Public Transport Planning Evaluation Tools and their Data Requirements and Availability

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Abstract: This paper describes two different public transport planning evaluation tools that are used to support planning activities in The Netherlands and Brazil. In the paper extra attention is paid to data requirements and availability. The Dutch tool generates so-called Public Transport Potential Maps that present the potential of public transport at the level of 6-digit postal code zones based on area and public transport related characteristics. With the Brazilian tool, existing and new implemented public transport routes can be evaluated. To identify urban features that influence the performance of the public transport system, the tool compares characteristics of the urban spaces with the different typologies of public transport routes. Examples of the use of both tools including data requirement and availability are shown in this paper, stressing the fact that GIS is currently an essential and universal tool for public transportation planning, despite the conditions of the site and the complexity of the model under analysis.

1. INTRODUCTION

The privatization of public transport companies in many countries around the world has resulted into a search for new public transport planning support approaches. In the past, planning for public transport was focused on social equity: everybody has to be able to use public transport in time and place. This strategy resulted into long public transport routes with many stops, serving as much as people as possible. Nowadays, public transport routes have to be efficient. The focus of today's public transport planning is serving mainly areas with high potential of use. The new strategy requires new evaluation tools to support the planning of public transport related infrastructure.

The aim of the paper is to present two new planning evaluation tools for public transport planning. The first tool consists of so-called Public Transport Potential Maps. This approach is developed at Eindhoven University of Technology, The Netherlands. The second tools concerns a GIS-based planning approach to evaluate existing and new implemented public transport routes. This approach is developed at the University of São Paulo, Brazil. The paper not only describes the developed planning evaluation tools but also discusses the data requirements and availability. The paper addresses two different research questions: '*How to evaluate planning and marketing measures for public transport*?' and '*How is public transport use related to area characteristics*?'

The remainder of the paper is organised as follow. First, the main characteristics of public transport in The Netherlands and in Brazil are presented. Next, a short overview of planning evaluation tools for public transport is given. In the next two sections the Eindhoven and Brazilian planning evaluation tools including the data requirement and availability are described. The paper ends with the conclusions regarding the suggested tools and their data requirement and availability.

2. PUBLIC TRANSPORT IN THE NETHERLANDS AND BRAZIL

2.1 The Dutch context

The public transport system in The Netherlands is organized at two levels: the national and the regional level (www.KpVV.nl). At the national level, the Dutch Railways takes care for the public transport system under the authority of the national government. At the regional level (including local services) public transport is the responsibility of 13 transport companies and 19 public transport authorities (provinces and city regions). The regional public transport system consists of almost 50.000 stops served by approximately 6200 buses, 578 trams, 258 metro trains, 86 regional trains and 17 boats. The number of public transport trips in the urbanized areas of the Netherlands is equal to 2.8 million.

In the past, public transport in The Netherlands was based on a lump-sum subsidization regime (Van de Velde & Leijenaar, 2001). According to this regime, the national government defined the required public transport services (based on social equity) and the regional transport companies, owned by the state or local authorities delivered the suggested services for a certain fixed amount of money. In 2001 the new Passenger Transport Act 2000 (PTA 2000) was introduced to stop the decline in public transport use. The objectives of this PTA 2000 were (i) creating conditions to improve public transport services' attractiveness, and (ii) achieving a higher cost recovery ratio by decreasing the subsidization from two-third of the full costs of public transport to 50%. Two important decisions were made in the context of PTA 2000. The first decision concerned the decentralisation of competences from national level to regional and local level. The decentralisation was based on the idea that local authorities are in a better position than the Ministry to develop and evaluate local transport policies. The second decision consisted of the separation of authorities and operators. The authority defines the public transport policy at the strategic level, while the operator defines the public transport services at the tactical and operational level. The philosophy behind this distinction was based on the idea that an operator has a better knowledge of the (potential) passengers' preferences and must therefore have all instruments in hand to adjust services to meet these preferences.

