

THE SELECTED ASPECTS OF THE QUALITY ASSESSMENT OF TRANSPORT SERVICES

Andrzej Świdorski

*Military University of Technology, Faculty of Mechanical Engineering
Quality Systems and Management Department
Gen. S. Kaliskiego Street 2, 00-908 Warsaw, Poland
tel.: +48 22 5830450, fax: +48 22 5830465
aswidorski@wat.edu.pl*

Abstract

The article characterises essential issues applicable to the evaluation of the transport services quality. While quoting appropriate literature, the article discusses the term of transport service quality and its influence on the social and economic development. The objective of the quality evaluation has been presented, from the point of view of the consumers and ordering parties, transport enterprises and independent evaluating entities (e.g. certifying bodies). The attention has been focused on the examples of the characteristics of quality in respect to the transport means, human as well as infrastructure resources. Some of the aspects of the process and mathematical modelling of the transport services quality evaluation, have been presented, pointing at the use of the artificial neural networks. The process approach in the quality assessment has been used to create mathematical model. To teach the neural network, the real data has been used, from the certification conducted at the Quality Systems and Management Department of the Military University of Technology. The summary of the article points at the scientific areas, where the presented aspects of the transport services quality evaluation, can be used.

Keywords: *transport, transport service, process, quality evaluation, modelling*

1. Introduction

The transport services (TS) represent an essential element of the economy and the social life, enabling effective functioning of its every aspect. Together with the social and economic development, necessitating in the need for mobility of people and freight, they represent a factor intensifying progress. That is because the freight should find itself where it is needed, in the right amount, at the right time, shape, quality and at the right cost [3]. The quality evaluation of TS has gained particular significance. It encompasses the activities necessary to provide the clients (consumers) with the evidence, that the service meets a certain requirements, concerning mainly time, transport destination, quality of the transport means and the freight being carried.

One of the main problems affecting the quality of the TS is adapting the haulage potential to the transport tasks being conducted. By that, we understand an optimal number of the transport means of a certain type, their load capacity, type of car bodies, reliability of the transport means their durability and efficiently operating technical servicing system [1]. That entails the necessity to look for new more effective methods of providing services, and with that – methods of evaluating their quality.

2. The essence of the transport services quality evaluation

TS takes place at the same time as being „consummated” by the users. It ceases to exist, the moment it is completed. Thus there is no chance of improving its quality after its completion. On the other hand we are faced with the impossibility of its physical presentation. The client, before

purchasing the TS can not evaluate its pro-consumer and quality aspects. Hence such an importance of the TS generated for the first time, while being conducted. It is possible though to talk about the quality improvement that is about the activities aimed at improving quality of the similar, successive services being provided, linked with the introduction of some organisational changes at the transport enterprise. These changes are closely linked with altering the transport processes conducted [2]. The formal expression of this situation is the compliance, by the transport firm, with the ISO 9000:2008 international standard and obtaining appropriate certificates, issued by the independent certifying bodies.

According to [15], the quality can be described, amongst other things as:

- relationship between what the consumers receive, and what they would like to receive,
- a degree, to which a given product resembles master pattern or specification,
- determining, when the clients' wishes are met, at the minimal production costs,
- a degree of perfection at the acceptable price and achieving it at the acceptable costs,
- measurements, thanks to which it is possible to create a characteristics of the essential qualities of the product, procedure or service and objectively determine, whether these qualities meet the expectations posed for them,
- a degree, to which all the quality of the product/services meet the requirements of the consumers.

The quality evaluation can be conducted in accordance with the certain measureable quality characteristics. For example [15]:

- maximum number of delays in a month, not exceeding 3 min.,
- certain percentage of trips should commence not earlier than with one minute before the schedule and not later than 3 minutes after the prescribed time,
- the complaints of the clients should be analysed during 48 hours,
- certain percentage of the planned trips should take place in a month,
- decreasing deficit to a determined level,
- achieving certain percentage of the income increase without raising the travel fares,
- decreasing costs by a certain amount,
- number of the kilometres travelled between the reported repairs of the transport means,
- frequency of delays caused by the breakdowns and accidents,
- not exceeding certain percentage of the transport means excluded from use, due to breakdowns,
- percentage increase of the number of regular clients in respect to the previous year,
- meeting technical and quality requirements by at least 90% of the inspected transport means.

