QUALITY ASSESSMENT IN URBAN PUBLIC TRANSPORT

Vasile DRAGU
University Politehnica of Bucharest, Splaiul Independentei 313, Bucuresti, Romania
v_dragu@yahoo.com

Eugenia Alina ROMAN
University Politehnica of Bucharest, Splaiul Independentei 313, Bucuresti, Romania
drg_alina2006@yahoo.com

Vlad Cătălin ROMAN
University Politehnica of Bucharest, Splaiul Independentei 313, Bucuresti, Romania
r_vlad85@yahoo.com

Abstract
The performance of a transport service is measured by its quality attribute, which is the most synthetic and comprehensive indicator. However, it is difficult to identify this service quality attribute because it involves the various customer perceptions and it may be influenced by the passengers' preferences or by the travel behavior corresponding to a certain social category. The modal split of passenger transport is also influenced by the quality of supplied services which establishes a market share for the transport mode analyzed, in this case the urban public transport.
The present paper aims to identify specific indicators for assessing the quality of urban public transport services, and to characterize the performance of the transport supply. It is well-known that a quality service guarantees the success of a public transport operator, with direct implications on user behavior. A case study was carried out, highlighting the compliance of the public transport operator in Bucharest with the traffic program, and an indicator of travel time accuracy was established. Conclusions are formulated in order to improve service quality and, in this way, to increase the attractiveness of urban public transport and the quality of life.
Keywords: transportation quality, public transport, quality indicators.

1. GENERAL CONSIDERATIONS

Quality is the best and most comprehensive indicator which measures the performance of the transport system. (Nevřela Jiří, 2008, Raicu and Masala, 1981, Raicu, 2002 b, Raicu, 2007, Tobias et. al., 2009)

The success and the market share growth of public passenger transport operators are determined by the quality of supplied services and moreover, by the passengers' perception of the provided quality (Anastase, 2012). In many cases, perceptions are subjective and based on users' lifestyle and travel behavior. (Dragu 2004, James, 2001, Raicu and Dragu, 2012)

Theoretical and Empirical Researches in Urban Management
Volume 8 Issue 3 / August 2013

The concern for the expansion of the quality concept in the transport sector is of relatively recent date and is marked by the ratification of the ISO 9000 standards by nations. These standards were derived from and inspired by British Defense standards (Drăgulănescu, 2004, a and b, Rusu and Bejan, 2004). Because the standards were developed to check the quality of products, their use in the transport sector and, in particular, in passengers transport has proved difficult and required major adaptations (Dina, 2004, Pascu et. al., 2011).

There are various quality measurements used by many transport companies; however, if they become quantitative, these measurements no longer reflect the existing theories and no longer focus on issues that beneficiaries consider essential. (Raicu 2007).

Quality standards are based on an assessment cycle which includes four distinct points of view (Raicu 2000, Raicu 2003): expected quality, perceived quality, desired quality, and achieved quality. The first two aspects of quality have to do with passengers' perceptions of public trasport services, and the last two reflect the concerns for the quality of urban public transport operators and more.

The expected quality of service is the quality desired by users; the perceived quality reflects each passenger's perception, in relation to his desires, of the service provided by transport operators (the overall discrepancy between passengers' expectations and perceptions of service experience).

The desired quality of service refers to the quality level that transport operators had set as their objective. It is defined in terms of the expected quality, taking into account the external and internal constraints of the public transport system, the budgetary constraints and the performance of competing services.

The definition of this quality level takes into account the quality standards required for compliance with a certain indicator and the establishment of a standard reference level. The achieved quality of the service refers to the level of quality offered daily by transport operators. The achieved quality aims to equal the desired quality; however, due to environmental conditions, the two types of quality will never be the same, although this in fact would be the ideal.

In many cases the perceived quality is different from the achieved quality. The difference between achieved quality and perceived quality depends on the passengers' experiences of using the service and on the user's cultural and social environment (Gordon, 1989, Takyi, 1995).