The PTA 2000 enables authorities to put concessions out for tendering. A concession is a kind of public services contract that gives an operator a temporary exclusive right to provide public transport services in a specific area or on a specific transport link. The authorities draw up a schedule of requirements that has to be met by bidding operators. Transport companies can submit a bit. Both authorities and operators need planning evaluation tools to evaluate proposals.

2.2 The Brazilian context

Urban public transportation in Brazil is mostly done with buses. Approximately 100,000 buses are in operation in the country, providing 60 million passenger trips per day (APTA, 2008). As a consequence, more buses are produced in Brazil than in any other country in the world. Because of it, the Brazilian bus industry has an important role in developing high capacity and comfortable vehicles and also in introducing technological innovations in the vehicles. That is the case of the "Padron" bus, introduced in the 1970s, with three wide doors and a capacity of 105 passengers, and articulated and bi-articulated buses with capacities of up to 170 and 220 passengers respectively. In terms of operational developments, Curitiba is internationally known as a good example of efficient planning and operation, with 1,300 buses carrying almost one million passengers a day in a network of more than 60 kilometres of exclusive bus lanes, 294 kilometres of feeder bus lines, and 167 kilometres of district bus lines.

Some other important Brazilian state capitals, such as São Paulo, Rio de Janeiro, Belo Horizonte, Goiânia, Porto Alegre, as well as many other large cities, also rely on buses to serve the demand for public transportation, even where there are rail systems. The situation in the other cities of the country is not different, except for the fact that the smaller cities often do not have a very effective planning process to guide the implementation and operation of the transit systems. Most of the planning activities are in this case often conducted by the bus companies, which are usually in the hands of private operators. In addition, according to Ferraz and Torres (2004), the operators are responsible for collecting the fares from the users. The total amount collected is used to cover the operational costs and the operator profit. No subsidy is provided by the municipal governments, which are responsible for the concession or permission contracts and for assuring the quality of the service provided. Thus, there is a strong need of simple but effective planning instruments and tools to be applied in those cities, as proposed by Rocha *et al.* (2007).

3. PLANNING EVALUATION TOOLS

Public transport planning (especially short range) includes service schedules, purchase of new vehicles, modification of existing or opening of new lines and networks, some infrastructure changes, as well as organizational aspects, such as fare types and methods of collection and intermodal integration measures (Vuchic, 2005). Thus, short range planning is dependent on present conditions and near-future trends since the changes that are made are easily modified or even reversed. Comparative evaluation of alternative plans using the set of goal-based criteria and public hearings, resulting in selection of the preferred plan is a basic step in a transportation planning process. Goals are broad statements addressing the desirable conditions with respect to mobility, travel opportunities, and public transport service performance characteristics and outcomes upon a plan's implementation. Goals with respect to the role of public transport in different categories of cities include:

In developing countries, public transport represents the basic mode of travel;

In countries with high auto ownership, the primary role of public transport in small cities is to provide a social service;

In medium sized cities, public transport not only provides social services, but it replaces some automobile travel;

In large cities, public transport must provide high-quality transportation services competitive with automobiles throughout the urban area.

The adopted goals can be used as the basis for the derivation of technical system specifications and service standards, considering existing conditions, such as the size of the city or public transport service area, population number, density and characteristics, trip purposes, as well as uses of other modes (auto ownership, taxis and other Para transit, bicycles and walking habits).

Information and data collection about the existing and future conditions are needed for planning a transportation systems as well as making models to evaluate various plans (Vuchic, 2005). Data collection and analyses are always large tasks, requiring numerous personnel, and are often the most costly part of the whole planning study. Vuchic categorizes information and data into several groups: socio-economic data, land use data, transport system infrastructure data, and public transport usage data. Socio-economic data includes gender, age, household size, and car ownership. It also covers economic factors relating to transportation such as employment data, household incomes, and forecasts for development of the area or its individual sectors. Land use data consists of the type and intensity of individual activities (e.g., number of employees for office blocks and size of retail area for stores). Transportation system infrastructure includes networks, stations, terminals, parking facilities, pedestrian areas, truck, and bicycle facilities. The public transport usage data consists of passenger volumes on each line, including: directional volume profile along each line; hourly, daily, and seasonal variations; boarding, alighting, and transferring passenger volumes; and passenger characteristics and travel patterns. Data from the first three groups of data are usually available while data about current and future usage of public transport is much more difficult to get.

