Multicriteria analysis and public transport management

Z. Kavran[1], G. Štefančić[1] & A. Presečki[2]
[1]*Faculty of Transport and Traffic Sciences, University of Zagreb, Croatia*
[2]*Presečki grupa d.o.o., Croatia*

Abstract

The efficiency of the public urban transportation system depends on the identification of relevant parameters and their weights, which directly or indirectly influence the quality of urban traffic. Based on the preferences of decision-makers, it is necessary to consistently determine the significance of criteria, compare the strategies, and determine the one used in decision-making. This paper presents a model of multiple criteria decision-making based on the analytical hierarchical model with the aim of improving the efficiency of the public urban transportation system.
Keywords: public urban transportation, multicriteria analysis, planning.

1 Introduction

The issue of the development strategy of urban transportation has been considered in numerous scientific and technical works, especially in the developed countries. The definition of various strategies for the future development of urban traffic represents a demanding task and it needs to be assigned to traffic experts. The decision-maker has to know the impact of various management measures on the efficiency of the system so as to be able to select the best one. The development of sophisticated computer models has provided support in evaluating the parameters and in testing their impact on the function of the set objective, even before the model is implemented in the actual process.

The public transport system in the city of Zagreb comprises three main transportation systems: tram, bus and rail. The relative number of the tram traffic users is almost 70%, whereas the rail system is represented by only 5%. The traffic on the existing tram network of the city runs mainly along the streets, so


WIT Transactions on The Built Environment, Vol 96, © 2007 WIT Press
www.witpress.com, ISSN 1743-3509 (on-line)
doi:10.2495/UT070091

that passenger cars, commercial vehicles, trams, buses and taxis fight for the limited area on the roads, which leads to high levels of traffic congestion in many areas, especially at main intersections and around the city centre. Within the downtown area, due to the network system, there are many traffic lights which are almost all fitted with fixed light intervals, and therefore with limited flexibility in responding to the changes in traffic flows.

The multiple criteria decision-making model is based on the optimisation of the objective function on the set of possible solutions.

2 Multicriteria analysis

The actual need to solve the problems for which it has been determined that they contain several functions of criteria or objectives, opens up a new chapter in mathematical programming under the title of multi-criteria programming or multi-criteria decision-making. The classical mathematical models have at least one criterion or one function of objective whose extreme is searched for. It is known, however, that in practice the important decisions are rarely brought only on the basis of a single criterion. The reality therefore requires models that would encompass several criteria at the same time. The finding of a solution that should be the best possible according to several criteria, some of which are to a lesser or greater extent conflicting, represents the task of multi-criteria optimisation. In the field of multi-criteria optimisation there are two types of problems from the aspect of the methods or forms of describing the considered reality by means of adequate mathematical model: multi-criteria programming or multi-criteria decision-making and multi-attribute decision-making or multi-criteria analysis.

The analytic hierarchical process represents the process which allows the decision-makers to set the priorities and make decisions for the case when it is necessary to take into account both quantitative and qualitative characteristics. The process allows reduction of the complicated decision-making process into a series of individual comparisons between the set objectives and criteria, thus allowing complete insight into the decision-making process in order to select the best scenario.

3 Multicriteria decision-making model

The efficiency of the public urban transportation system depends on finding the relevant parameters and their weighted values on the set objectives and criteria. Today's computer systems which can be characterized by high efficiency allow the application of algorithms in the process of decision definition.

In accordance with the set objectives of increasing the efficiency of public urban transportation the following criteria have been defined; safety of the participants, ecology of the environment, availability of the system, throughput capacity of the network of traffic routes, and economic indicator.