The four different points of view refer not only to the service quality in transport terminals and in means of transportation, but also to the passengers' comfort and convenience during the journey, resulting from the performance of the transport supply. (Dragu, 2004, Roşca, 2001, Ruscă et. al., 2004, Stopher and Jones, 2003)

2. ASSESSMENT OF THE SERVICE QUALITY OF URBAN PUBLIC TRANSPORT

The assessment of the quality of public transport services is based on a set of criteria that represent the views of passengers and of those who frequently use the service. Eight main categories of criteria can be defined (table 1): the first two categories of criteria provide a general description of the public transport service; categories 3-7 are useful for a detailed description of service achievement; and the last category refers to the service effects on the environment, effects that are perceived both by service users and by individuals who are not involved in the transport and even the system.

Each of the eight criteria requires a certain desired performance and specific indicators for measuring the achievement of the required performance. Certain qualitative indicators should be measured by quantitative indicators, in which case their semantic information might be lost.

Table 1 shows a detailed presentation of criteria for assessing the quality of public transport services, based on passengers' points of view and on indicators that can be used to quantify the quality.

TABLE 1 - INDICATORS OF DESIRED QUALITY IN PUBLIC PASSENGER TRANSPORT

No. crt.	Quality		
	Criterion	**Desired**	**Indicator**
1.	Offer of services (modes and transport network, operation, adjustment of offer, reliability)	The existence of a high density transport network	The percentage of people with access to each mode of transport
		A station can be reached within a clearly-defined time frame	The percentage of people taking trips without transfer
		The minimum frequency of service	% of the minimum frequency
		Providing a service adapted to special categories of passengers	-
		Services that inspire the passengers' confidence	-
2.	Accessibility (access to the system and within it, travel tickets)	Facility to access the service	Availability defined according to various criteria
		Travel facility inside the network	Travel time; Access, output and transfer time Distance/time to go between two points of the network
		Tickets distribution devices within the network; Tickets distribution devices outside the network; The possibility of choosing the most advantageous ticket, appropriate to user needs	Sold tickets

No. crt.	Quality		
	Criterion	Desired	Indicator
3.	Information (General, relating to travel, relating to special situations)	Providing accurate and useful information	The availability of schedules and informative material; % of responses to telephone information requests. Information in stations; Staff ability to provide accurate information with kindness; Number of passengers receiving accurate information;
		Providing information in a timely manner	The accuracy and timeliness of information
4.	Time (compliance with the schedule, travel time)	Reducing the duration of movement	Total volume passengers-hours; Travel time in vehicle; Time of walking; Time required to buy the ticket;
		Reducing traffic deviations from schedule	The waiting time; % of passengers arriving at the destination in the scheduled time; Percentage of travelers who are sent with delay / advance; Additional travel time; Additional time waiting in transport vehicle; Additional time for ticket purchase.
5.	Attention given to passengers (relationships with the passengers, staff behavior, support provided)	Compliance criteria and response time to complaints	Time of solving complaints
		Staff availability for all travelers	Staff ability to provide accurate information with kindness; Staff behavior;
		Staff availability	Accurate and in time information in stations and in means of transport
6.	Comfort (the comfort of the passengers, the ambiental conditions, additional installations)	Facilities to ensure the passengers comfort	% of installations in working order
		Cleaning in stations and in means of transport	Degree of cleanliness
		Pleasant ambiental conditions	Noise level, temperature
7.	Safety and security (accident prevention, protection against any kind of aggression)	Providing a service in terms of safety and security	% accidents, differed in relation to the consequences; % aggressed people;
8.	Effects on the environment (the level of pollution, natural resources used, infrastructure)	Low level of pollution	The percentage of vehicles which meet environmental standards
		Reducing energy consumption	Energy consumption
		Space occupied by infrastructure	The percentage of the urban area occupied by public transport infrastructure

(processed after: Research on implementation of urban public transport system to served areas of the Municipality of Bucharest, contract 5C03\7.09.2003, developed by PUB-CCPCT)

The introduction of transport systems in the category of large technical systems results in a variety of items which require quality assessment indicators corresponding to transport terminals, paths segments and the entire transport system (Hopkins et. al., Raicu 2002).