Evaluation of the *present* public transport system is mainly based on the actual number of passengers at bus stops and in buses, the distance travelled, and the evaluation of the public transport system (e.g., Vuchic, 2005). Passengers' counts and interviews at bus stops or in buses are used to examine the use and valuation of bus stops or bus lines. The Dutch Ministry of Transport introduced in 2001 the Public Transport Monitor System

(PTMS). This system monitors progress in the public transport market and provides results on performance (Chueng, 2004). The information generated with the PTMS can assist planners to evaluate the effects of policy measures (ex-post evaluation). The system gives insights into the performance of the public transport system based on mobility data, regional statistics, and passengers' valuation and importance scores. On the other hand, there is a need for the evaluation of a *future* public transport system (ex-ante evaluation). A limited number of studies exist concerning future travel demand in the context of public transport. Sugiki *et al* (2001) developed a traffic demand model that was used to generate future demand predictions of potential traffic per household. The probability of the potential traffic demand generation was calculated with a binary logit model. The model contained only two household characteristics: householder age and household type, and the service rate of public transport in a zone (services/hour). More recently, Zhou *et al* (2004) presented an approach to identify market shares of public transport. They adopted the following approach to find out who uses public transport, why they are using public transport, where they are living, and how they use public transport. First they identified market segments based on three attitudinal factors that cover 'value of time', 'schedule constrains', and 'sensitivity to privacy and comfort'. They defined eight market segments: intrepid amblers, solo ramblers, outgoing multi-taskers, tense trekkers, brave runabouts, shy cruisers, diligent chargers, and rigid flyers. Next, they assign specified market segments to areas based on the population characteristics of market areas and a structural equation model. With a two-level nested logit model the modal split for each market segment and geographic market area was calculated. Finally, they calculate the market share of public transport per market area. The market shares are not directly related to area characteristics.

It appears that most studies mainly focus on the actual use of public transport and not on the potentials of public transport per area. If studies pay attention to potentials, the data collection is extensive and expensive. Potentials are related to a limited number of area and transport system related characteristics. Also the level of spatial detail is not very high as might be expected in the case bus stops are involved. These shortcomings were the base of the new planning evaluation tools that are described in the next two sections.

4. EINDHOVEN TOOL

A Public Transport Potential Map (PTPM) is a tool that presents, at the level of 6-digit postal code zones, the potential of public transport based on various area and transport system characteristics (Bérénos *et al*, 2001; Van der Waerden *et al*, 2005). The aim of the PTPM is to provide public transport planners and decision makers an easy accessible tool that predicts and spatially presents the potential of public transport for different planning scenarios. For example, the tool can be used to evaluate different bus route alternatives (Van der Waerden *et al*, 2005). The PTPM is built up using a multinomial logit model that describes travellers'' mode choice behaviour. In the travel mode choice model, five mode alternatives are distinguished: Bus, Car replaceable by bus, Car not replaceable by bus, Bike replaceable by bus, and Bike not replaceable by bus. Potential of public transport includes bus use, and car and bike use that could be made or replaced by public transport.

The travel mode choice model underlying PTPM requires data at the level of 6-digit postal code zones. Area characteristics are readily available and can be purchased from various firms specialized in Geo-data. The model includes the following characteristics: dominant dwelling type, dominant household type, household size, and number of houses per hectare (Table 1). The transport system characteristics can be generated using GIS-software. The following transport system characteristics are incorporated in the model: distance to centre, distance to highway, ratio of car and public transport travel time, and number of bus stops within 350 meter.