While using TS quality characteristics, the following rules apply [10]:

a) **The rule of usefulness of the characteristics.**

TS quality characteristics must express directly or indirectly the requirements of the TS consumer/ordering party and the legal requirements. In the selection of the characteristics, the prominent position has to be taken by the interests of the TS ordering party, as meeting his requirements is a prime demand of the quality delivery of TS. Thanks to that there will be a demand for TS and the carrier will make a profit.

b) **The rule of objectiveness of the characteristics.**

TS quality characteristics must be parameterized, that is, they must be expressed in the form of numbers. The rule of objectiveness of the characteristics fulfils one of the basic demands of the rationality of this evaluation, according to the theory that, if something is impossible to be measured then it is impossible to be managed.

c) **The rule of optimisation of the characteristics.**

This rule says that deviations from the optimal characteristics value are linked with losses. The essence of this, described by Taguche is that for each characteristic it is possible to determine

such a value at which a function of losses is the smallest. This level of losses can be described as target or optimal.

d) The rule of globalisation of the characteristics.

Wherever possible, the effort should be made of the TS quality characteristics to represent the highest possible number of the partial characteristics. The globalisation properties are exhibited by, for example, the criteria of the costs of the quality, reliability, functionality, or ergonomics.

e) The rule of diversification of the characteristics.

This rule is opposite to the globalisation.

f) The rule of variability of the characteristics.

For the TS quality evaluation it is necessary to keep an attention on the fact that the characteristics do not have to be constant and can vary. This variability may be inspired by the change of the requirements of the consumer ordering TS, changes on the market and on the part of the competition, changes in the legal regulations, scientific progress, etc.

The examples of the TS quality characteristics are presented in the Table 1.

Tab. 1. TS quality characteristics

Name of the characteristics	Description
Transport means used	<ul style="list-style-type: none"> – reliability, – cleanness and maintenance of the transport means, – noise and vibrations, – load capacity, – durability, – technical services system, – costs of the technical services, repairs and overhauls, – fuel consumption, – travelling comfort, – safety,
Human resources	<ul style="list-style-type: none"> – qualifications, competencies, – politeness, – communicativeness, – trustworthiness, – accessibility,
Infrastructure resources	<ul style="list-style-type: none"> – routs scheme, – number of the necessary transport means, – storage capacities, – quality of the transport means and storage infrastructure, – availability of the transport network, – flow capacity.

The characteristics presented do not exhaust the arsenal of the characteristics described, among the others, in the works [4, 8, 9, 15], possible to be used for the TS quality evaluation.

The TS quality, and thus the objectives of conducting such an evaluation, can be considered from the point of view of:

- a) the consumers (e.g. as far as passenger transport is concerned, using various transport means: travelling of youths to schools, municipal, intercity and international transport, excursion trips, special purpose trips and those associated with the health safety and therapy),
- b) ordering party, including:

- state administration and local authorities concerning municipal, intercity and international transport, as well as utility services transport,
 - production and service firms concerning freight transport to the client,
 - legal entities and private individuals concerning transport of small consignments including : letters, parcels and purchases, transport services associated with the supplying the population and other passenger transport services,
 - educational and tourist organisations concerning excursion trips,
 - health service institutions (transport services associated with the health safety and therapy).
- c) transport enterprises (based on the functioning of the quality assurance systems and the information gathers from: consumers, ordering parties and independent evaluating bodies),
- d) independent evaluating bodies (e.g. certifying bodies).

3. Modelling of the transport services quality evaluation

The author developed methodology for the TS quality evaluation, based on the theory of the process approach to the quality [6]. The process is understood as a set of interconnected activities (operations), which are aimed at achieving certain fragment of the undertaking [1]. It was assumed also, that the process is a set of actions connected with each other or affecting each other, which convert entries into exits [6]. The Fig. 1. shows the conducting of the k-tieth process. The inputs to this process are evaluations of meeting individual quality requirements. The output represents the process quality assessment.