The indicators relative to public passenger transport terminals characterize the accessibility, the comfort and the convenience features of a station and varies from one station to another. The indicators for path segments refer to the accessibility, the comfort and the convenience on a portion of the path, or they refer to a set of parallel services serving common origins and destinations. The system indicators refer to the accessibility, the comfort and the convenience characteristic to several public transport routes which serve a certain city area.

Urban transport involves a multitude of decisions of moving people, such as the decision to travel and the modal split.

An important decision is to determine if public transport can be selected for a given journey. Public transport can be selected to perform a shift when the transport service simultaneously meets the five conditions laid down in Figure 1.

If one of these 5 conditions is not met for a given journey, then the public transport will not be selected for the travel; consequently, another mode of transport will be selected, or the journey will be made at a less convenient time, or it will not be made at all. The quality of public transport service is no longer important if the service is not accessible for the person considered, no matter how good the quality of service is for another place or another time.

Accessibility of public transport lines is defined by by the length of the service program.

The duration of the service is defined as the number of hours per day during which the service is provided along the path or between two points. If the service is not offered in the period of the day when a potential passenger wants to travel, the frequency and area of influence offered by the public transport service for the rest of the day does not matter anymore.

Service quality levels for the period of circulation (Table 2) are based on the number of hours during which a service is provided with a frequency of at least one vehicle per hour.

TABLE 2 - QUALITY LEVELS OF SERVICE (QLS) FOR THE DURATION OF THE SCHEDULE

QLS	Period of service [hours]	Observations
A	19 – 24	Service provided day and night
B	17 – 18	Service provided till late-night
C	14 -16	Service provided until the evening
D	12 -13	Service provided during the day
E	4 -11	Limited service only at peak times
F	0 -3	Very limited service

Source: Transit Capacity and Quality of Service Manual – 2nd Edition, TRB 2003

Theoretical and Empirical Researches in Urban Management
Volume 8 Issue 3 / August 2013

1. SPATIAL ACCESSIBILITY- ORIGIN
Can the distance from the starting point of the travel to the nearest station be covered on foot?
Is there a bike available and an existing bicycle parking in a station on your path?
Is there a bike available and are you allowed to carry a bike on the means of transportation?

↓

2. SPATIAL ACCESSIBILITY-DESTINATION
Can you walk the distance from the station to the final destination?
Is there a bicycle that was allowed on the means of transportation?

↓

3. AVAILABLE INFORMATION
Are the path and the schedule known?
Is there a phone number or an Internet address where you can obtain information and the phone line isn't always busy? (Is the information accurate and up to date?)

↓

4. TEMPORALLY ACCESSIBILITY
Is the service accessible and available when requested?

↓

5. AVAILABLE CAPACITY
Are there available places in the means of public transportation at the time of request?

FIGURE 1 - THE CONDITIONS OF ACCESSIBILITY TO A PUBLIC TRANSPORT SERVICE

(processed after: Research on the implementation of the urban public transport system to cover the areas of the Municipality of Bucharest, contract 5C03\7.09.2003, developed by PUB - CCPCT)

It can be said that a certain destination is in the service area of the public transport service if it is at a distance of less than 800 m (SR 13342 1996, Transit Capacity and Quality of Service Manual 2003), distance measured in *bird flight*. Due to the topography of the places, which involves different urban forms and gradients, this distance may decrease. The relationship that determines the service area of the public transport service is:

$$r = r_o * f_{sc} * f_g * f_{pop} * f_{px}, \quad (1)$$

where:

- r_o - represents the radius of transport service area under ideal conditions (800 m);
- f_{sc} - the coefficient of streets connectivity. Its value varies depending on the configuration of the street (grid, radial annular, mixed) between 0.45 and 1,00;
- f_g - represents the coefficient that depends on the streets declivity (this coefficient has values between 0.65 and 1,00);
- f_{pop} - represents the coefficient that depends on the age structure of the population that travels to public transport stations. It has values under 1;
- f_{px} - represents the coefficient for proportion of pedestrian crossings.

In Highway Capacity Manual a value limit of 30 sec is indicated as the time that pedestrians are willing to lose while crossing a street.