Table 1: *Area and transport system characteristics*

Characteristic	*Characteristic level*
Dominant household type	Youngsters; Family with children; Elderly
Dominant dwelling type	Other, Rows/apartments
Household size	Less than 2 persons; 2-3 persons; More than 3 persons
Number of houses per hectare	Less than 31 houses per hectare; 31-60 houses per hectare; More than 60 houses per hectare
Distance to centre	Less than 1 kilometre; Between 1 and 2 kilometres; More than 2 kilometres
Distance to highway	Less than 6 kilometres; 6 kilometres or more
Ratio of car and public transport travel time	Less than 1.5; Between 1.5 and 2.5; More than 2.5
Number of bus stops within 350 meter	No bus lines; 1 or 2 bus lines; More than 2 bus lines

The Dutch public transport system is stored in a national database that is managed by an organization called ‘REISinformatiegroep bv’ (www.9292ov.nl). The organization provides public transport related travel information. The database is not generally available yet for studies. This means that the relevant public transport system has to be built up by the researcher based on information delivered by the various public transport companies in the study area.

Respondents’ travel behaviour at the level of 6-digit postal code zones is not standard available. Several data collections are set up to gather the relevant information such as mode choice and substitution of transport mode. Table 2 presents the estimation results for the model that is specified to describe the relationship between transport mode choice and area and transport characteristics. The transport alternative ‘Bike not replaceable by bus’ was used as base alternative. Effect coding is used to represent the levels of the characteristics. The log-likelihood ratio statistic shows that the optimal model outperforms the model with no coefficients (null model). In addition, the R-squared value indicates that the model performs satisfactory.

Only a limited number of parameters are significant at conventional level (α=0.05). The values of the constants show that all transport alternatives are, as could be expected, less attractive compared to the base alternative ‘Bike, not replaceable’. Compared to the base alternative, the most unattractive alternative is the ‘Bus’ followed by ‘Car, replaceable’ and ‘Bike, replaceable’. The positive parameter for the characteristic level ‘Household type – Elderly’ indicates that the utility of the alternative ‘Car, replaceable’ increases in the case an area is dominated by elderly people. The negative sign for the characteristic ‘Dwelling type’ means that the utility of ‘Bus’ decreases when areas are dominated by row houses and flats. In the case that an area is dominated by households with 2 or 3 persons the utility of the alternative ‘Car, replaceable’ increases. The utility of the ‘Bus’ decreases when households with more than 3 persons are the major household type in an area. For areas located at some distance of the city centre (more than 2 kilometres), the alternative ‘Car, not replaceable’ is more favourable than the base alternative. The utility of the alternative ‘Bike-replaceable’ decreases when an area is located at 6 kilometres or more from a highway. If the travel time ratio is higher than 2.5 then the utility of the alternative ‘Car-Not replaceable’ increases. The utilities of ‘Bus’ and ‘Car- replaceable’ increase when an area is close to three or more bus lines. The latter effect is not as expected. The utilities of ‘Car, Not replaceable’ and ‘Bike, replaceable’ decrease when an area is close to 1 or 2 bus lines.

To illustrate the use of public transport potential maps, in this section a small example is worked out.