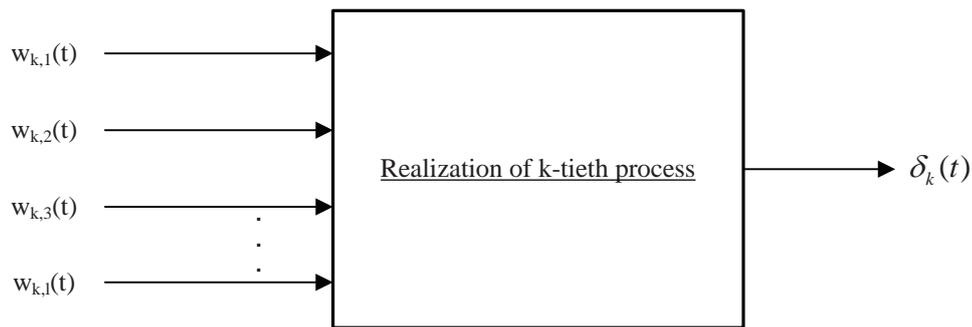


Fig. 1. K-tieth process of providing TS

Taking also, as the author's experience, it can be concluded that, the processes creating TS partial quality evaluations are as follows:

- δ_1 - enterprise management functions,
- δ_2 - configuration management,
- δ_3 - TS planning,
- δ_4 - processes associated with the TS ordering party, including risk management,
- δ_5 - storage,
- δ_6 - purchases,
- δ_7 - supervision over an infrastructure and work environment,
- δ_8 - personnel management,
- δ_9 - managing measurements processes and measuring equipment,
- δ_{10} - supervision over documents and entries,
- δ_{11} - internal audits,
- δ_{12} - corrective and preventive actions,

– δ_{13} - dealing with the TS non-compliant with the requirements.

Thus mathematical model of the TS quality evaluation (Fig. 2) can be recorded as a function $\Delta(t)$ in the form of:

$$\Delta(t) = f(\delta_1(t), \delta_2(t), \dots, \delta_K(t)), \quad (1)$$

where:

$\Delta(t)$ - TS quality evaluation during time t,

$\delta_k(t)$ - evaluation during time t of the k-tieth process, while $k = 1, 2, \dots, K$.

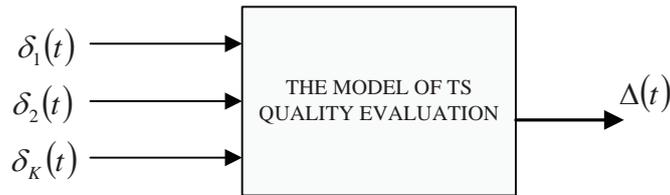


Fig. 2. Model of the TS quality evaluation

In the investigations over modelling quality evaluation [11, 12, 13, 14] the author also took into account the outcomes of the evaluation obtained earlier, in the annual intervals, that is in the time spaces $t, (t - \Delta t), (t - 2\Delta t), \dots, (t - i\Delta t)$, where i means the number of the investigated evaluations preceding a current one. The objective of such an approach was among the others, observation of the quality development trends, that is – how the TS quality has changed in time. The formula 1. takes the form of (Fig. 3):

$$\Delta(t) = f(\delta_1(t), \delta_2(t), \dots, \delta_K(t), \Theta(t - \Delta t), \Theta(t - 2\Delta t), \dots, \Theta(t - i\Delta t)). \quad (2)$$

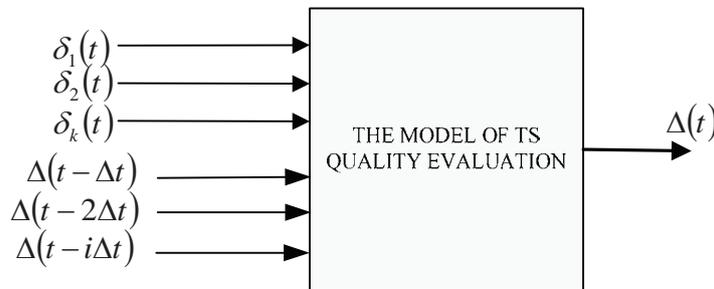


Fig. 3. Model of the TS quality evaluation using earlier evaluations

Due to the fact, that the form of the above functions is not known as well as non-linear character of the quality evaluation, it is possible to use artificial neural networks (ANN) to determine it. The essence of such an approach is finding TS quality evaluation model for the input and output data from the real certification processes conducted in Quality Systems and Management Department of the Military University of Technology. For the modelling purposes it is possible to use various available computer programs, e.g. STATISTICA 7.1, JETNET 2.0. Program JETNET 2.0 uses algorithm of the momentary backward error propagation method [7], STATISTICA 7.1 – also other methods of teaching network, such as: coupled gradients, of Levenberg-Marquardt, Quasi-Newton. Majority of them have been tested by the author during modelling and looking for the best ANN structure, which was proposed for the practical application. During modelling and determining the ANN structure, several values were adopted for the momentum coefficient, teaching coefficient (teaching speed), the number of the hidden layers and the number of neurons in these layers. To determine mathematical models for the TS quality

evaluation, sufficient are linear networks, unidirectional and multilayered. The Fig. 6. shows the application of such ANN to assist in the TS certification decision making [11].