The fpx value is determined by relation (2):

$$f_{px} = \sqrt{\frac{-0{,}005t_{ec}^{2} - 0{,}1157t_{ec} + 100}{100}} \qquad (2)$$

where t_{ec} is the time that includes the waiting time before crossing the street, the time for insurance before crossing and the time of crossing. This period of time varies according to the curve shown in Figure 2.

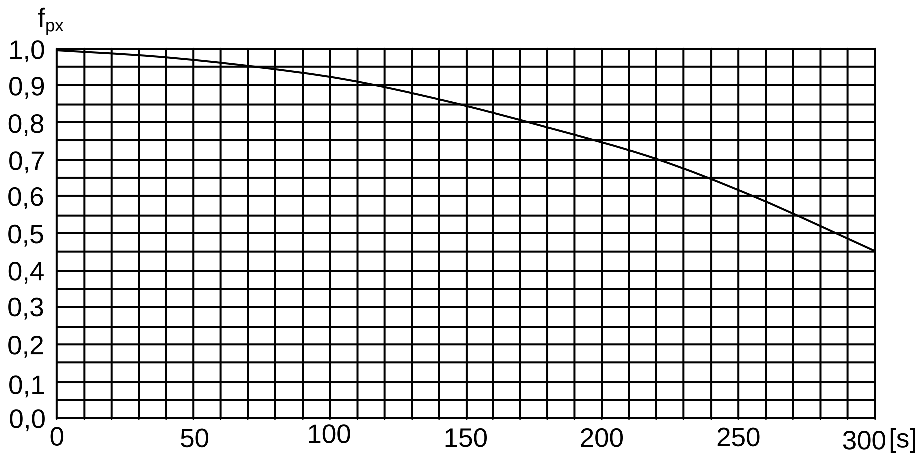

FIGURE 2 - THE COEFFICIENT FOR THE PROPORTION OF PEDESTRIAN CROSSINGS
(Source: Transit Capacity and Quality of Service Manual – 2nd Edition, TRB 2003)

The choice of public transport as an option for travel also depends on travel time accuracy (Hellgren 1994, Raicu 2000). The accuracy regarding the transport duration is measured by the Ct indicator defined by relation (3).

$$C_t = \left(1 - \frac{|T_r - T_p|}{T_p}\right) \cdot 100\,[\%] \qquad (3)$$

where: T_r is the real travel time (recorded);

T_p - scheduled travel time.

The C_t indicator can be calculated for each traveler, but can also be aggregated at bus level, at motor depot or transport operator, for a certain period of time, providing information on the compliance with schedules that are made public.

Theoretical and Empirical Researches in Urban Management
Volume 8 Issue 3 / August 2013

3. CASE STUDY

Through the case study, the degree of compliance with the schedule of the means of transport serving a particular area, mainly a residential area of the city of Bucharest was determined, and also the indicator that reflects the accuracy of the travel time on Saturdays and Sundays in May 2011. The case study helped to determine the extent to which the means of transportation that serve a mainly residential area of Bucharest City comply with the schedule; the indicator that reflects the accuracy of the travel time on Saturdays and Sundays in May 2011 has also been determined. The case study was conducted by an original method proposed by the authors and it aimed to analyze the regularity of traffic on holidays when the influence of congestion is minimum. The expected result of the case study was the absolute regularity of movement. The current network of urban public transport managed by the Bucharest Transport Company (R.A.T.B.) serves a metropolitan area of about 710 km2 of which 228 km2 in the urban area, with a population of over 2.3 million inhabitants, covering the city itself and the Ilfov district, functionally and structurally connected to the city (Pârlea and Dicu, 2011, Purcar and Ţîţu, 2011, Sterian, 2003). Of the approximately 5 million travels generated daily in this territory, 1.6 million journeys (32%) / are made with personal means of transport or otherwise, about 600 thousand (12%) with underground transport and 2.9 million (58%) with the surface means of transportation (trams, trolleybuses and buses). In this paper, we conducted a study on the compliance with the schedule of the 268 bus line that connects Drumul Taberei neighborhood (Valea Argesului Street) and the city center (21 December 1989 Square); on this path, there is no underground transport. The study was done on Saturdays and Sundays when, due to the low intensity of the urban traffic, the schedule should be respected.