Table 2: *Parameter estimates of the travel mode choice model*

Characteristics	*Levels*	*Travel modes*			
		Bus	*Car, Replaceable*	*Car, Not replaceable*	*Bike, Replaceable*
Constants		**-2.7290**[1]	**-1.6143**	**-0.9253**	**-1.5658**
Household type	*Youngsters*	-[2]	-	-	-
	Families with children	0.4090	-0.2573	-0.0414	-0.1300
	Elderly	0.0513	**0.2644**	**0.3701**	0.1545
Dwelling type	*Other*	-	-	-	-
	Row houses/flats	**-0.2811**	-0.0264	-0.0343	-0.0743
Household size	*Less than 2 persons*	-	-	-	-
	2-3 persons	-0.0268	**0.3056**	-0.0035	0.1812
	More than 3 persons	**-0.4763**	0.0887	0.0373	0.1683
Density	*0-30 dwellings /ha*	-	-	-	-
	31-60 dwellings /ha	0.1191	0.1330	0.0860	-0.1125
	61 and more dwellings/ha	0.2339	0.1642	0.0927	0.1464
Distance centre	*Less than 1 kilometre*	-	-	-	-
	1-2 kilometres	-0.2566	-0.1253	-0.1444	-0.0089
	More than 2 kilometres	0.0825	0.1254	**0.3920**	0.1761
Distance highway	*Less than 6 kilometres*	-	-	-	-
	6 or more kilometres	0.0263	0.1299	-0.1512	**-0.1829**
Travel time ratio	*Less than 1.5*	-	-	-	-
	Between 1.5 and 2.5	-0.0775	0.0389	0.0301	0.0958
	More than 2.5	0.0491	-0.0136	**0.2466**	-0.1144
Bus stops	*0 bus lines*	-	-	-	-
	1-2 bus lines	0.2344	-0.0998	**-.4141**	**-0.3053**
	More than 2 bus lines	**0.4317**	**0.2690**	0.1028	-0.0796
Goodness-of-fit measures					

Log-likelihood null model (LL_{null})	-3959.217
Log-likelihood optimal model ($LL_{optimal}$)	-3052.263
Log-likelihood Ratio Statistic	1813.908 (Degrees-of-Freedom=56)
R-squared ($1-LL_{optimal}/LL_{null}$)	0.229

[1] **Bold:** significant at conventional level (α=0.05)

[2] No parameter estimated for base level

Together with the municipality, public transport company Veolia Transport (Veluwe Group) plans a new bus system in the city of Apeldoorn. The new bus system aims to be less complex with more straightforward bus lines (Figure 1). Both organizations want to know what the effects of the new bus system will be in terms of potential. The estimated model is used to predict the effects. The change from current to new bus system affects two characteristics: the travel time ratio car-public transport and the number of the bus lines within 350 meters. The other characteristics are not affected by the introduction of the new bus system.

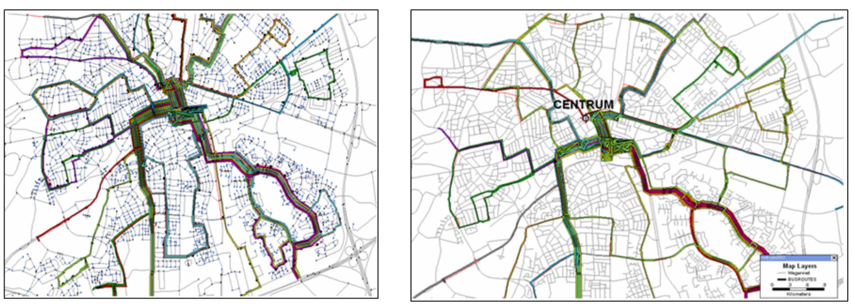

Figure 1: *The Apeldoorn bus system, current (left) and new (right) system*

Table 3 presents the overall difference between the base situation and the new situation for the two variables. The Table shows the number of 6-digit postal code zones per type of difference (including no change). In case of both characteristics most values per postal code zone decreases due to the change in bus system. In the case of travel time ratio the values changes more than in the case of number of bus lines.

Table 3: *Overall difference between base and scenario*

Effect	*Travel time ratio*		*Number of bus lines*	
	Frequency	*Percentage*	*Frequency*	*Percentage*
Increase	708	17.3	623	15.2
Equal	305	7.5	1058	25.8
Decrease	3075	75.2	2422	59.0
Total[1]	4088	100.0	4103	100.0

[1] For some zones the travel time ratio could not be calculated

With the new variable values, the market shares are calculated. Table 4 presents the overall result of the calculation. It appears that the new bus system does not result into big changes. This is an interesting finding because with a smaller bus system the same market shares can be reached. The potential of public transport (bus + car replaceable + bike replaceable) will increase with 0.59 percent. The real growth (car replaceable + bike replaceable) is equal to +0.83 percent. The results indicate that the changes in market share at the level of the city are limited.