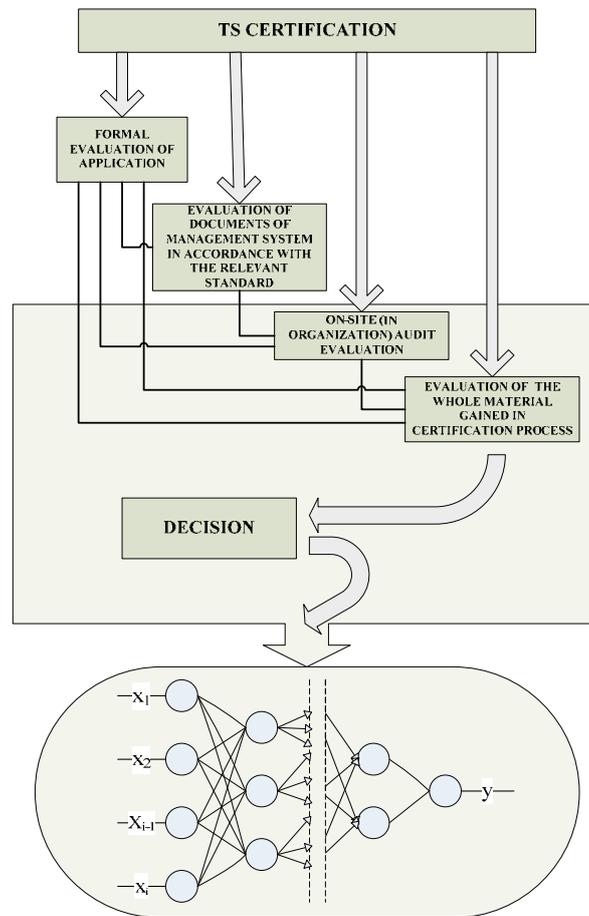


Fig. 6. Neural model of the certification decision making

4. Improving quality of the transport services

The requirements of the international ISO 9001:2008 standard recommend constant quality improvement, and thus increasing the capabilities of the transport enterprise to fulfil the requirements of the TS ordering parties. Therefore it is necessary to monitor the information on the compliance with these requirements and define the methods for obtaining and using that information. The quality evaluation results; and by that of the studies on the TS clients' satisfaction, represent the basis for the quality improvement.

The firms ought to search for the methods to improve ways to provide TS, not waiting for the problem to occur, which in turn will influence the TS quality and reveal the necessity for improvement. Therefore firms should have at their disposal the appropriate arrangements in order to identify and manage the actions aimed at the improvements. The result of them may be changes in the service, process, quality management system or the organisation of the firm.

The quality improvement represent the improvement of all its elements, that is: the organisational, the distribution of responsibilities and authorisations, procedures, processes (e.g. planning, or providing TS), personnel and the infrastructure possessed. The impulses to commence the changes may be many. Every information about the room for improvement represents to the management a basis for initiating corrective or preventive actions. The sources of such information may be:

- current use of the documentation,

- monitoring of the indicators of conducting individual stages of providing the TS,
- analytical compilation of the quality costs,
- reports about the planning and providing TS, from the sales and the analysis of its trends, service, etc.,
- reports from the internal audits, reports from the review of the management system,
- every day observations from the documents entries and providing TS, conducted, amongst the others, with the view of their effectiveness in respect to the expenditures incurred, and in the context of the dangers to the natural environment, in the context of the work health and safety requirements and in connection with the information from the TS ordering parties.

The above mentioned sources represent organisational preparation of the TS quality improvement process. Only the use of the appropriate statistical methods provides the right effect. These methods are known (and described in the subject literature) as „techniques” and „tools” (analytical and decision making) perfecting quality and raising effectiveness and efficiency of the processes. The division into methods, techniques and tools of improvement are always an artificial fragmentation, because their essence and application involves conceptual work and is associated with adapting somebody’s idea to solve ones own problem. This brings about a variety of definitions of the same things generated by different authors, which in practice means that it is difficult to find unequivocally defined affiliation of the tool, technique and method with the right category.