In order to analyze the the schedule accuracy, four measuring points were chosen for every sense of movement, as follows:

- For the path Valea Argesului Street-21 December 1989 Square, the two ends of the line and the intermediate points-Drumul Taberei Square and Pod Eroilor Station have been considered;
- For the path 21 December 1989 Square-Valea Argesului Street, the two ends of the line and the intermediate points-University Hospital and Drumul Taberei Square-have been considered;

The results of data processing were introduced in four tables and one of them is presented as Table 3. In Table 3 one can notice that delays at terminal 2 (21 December 1989 Square) are much bigger than at terminal 1. The explanation would be that terminal 2 is in the downtown, where congestion starts to make sense and disturbs urban traffic in which the RATB buses are also trapped.

This can be explained by the fact that terminal 2 is in the city center where congestion disturbs urban traffic (in which the RATB buses are also trapped).

Probably when traffic conditions are favorable, drivers travel at higher speeds in order to reduce the delays caused by congestion periods and to fit into the schedule. In conclusion, at terminal 2 the value of early arrivals is also high, as compared to those in 1. From relation (3) the indicator that shows the accuracy of reaching the destination at the scheduled time was established (table 4). This indicator was calculated for all Saturdays and Sundays.

TABLE 3 - THE COMPLIANCE WITH THE SCHEDULE ON SATURDAYS, ON THE WAY TO 21ST DECEMBER 1989 SQUARE

Date	Terminal 1		Intermediate point 1		Intermediate point 2		Terminal 2	
	Early [min]	Delayed [min]	Early [min]	Delayed [min]	Early [min]	Delayed [min]	Early [min]	Delayed [min]
07.05.2011	17	8	27	32	43	54	52	109
14.05.2011	22	15	40	22	98	25	56	51
21.05.2011	16	26	25	50	70	53	53	94
28.05.2011	17	8	27	32	43	54	52	109
04.06.2011	16	24	11	77	25	123	38	159

TABLE 4 - ACCURACY OF TRAVEL TIME

Accuracy of travel time [C_t] %								
Date	Way	Time	Delay	Total	Date	Time	Delay	Total
07.05.2011	To downtown	96,75	93,19	89,94	08.05.2011	99,06	96,00	95,06
	From downtown	94,93	92,40	87,33		96,07	95,67	91,73
14.05.2011	To downtown	96,50	96,81	93,31	15.05.2011	95,31	97,50	92,81
	From downtown	96,13	92,13	88,27		95,80	94,27	90,07
21.05.2011	To downtown	96,69	94,13	90,81	22.05.2011	96,88	97,06	93,94
	From downtown	96,00	93,67	89,67		94,87	96,07	90,93
28.05.2011	To downtown	96,75	93,19	89,94	29.05.2011	96,00	97,31	93,31
	From downtown	94,93	92,40	87,33		95,40	94,40	89,80
04.06.2011	To downtown	97,63	90,06	87,69	05.06.2011	95,31	97,13	92,44
	From downtown	95,13	90,07	85,20		93,60	97,20	90,80

For the accuracy of reaching your destination to be very good, the value of the coefficient C_t should come as close to 100% as possible. In the table, "direction" refers to the way to the center of the city. In table 4 it can be noticed that the accuracy of the arrival time values at terminal stations are best for the direction to the center of the city; therefore, drivers can take passengers to their destinations in a timely manner or they can stay at the inactive terminal (21 December 1989 Square) as they have introduced a rest break (a minimum of 10 minutes after every hour of driving). It can be said that buses are already late when they leave the city center, and this delay increases on the return, due to traffic conditions.

However, we appreciate that the average delay per journey is small (for the example shown in table 3 the value is 159/50 which means 3,18min/tour).

During Saturday or Sunday, the four buses number 268 run a total of 50 tours. Thus, the number of travels with early, late and regular arrivals, determined every day and for every direction, in relation to the total number of travels, established the percentage of early, regular and late arrivals, presented in Figures 3 and 4.