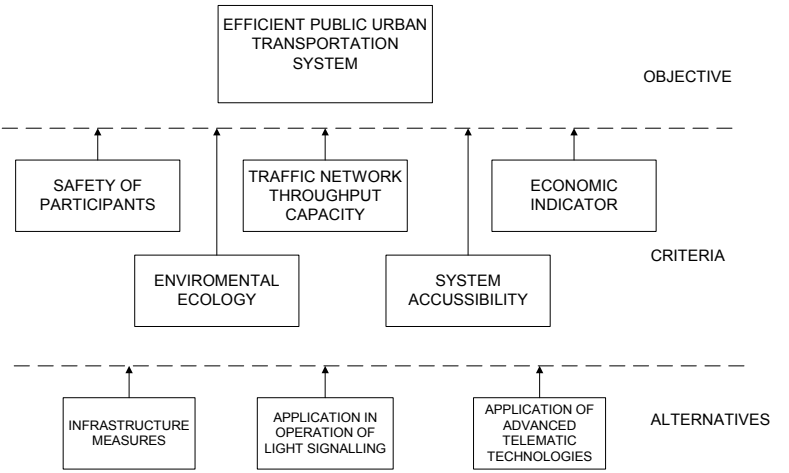

Figure 1: Multicriteria model.

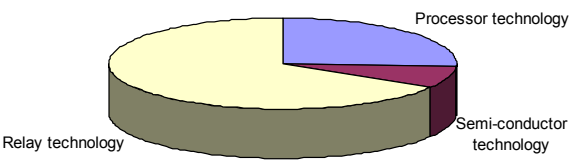

Figure 2: Technologies of light signalling (City of Zagreb).

Possible alternatives in the function of future development of urban transportation include; infrastructure measures, changes in the operation of the existing light signalisation, and application of advanced telematic technologies.

Infrastructure measures represent one of the frequent solutions in increasing the efficiency of the public urban transportation system which requires substantial investments. Complex urban problems need to be solved in all the areas of their occurrence, rather than only by satisfying the traffic demand exclusively on the side of the traffic supply. The physical-traffic concept of urban development requires synchronized application of comprehensive measures for alleviating the main traffic problems. The changes in the operation of the existing light signalling have to be designed so as to match the traffic flows at intersections and thus reduce the traffic standstills. Regarding the existing obsoleteness of the control equipment which is presented in Figure 2 there is no possibility of efficient control in the whole network. Often, efficient control in one part of the network represents a cause for traffic congestions in the adjacent sections.

By introducing the telematic technology system in the traffic system, individual traffic components gradually come closer and equal regarding their information-communication properties. By introducing a greater number of

information-communication modules of different levels of intelligence into the levels of controlled and controlling system of all the traffic modes, the quantity of available information about the traffic process is increased, thus reducing the ambiguity, increasing the reliability and the safety of traffic flows.

4 Survey method

For the gathering of data about the weights of the functions of criteria and alternatives, the survey method of traffic experts has been applied. The survey participants in the questionnaire compare two notions, each at the same level of hierarchy. In order to avoid, i.e. eliminate the epistemological difficulties the survey was applied on the sample of respondents who have an approximately same level of education, making each response of the respondents render the same value and equally forming the statistic mass. The example of the analysis of the gathered data for the safety criterion of the participants in the traffic process and ecology is presented in Figure 3.

Comparing all the criteria follows the matrix of inter-comparisons related to the set objective of research. The weighted values have been selected in compliance with the Saaty scale for determining the relative importance, which says that value 1 represents equal importance, value 3 slight preference, value 5 strong preference, value 7 very strong preference and value 9 extreme preference of the activity.

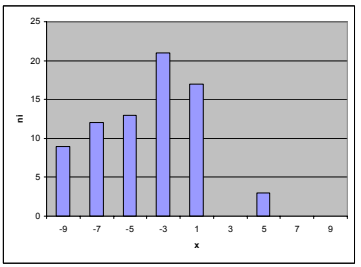

Figure 3: Number of responses of safety and ecology criteria.

OBJ	*SAF*	*ENV*	*ACC*	*THR*	*ECN*
SAF	1	5	5	3	5
ENV	$\frac{1}{5}$	1	3	1	3
ACC	$\frac{1}{5}$	$\frac{1}{3}$	1	$\frac{1}{3}$	1
THR	$\frac{1}{3}$	1	3	1	3
ECN	$\frac{1}{5}$	$\frac{1}{3}$	1	$\frac{1}{3}$	1

Figure 4: Matrix of inter-comparison criteria.