Table 4: *Overall market shares of transport modes current and new situation (in percentages)*

Situation	**Bus**	**Car replaceable**	**Car not replaceable**	**Bike replaceable**	**Bike not replaceable**	**Potential public transport**	**Growth public transport**
Current situation	6.63	7.24	19.02	8.46	58.65	22.32	15.59%
New situation	6.50	7.08	19.32	9.34	57.77	22.91	16.42%
Difference	*-0.13*	*-0.16*	*+0.30*	*+0.88*	*-0.88*	*+0.59*	*+0.83%*

Considering the results at the level of 6-digit postal code zones (Figure 2), the effect of the new bus system seems to be more diverse. Figure 2 shows the growth in public transport (share of car and bike replaceable). In some areas the market share of public transport will grow due to the introduction of the new bus system (red circles). In other areas (mainly in the North-East) the market share of public transport will decrease. In some cases it will be more than 5 percent (light grey colour).

The application shows that the market share of public transport will increase little when a new bus system is implemented. In more detail, the maps show where the growth of public transport decreases or increases. Some areas show an increase of more than 5 percent while other areas show a decrease of more than 5 percent.

Figure 2: *Growth of potential of public transport*

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5. SÃO CARLOS TOOL

The second instrument concerns a GIS-based planning approach to evaluate existing and new implemented public transport routes. As the procedure developed in Brazil is based on the Lancaster's Characteristics Approach (Lancaster, 1966), the transit system is seen as a set of products (i.e., the routes) that shall reach a certain performance level to meet the needs of the users, of the operators and of the entire community. Lancaster's theory is based on four basic assumptions: i) consumers look for attributes when consuming a product and not for the product itself; ii) the set of attributes desired by the consumers can be found in only one product or it can be distributed in several products; iii) the combination of several products can provide the set of attributes desired by a consumer; iv) depending on their needs, distinct consumers may require different characteristics from the same product.

Some of the characteristics of the urban spaces considered were: the connectivity of streets, relief features, population density, and the overall urban configuration. Those attributes were cross-compared with the different typologies of public transport routes, such as radial, trunk, and feeder. The comparison helps in the identification of urban features that can influence the performance of the public transport system.

The first step to incorporate the basic concepts of Lancaster's theory into a tool for practical applications is to identify the characteristics that play an important role in the process and the ways they relate to one another. In the case of public transportation, the product can be defined as a trip done in a certain route. The consumer is the system user, who needs to move around in the city and who will select the route (or routes) that can better serve his/her individual needs to do so. User's needs are essentially related to: characteristics of the trip, such as travel time, comfort, and out-of-pocket costs; and conditions of accessibility, such as stops, service frequency, and user information systems. Given those elements, one of the challenges faced by planners and by transit systems managers is to understand how the urban space and the routes operating in it can influence the characteristics of the product.

The evaluation of the performance of each bus route was done by looking at the characteristics observed along the itinerary. In the study carried out in São Carlos, the existing bus routes were analyzed taking into account two quality factors that have been cited as critical by the users in a recent appraisal of the system: the excessive number of passengers per vehicle and the irregular frequency. Data of the urban area were then combined in thematic maps built with GIS tools, as in the examples shown in Figure 3. The data can be used to tag the different urban areas with positive or negative points according to the performance indicators considered. After the process is conducted in the entire urban area, new bus itineraries can be designed. The design strategy is to increase the efficiency of the route by reducing the number of negative points along the way. In the case study discussed in this paper, we used the same reasoning to evaluate the existing routes, instead of proposing new ones. The data considered were: the route length, the demand and its distribution in the urban area, relief conditions, connectivity of streets and congestion levels. In the maps of Figure 3, for example, characteristics such as route length, demand values and demand distribution can be seen for two distinct bus routes (or bus lines). While line 4169 is a long route crossing areas with a heterogeneous distribution of demand (sometimes high, sometimes low), line 4256 is short and crosses areas with low and homogeneous demand. All other characteristics can be analyzed in a similar way. The appropriate maps play an important role in the process.