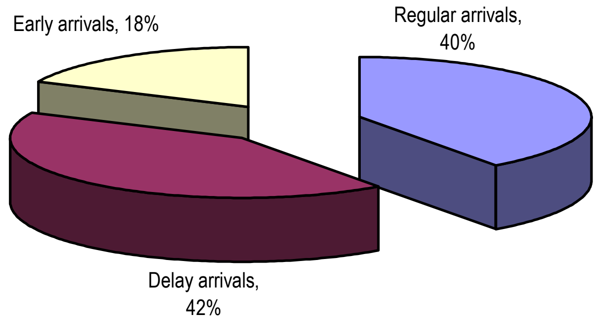

FIGURE 3 - THE REGULARITY ON 08.05.2011 TO 21 DECEMBER 1989 SQUARE

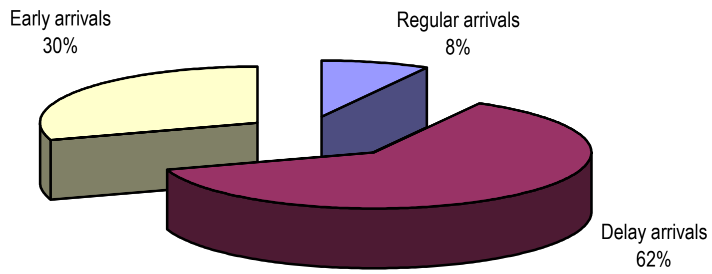

FIGURE 4 - THE REGULARITY ON 07.05.2011 TO 21 DECEMBER 1989 SQUARE

The regular arrivals percentage is 40% in Figure 3 and 8% in Figure 4; the delay percentage is 42% in Figure 3 and 62% in Figure 4; the other percentages mentioned in the chart represent the early arrivals to the area.

4. CONCLUSIONS

The quality of urban public transport is the attribute which can lead to widespread use of public transport with major implications in reducing traffic congestion and in improving the quality of life in cities.

Certain aspects of public transport perfomance can be quantified, that is, expressed in numeric values. The numerical values do not provide information about how good or bad a result is. In order to interpret these values, they can be compared to standard values. As shown above, the default values are recorded within the service levels that define the areas on the steps levels A to F.

It is considered that between two levels of transport service, users report significant quality differences.

What users consider the best service quality is often inefficient from the economic point of view, and the operators must balance the quality of service with the possibility of providing the service.

The case study presented in the paper has shown that there are both positive and negative deviations from the running schedule of the means of transportation. It should be stressed that in the urban public transport, the negative deviations from the schedule are bothersome for users who can miss the bus because of these deviations. The average values of the delays are between 0 and 3,18 min/ travel which, for a non-working day, is quite a lot in our opinion. The average values of early arrivals are between 0 and 1.5 min/travel. The analysis also shows that the delays accumulated in the inactive periods always increase, until the bus arrives at the active terminal again; this means that the accumulated delay cannot be recovered due to the congested traffic conditions.

Solutions to improve the quality of the transport circulation should be of primary concern. They should mainly refer to: the use of special public transport lanes, the monitoring and the real-time intervention to reduce early arrivals, increasing discipline in traffic for all those involved, the reduction in the shipment of goods during peak traffic hours, and finding solutions for levelling passenger traffic.

REFERENCES

Anastasie D. (2012). Proiectul ENERQI – Monitorizarea şi îmbunătăţirea calităţii serviciilor de transport public, *Transurb*, no. 61, pp. 4-6.

Dina M. (2004). Specificul proiectării unui sistem de management al calităţii într-o organizaţie prestatoare de servicii, *Buletinulul Agir*, no. 3, pp. 94-99.

Dragu V. (2004). Aspecte specifice ale calităţii în transporturi, *Buletinul AGIR*, no. 3, pp. 104-107.

Dragu V., Roşca E. & Ruscă F.(2004). Service quality in the terminals joining magistral and urban transport. In *CODATU XI, Congres Mondial – Comment Rendre les Transports Urbains plus Attractifs?*, Bucharest 2004, pp. 123-129.

Drăgulănescu N.G. (2004a). „Standarde româneşti" sau "standarde europene" în cultura noastră organizaţională", *Buletinul AGIR*, no. 3, pp. 108-112.