By analysing the obtained values of criteria comparison, it follows that the safety of participants is the most important criterion in the function of objective. The throughput capacity of the traffic routes network is the next important criterion, since the traffic flows should be organized in such a way as to optimally use the very traffic network. Regarding the increasing ecological awareness which is the consequence of growing pollution at present, the criterion of ecology has approximately the same importance as the criterion of throughput capacity. The remaining criteria of system accessibility and economic indicator are of the least importance for the traffic participants.

The influence of the choice of the defined strategies of urban traffic development is presented in Figure 5. The infrastructure measures as usual practice to satisfy the transportation demand by infrastructure measures, represent partial solutions for a shorter period of time. The changes in the operation of light signalling should not be applied as an independent measure, but rather those in the concept of the information system development represent only one of the subsystems. The choice of the future strategy is to the greatest extent in today's environment dependent on the application of telematic technologies.

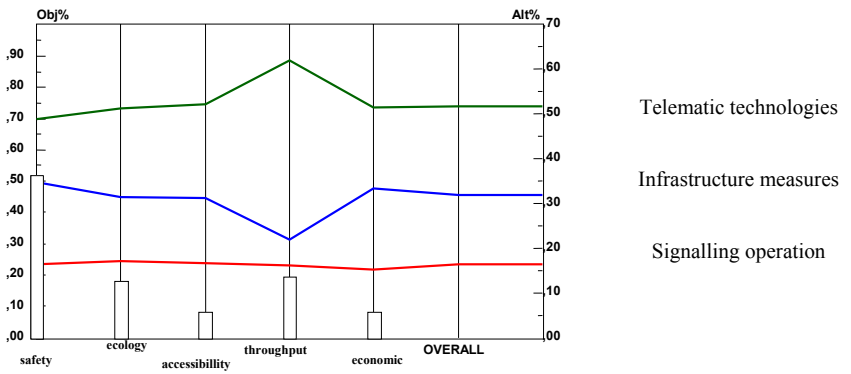

Figure 5: Influence of alternatives on the criteria.

5 Conclusion

The traffic process planning in the cities is very important, if not the most important component and precondition for the successful realization of relevant economic and social objectives. Regarding the complexity of finding optimal/acceptable solutions and the facts that numerous parameters participate in the search, the application of multi-criteria model can allow the selection of an acceptable traffic scenario.

The decision-oriented approach to urban traffic planning and the choice of the strategy should be directed towards information needs of the decision-makers. It is essential to provide the decision-maker with the information required for

complete comprehension of the problems as well as the information about the influences of the choice of individual solutions (strategies).

The advanced approach to urban traffic planning and the choice of relevant strategies indicate the increased need to use advanced telematic technologies. Successful implementation of the technologies depends on the technical integration of the system as well as the institutional integration which includes coordination of the work of different services.

References

[1] Meyer, M.D., Miller, E.J.: *Urban Transportation Planning*, McGraw Hill, New York, USA, 2001.

[2] Papacostas, C.S., Prevedouros, P.D.: *Transportation Engineering & Planning*, Prentice Hall, New Jersey, USA, 2001.

[3] Saaty, T.L.: *Decision Making for leaders – The Analytic Hierarchy process for Decisions in a Complex World*, RWS Publications, USA, 2001.

[4] Longo, G., Rosato P., Tassan Zanin L.: Multiple criteria analysis and ITS evaluation, *Proceedings of 7th World Congress on Intelligent Transport Systems*, Torino, Italy, 2000.

[5] Štefančić, G. : Informacijski sustavi na putničkim terminalima, *Suvremeni promet*, Zagreb, **16(1)** , pp. 186-188, 1996.,

[6] Anžek, M., Golubić J., Lanović Z.: Architecture Development of Automatic Traffic Control System in the City of Zagreb, *Proceedings of 5th International Conference "Traffic Safety Management for Big Cities*", St. Petersburg, Russia 2002.