difference is the propulsion and the seating capacity.

In the second part of the questionnaire, respondents are asked to choose between the bus and the ITS in different supply scenarios for a journey of a given length; the supply scenarios are defined according to different levels of the unproductive time, time of drive and travel fee of the bus and the ITS.

The third part relates to the personal characteristics of the respondents: gender, age, income, occupation, vehicle possession. The criteria and corresponding levels of the preferred criterion are stated in Table 1. The number of combinations in the full factorial draft has been reduced to 4 combinations using the specific method.

Specimens are composed by potential passengers of the ITS under planning in each city. Data gathering activities took place in Summer 2014. The majority of surveys used face-to-face interviews. In two from six cities, the level of the extra-fee was reduced to 1 EUR per return journey to take into consideration the local circumstances.

DRAFT OF THE USED MODEL

Followed mathematical model is utilized. We mark by V_1 the bus variant, by V_2 the ITS variant. The general shape of the model has the following specifications:

$$
\begin{aligned}
V_1 &= \beta_1 . UT + \beta_2 . TD + \beta_3 . FE \\
V_2 &= \beta_1 . UT + \beta_2 . TD + \beta_3 . FE + VSC
\end{aligned}
\tag{1}
$$

where:

UT - unproductive time,

TD – time of drive,

FE – travel fee,

$\beta_{1,} \beta_{1,} \beta_1$ - the coefficients,

VSC - the variant-specific constant of ITS.

For travel fee, coding (-1/1) has been utilized instead of coding (0/1) in order to eliminate the confusion with the VSC: the code -1 represents the case where the extra-fee is paid; the code +1 represents the case where the same travel fee as other public passenger transport is paid.

In the general specification, the coefficients, which are representative of the criteria marginal usefulness, are mutual to the two variants. A specification with variant-specific coefficients has been deemed as well.

Other specifications involve socio-economic variables of the passengers (gender, age, income, education, occupation, car possession) in the systematic usefulness of ITS.

The estimation of the VSC of the ITS is the specific matter, since this represents the mean of all the unobserved criteria that influence the selection: with a mutual specification of the systematic usefulness of ITS and bus, the observed criteriaare the same, a positive value of the VSC is indicative of a relatively higher preference for the ITS than for the bus, since the resulting higher selection probability.

Table 1 Preferred criterion and level

Variant	Criterion	Number of levels	Levels
Bus/ITS	Unproductive time	2	3/7 minutes
	Time of drive	2	7/10 minutes
	Travel fee	2	as other means of transport in the city/extra-fee of 1,5 EUR per return journey

The estimation of the influence on the VSC of the socio-economic criteria of the passengers is the specific issue as well, since this is indicative of the influence of the socio-economic criteria on the relative preference for ITS [10], [11].

THE APPLICATION OF THE MODEL TO REAL TRAFFIC CONDITIONS

In accordance to the routings proposed for the ITS implementations by the six cities, the following three real traffic conditions types are included [12], [13]:

- A - the center of the city: České Budějovice (Czech Republic), Košice (Slovak Republic);
- B - the main subject of the interest: Žilina (Slovak Republic), Opole (Poland);
- C - from the intermodal terminal (transit hub) to the main subject of the interest: Szolnok (Hungary), Tábor (Czech Republic).

The ITS that are planned for the implementation may be different from the scenarios of the executed surveys. In the planned systems, specific traffic lines will be used. The infrastructure at stops will tend to be minimized given the fact that the system will be operated on a permanent basis [11-13].

THE CENTER OF THE CITY

In České Budějovice, the ITS will be connected to the railway station and the main transit hub in the center of the city – the actual length 8.2 km. In Košice, the ITS willconnect the railway station and the main touristicpoint – the actual length 7.1 km.

THE MAIN SUBJECT OF THE INTEREST

In the Žilina city, the ITS is to be served the central city hotel and its area – the actual length of the connection 3.6 km. In Opole, the system will be distributed to the central city administrative area where it will connect the east with the west part of this area – the actual length 2.4 km.