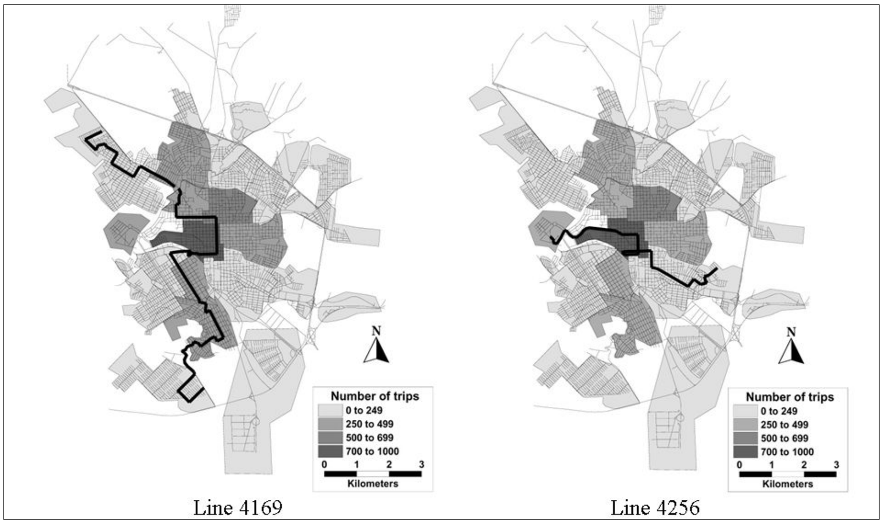

Figure 3: *Total number of bus trips (produced plus attracted) per census tract and two bus routes (codes 4169 and 4256) in São Carlos, Brazil*

Examples of the criteria used to define positive or negative points are presented in Tables 5 and 6, for the factors *Number of passengers per vehicle* and *Frequency*, respectively. The maximum possible number of negative points is three for the factor *Number of passengers per vehicle* and five for the factor *Frequency*. We assumed for the case study that routes with zero or one negative points in the factor *Frequency* would be considered efficient and routes with two or three negative points would be considered inefficient. Regarding the factor *Number of passengers per vehicle*, zero to three negative points would be good for the routes and four or five negative points would not be good for the routes. Based on these general criteria, any bus route can be analyzed, as shown in Table 7. Line 4169 shown in Figure 3, for example, presented five negative points in the factor *Frequency* and three in the factor *Number of passengers per vehicle*. Therefore, it was considered inefficient in both aspects.

Table 5: *Evaluation criteria of different characteristics considering the factor* ***Number of passengers per vehicle***

Characteristic	The characteristic is negative to the factor	The characteristic is positive to the factor
Route length	Long	Short
Demand	High	Low
Spatial distribution of	Heterogeneous	Homogeneous

Table 6: *Evaluation criteria of different characteristics considering the factor* ***Frequency***

Characteristic	The characteristic is negative to the factor	The characteristic is positive to the factor
Route length	Long	Short
Demand	High	Low
Relief	Hilly	Flat
Connectivity of streets	High	Low
Congestion level	High	Low

Table 7: *Examples of the application of the evaluation criteria of different characteristics considering the factors* ***Number of passengers per vehicle*** *and* ***Frequency***

Characteristic	Bus line	
	4169	4256
Route length	Long (negative)	Short
Demand	High (negative)	Low
Spatial distribution of	Heterogeneous	Homogeneous
Relief	Hilly (negative)	Hilly (negative)
Connectivity of streets	High (negative)	Low
Congestion level	High (negative)	Low
Negative Points (*Pass.*	3	0
Evaluation (*Pass. per*	INEFFICIENT	EFFICIENT
Negative Points	5	1
evaluation (*Frequency*)	INEFFICIENT	EFFICIENT

[1] According to Table 5

[2] According to Table 6

The evaluation was completed using data of a survey conducted with the system users. In that poll, the users were asked to assess several factors, including those aforementioned (*Number of passengers per vehicle* and *Frequency*). With that information, it was possible to classify the routes as satisfactory and unsatisfactory regarding the same aspects also from the users' point of view. The combination of the previous evaluation of the system characteristics with the users' classification generated four possible groups of routes, as shown in Table 8.