Drăgulănescu N.G. (2004b). Nouă viziune asupra calităţii europene, *Buletinul AGIR*, no. 3, pp. 14-19.

Gordon J. (1989). The evolution of quality campain. *Distribution*, vol. 88, pp. 68-71.

Hellgren J. (1994). *Model for Quantifying Transport Quality – Pilot Study,* Chalmers University of Technology:Goteborg.

Theoretical and Empirical Researches in Urban Management
Volume 8 Issue 3 / August 2013

Highway Capacity Manual (2000). *Highway Capacity Manual*, Transportation Research Board, National Research Council Washington, D.C.

Hopkins S.A., Strasser S., Hopkins W. E., Foster J. R. (1993). Service quality gaps in the transportation industry: An empirical investigation, *Journal of Business Logistics*, vol. 14, no. 1, pp. 145-161.

James, S. (2001). Put the Passenger First in Integrated Transport, *International Railway Journal*, no. 9, pp. 15-19.

Nevřela J. (2008). Quality in passenger railway services. In: *Transportation and Land Use Interaction Conference Proceedings*, Ed. Polytechnic Press, pp. 449-463.

Pârlea E. O. & Dicu M. (2011). Concepţia tramei stradale pe criterii de performanţă a traficului urban. In: *Simpozion Ştiinţific – Cercetare, Administrare Rutieră*, pp. 266-275.

Pascu V., Zerbes M. V., Popescu G. Liliana (2011). A Conceptual Model for the Project Quality Management Proccess. In: Proceedings of the 5th International Conference on Manufactoring Science and Education – MSE, vol. II, pp. 176-184.

Purcar C & Ţîţu M. A. (2011). Brief Review on Urban Public Transport in Romania. In: Proceedings of the 5th International Conference on Manufactoring Science and Education – MSE, Sibiu, vol. I, pp. 471-475.

Raicu, Ş. (2002a). Aspecte ale calităţii în transporturile feroviare, *Jurnal Feroviar*, no.3, pp. 12-18.

Raicu Ş. (2002b). Pentru un management al calităţii în transporturi, *Jurnal Feroviar*, no.1(42), pp. 22-25.

Raicu Ş. (2007). *Sisteme de transport*, Editura AGIR:Bucureşti.

Raicu Ş. & Dragu V. (2012). Pentru un transport public mai atractiv, *Transurb*, no. 61, pp. 34-40.

Raicu S. & Maşală Gh. (1981). *Transport feroviar. Funcţionare-Dezvoltare-Eficienţă*, Ed. Ştiinţifică şi Enciclopedică:Bucureşti.

Roşca E. (2001). Ameliorarea servirii călătorilor în terminalele de transport, *Buletinul AGIR*, no. 4, pp. 43-51

Roşca E., Ruscă F. & Panica A. (2004). Aspecte ale calităţii servirii călătorilor în terminalele de transport, *Buletinul AGIR*, no. 3, pp. 121-126.

Rusu T. & Bejan M. (2004). Efectele implementării standardului ISO 9000 în contextul integrării României în spaţiul economic european, *Buletinul AGIR*, no. 3, pp. 19-24.

SR 13342 (1996). *SR 13342 – Transport public urban de călători – parametri tehnici*, G76

Sterian Al. (2003). *Transportul public urban între trecut şi viitor. Evoluţie, calitate, eficienţă*, Ed. Libra Vox: Bucureşti.

Stopher P. & Jones P. (2003). *Transport Survey Quality and Innovation*, Amsterdam:Pergamon.

Takyi I. K. (1995). Total quality management: A strategy for de '90S and beyond, *ITE Journal*, Vol. 65, no. 3, pp. 24-36.

Tobias M., Waisman J. & de Paiva H. Jr. (2009). Service quality attributes in urban bus services: the experience of Belem – Para/Brasil, In: *Urban Transport XV Conference Proceedings*, Ed. WIT Press, pp. 405-417.

Transit Capacity and Quality of Service Manual (2003). *Transit Capacity and Quality of Service Manual – 2nd Edition,* Transportation Research Board, National Research Council: Washington, D.C.