FROM THE INTERMODAL TERMINAL TO THE MAIN SUBJECT OF THE INTEREST

In Szolnok, the ITS routings are planned to be 5.6 km long and will connect the city shopping center with the main intermodal transit hub. In Tábor, the system will connect the city train station and the central part of the occupied passage - the actual length 5.3 km.

THE OUTCOMES OF THE RESEARCH PROBLEM

The outcomes of the mathematical model application with the basic specification of the systematic usefulnessfor sixspecimens are stated in Table 2. All the time, the travel fee coefficients have the right sign. On the basis of the sign of the VSC, a relatively higher preference for ITS is seen in all cities of the real traffic conditions type "the main subject of the interest"; in one of two of thistypethe VSC of ITS is statistically significant (null hypothesis of a zero coefficient, 10% significance level, two-tailed). In other real traffic conditions type, the relative preference is in some cities for the ITS, in other for the bus.

Estimation with specifications of the usefulness of ITS including socio-economic characteristics of the passengers have shown the following outcomes. In 5 cities out of the 6 the variable "male" induces a relatively higher preference for the ITS, while the variable "female" induces a relatively lower preference for the ITS. This occurs, with statistical significance (null hypothesis of a zero coefficient, 10% significance level, two-tailed), in both cities of "the main subject of the interest" real traffic conditions type.

A match among cities in the sign of the influence on the variables preferences such as age, income, education, occupation and car possession, is not found; the influences of these variables are heterogeneous among cities. In one of two cities of the "the center of the city" real traffic conditions type, a higher education level induces a statistically significant relatively higher preference for ITS.

The mathematical approach has shown that variant-specific coefficients for the time and fee criteria are not statistically significant, with the exception of the time of drive in one city only (České Budějovice). This means that the marginal uselessness of time of drive (particularly, the time of drive spent on-board) is seen to be the same – for two systems (ITS or bus). Just in the case of České Budějovice, the uselessness of the time of drive spent on-board of the ITS is seen to be lower than the bus.

Table 2 The obtained outcomes in 6 cities

	A		B		C	
Criterion	České Budějovice	Košice	Žilina	Opole	Szolnok	Tábor
Unproductive time	-0.0563 -1.74	-0.1168 -2.69	-0.2664 -9.54	-0.3131 -6.71	-0.2237 -5.14	-0.1967 -4.77
Time of drive	-0.2416 -7.92	-0.2257 -6.16	-0.3552 -19.73	-0.2004 -5.97	-0.1769 -5.88	-0.1869 -5.17
Travel fee	1.4927 8.66	0.4332 3.29	0.5261 7.46	0.7193 5.84	0.5689 2.28	0.9953 6.27
Specimen size	120	97	135	78	84	106

Explanatory notes:

A = the center of the city

B = the main subject of the interest

C = from the intermodal terminal to the main subject of the interest

CONCLUSION

On the basis on the surveys realized in sixcities located in the central part of the EU, the conception of the subjective point of view of passengers onIntegrated Transport Systems have been outlined. The specimens concerned the potential passengers of ITS for specific planned routing in a diversity of implementation contexts in six various central EU cities. The outcomes have had the representative values of the subjective point of view of passengers who have had some information on ITS, and who have had no knowledge of these progressive transport systems. Knowledge is the significant aspect of preference creating in accordance with the selection of the behavioral model. This is the crucial matter with a view to the future research on the stability of subjective perspective with knowledge.

The outcomes confirmed that Integrated Transport Systems are not inevitably considered to be valuable, if the time of drive and travel fee of the ITS are the same as those of an individual bus. The mutual characteristic of the outcomes among the individual real traffic conditions types is the relatively higher preference for ITS in the case that this is established within the main subject of the interest. The mutual feature regarding the effects on preferences of socio-economic characteristics of the passengers have not been observed.

The mathematical model that have been applied within the paper convinced to be the useful instrument in order to acquire the view of changes in preferences that would lead from the increasing the relative frequency of the ITS on that of a bus, or to calculate the increasing in the relative frequency of the ITS that is necessary for obtaining a relatively higher preference. They indirectly expressed the evaluation of the passengers' willingness to pay for progressive transport systems, given the fact that they can provide estimates of the preferences changes that would follow diverse travel fee circumstances.

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