Table 8: *Classification of the routes in groups, taking into account two different evaluations*

Groups	Evaluation by the system characteristics	Evaluation by the users
A	Efficient	Satisfactory
B	Inefficient	Unsatisfactory
C	Inefficient	Satisfactory
D	Efficient	Unsatisfactory

Looking at the groups described in Table 8, planners can determine which routes need adjustments and also the measures that must be taken to improve them. Routes in Group A obviously do not need any adjustment. For routes in Group B, a few adjustments in the itinerary or in operational characteristics can make the routes even better for the users. In the case of Group C, even considering that the routes are satisfactory for the users, a few adjustments in the itineraries can make the routes more efficient, what is interesting for the entire system. In the case of Group D, several adjustments and operational changes may be needed, what may suggest the need of more comprehensive studies.

The concepts of efficiency and satisfaction are connected, given that both represent the capacity of the routes for meeting the users' needs. It means that in ideal conditions, all routes evaluated should be in Groups A or B. However, in the evaluation conducted in São Carlos, 68% of the bus lines were classified in those groups, for both *Number of passengers per vehicle* and *Frequency*. Given the values found, at least three aspects can interfere in these results. The first one is the fact that the users' evaluation is very subjective. The judgment of any individual reflects the knowledge that he/she has about the system, which is sometimes limited to just a few routes (not rarely, just one). The second factor is related to performance characteristics that are not directly influenced by urban characteristics or by the type or itinerary of the route, but instead by operational aspects and procedures. Finally, the third factor is the quality and availability of data for assessing the system

In the search for a more efficient system, several performance measures can be simultaneously considered. The urban area can be divided in sectors, for example, to indicate the influence of each one of them in the total performance of the system. If the factors considered are weighted and combined in a multi criteria evaluation, the final outcomes can be represented in thematic maps. Those maps would be quite similar to the map in Figure 3, but they would show a synthesis of several factors at once, instead of isolated characteristics. Thus, they would be quite useful as a reference for the design of new routes or for the evaluation of the existing ones. In addition, if maps with near-future projections of the urban characteristics are built, the new routes can be designed to increase the efficiency of the system by anticipating those changes.

6. CONCLUSIONS

To support planning activities of both public transport authorities and companies there is a need for easy accessible planning evaluation tools. This paper describes two examples of planning evaluation tools developed in two different parts of the world. The tool developed in The Netherlands produces Public Transport Potential Maps based on traveller's mode choice behaviour related to area and transport system characteristics. The underlying travel mode choice model is still under development. Based on findings regarding model parameter estimates, the selection and specification of the area and transport system characteristics have to be reconsidered. An extension of the evaluation tool concerns the translation of the relative potential to absolute number of potential travellers.

The tool developed in Brazil concerns a GIS-based planning approach to evaluate existing and new implemented public transport routes. The analysis carried out in São Carlos used only available data, such as census information and a survey with public transportation users. No data was exclusively collected for the study, what suggests that similar evaluations can be easily applied in other places. A drawback in this case, however, was the quality of the available data. As it was not intended to the type of the application conducted, it was sometimes incomplete or inadequate. The use of ITS devices in the public transportation system, for instance, could add useful data to the survey with the users, such as more accurate and continuous operational information of the system (e.g., Transit Smart Card; Utsunomiya *et al*, 2006). Those data would also help the operator to improve the management conditions and increase the profitability of the service.

The flexibility of GIS is proved once again in the applications discussed in this paper. That shows the importance of the tool as a platform for planning activities also in the field of public transportation planning, regardless the development level of the place under analysis or the amount and quality of the available data.

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