The methods are thus characterised by planned, repeatable and based on the scientific foundations, way of dealing with the tasks associated with quality. They allow shaping both the projected quality as well as the quality of performance, relying on generally accepted algorithms of proceeding.

The tools and techniques, in turn, serve the purpose of collecting and processing the data linked with various aspects of quality. They represent the instruments of monitoring and diagnosing of processes, enable taking decisions, analysing the results of the actions taken, make it easier to improve services or processes. The practice shows however, that it is possible to accept their traditional division, which can be as follows [5]:

- for the daily control of processes, the sufficient are typical analytical tools For example: control sheet, histogram, diagram of causes and consequences (Ishikawa diagram), Pareto-Lorenz analysis, block diagram,
- in case of the need for taking a decision it is necessary to use a logically arranged sequence of selected decision tools. For example: faults tree analysis diagram (FTA), events tree analysis (ETA), affinity diagram, relationships diagram (co-relations graph), tree diagram, decision process diagram.

5. Summary

Deliberations contained in this article entitle to form the following conclusions:

- the approach to TS quality evaluation presented here may be used as a tool assisting decisions concerning , amongst the others:
 - verification of the TS quality evaluation results as part of the certification process at the transport enterprise,
 - ordering transport services,
 - granting a certificate by the certificating body,
 - issuing, by the state administration body or other independent evaluating (supervising) body, an opinion, permission, authentication.
- ANN may be used to assist decision making also in the other management systems, e.g. in the environmental management, work health and safety management, security of information linked with the transport services,

- also other issues, linked with the quality evaluation of the transport services, may be solved using the proposed methodology, such as e.g.: reliability of the transport means, quality planning, services management. These problems however require to be separately addressed in the scientific work.

References

- [1] Ambroziak, T., *Modelowanie procesów technologicznych w transporcie*, Prace Naukowe PW, TRANSPORT, z. 40, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 1998.
- [2] Ciesielski, M., Długosz, E., Gołemska, E., *Zarządzanie przedsiębiorstwem transportowym*. Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznań 1996.
- [3] Fijałkowski, J., *Transport wewnętrzny w systemach logistycznych, Wybrane zagadnienia*. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2003.
- [4] Grigoroudis, E., Siskos, Y., *A survey of customer satisfaction barometers: Some results from the transportation-communications sector*, European Journal of Operational Research, Vol. 152, pp 334–353, 2004.
- [5] Hamrol, A., Mantura, W., *Zarządzanie jakością. Teoria i praktyka*, PWN, Warszawa-Poznań 1999.
- [6] ISO 9000:2005 *Quality management systems – Fundamentals and vocabulary*.
- [7] Lonnblad, L., Peterson, C., Rognvaldsson, T., *Pattern recognition in high energy physics with artificial neural networks – JETNET 2.0*, Computer Physics Communications 70, pp 167-182, 1992.
- [8] Rudnicki, A., *Jakość komunikacji miejskiej*, Wyd. Stowarzyszenia Inżynierów i Techników Komunikacji, Kraków 1999.
- [9] Starowicz, W., *Jakość przewozów w miejskim transporcie zbiorowym*, Wydawnictwo Politechniki Krakowskiej, Kraków 2007.
- [10] Szkoda, J., Świdorski, A., *Problemy oceny skuteczności jakościowej procesów realizacji usług w aspekcie wymagań AQAP*, Wydanie Europejskiego Instytutu Jakości, Warszawa 2005.
- [11] Świdorski, A., *Quality assurance prototyping of technical transport means*, Archive of Transport. Polish Academy of Sciences Committee of Transport, Volume 19, issue 4, pp 99-110, Warsaw 2007.
- [12] Świdorski, A., *The assessment of product configuration management with usage of artificial neural networks*. Polish Journal of Commodity Science nr 3/2009, pp 35-43, Radom 2009.
- [13] Świdorski, A., Wojciechowski A., Dębicka E., *Quality management system modelling of vehicle inspection stations*, Transport Problems, Volume 4, issue 4, pp 69-78, Gliwice 2009.
- [14] Świdorski, A., *Studies and quality assurance neural modelling of the technical transport means*, Archive of Transport. Polish Academy of Sciences Committee of Transport, Volume 21, issue 3-4, pp 177-188, Warsaw 2009.
- [15] Vinck, S., Mopin, P., Molina, J. M., Nost, K., Als, P., *Barometr jakości satysfakcji pasażerów*, Biuletyn Komunikacji Miejskiej nr 40, s. 50-79, Warszawa 1998.