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Evaluation of different transportation solutions with the application of Macro Simulation tools and Multiple Criteria Group Decision Making/Aiding methodology

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Abstract

This article presents a multiple criteria evaluation of different redevelopment variants of a certain section of a major street in a medium – sized metropolitan area. Each of the variants comprises different transportation solutions and concepts as well as distinct investments in transportation infrastructure. The variants have been designed heuristically with the application of PTV VISUM 11.0 computer traffic simulation system and evaluated according to the principles of Multiple Criteria Decision Making / Aiding (MCDM/A) and Group Decision-Making (GDM) methodologies. Traffic simulation for all variants considered has been carried out and different parameters distinctive of particular variants have been generated. A consistent family of criteria has been defined to evaluate the proposed transportation variants. In the set of criteria interests of the group decision maker (Municipal authorities) and three major stakeholders, including: passengers, investor, public transport operator, and municipal authorities have been taken into consideration. Computational experiments have been carried out with the use of ELECTRE III and AHP methods.

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Keywords: Evaluation of Transportation Projects; Multiple Criteria Decision Making / Aiding; Group Decision Making; Electre III; AHP.

1. Introduction

Many authors (Hensher & Button, 2000, Vuchic, 2007) claim that continuous improvement and enhancement of transportation systems is required to satisfy increasing expectations of travellers (passengers), goods suppliers and customers. All users of transportation systems want to receive a reliable transportation service that corresponds to well – known, general transportation – logistics standards of "7 rights" (Shapiro & Hasket, 1985).

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To satisfy these requirements new technological, infrastructural and policy – based transportation solutions need to be implemented in transportation systems. Many authors report on various advanced and original solutions applied in different countries that are frequently developed as a set of combined tools constituting comprehensive transportation projects (Novak et al., 2012, Small, 1999, Vuchic, 2007, Zak & Thiel, 2001). This refers also to urban transportation systems (Vuchic, 2007, Zak, 2011) which are good example of complex and dynamic transportation systems.

The developed transportation solutions and projects need to be evaluated. Several approaches of this evaluation exist (De Brucker et al., 2011, Lee, 2000, Salucci and Delle Site, 2010). The most commonly used methodologies of evaluating transportation solutions, projects and systems are: Cost-Benefit Analysis (CBA) (Marshall, 1920) and Multiple Criteria Analysis (MCA), often-called MCDM/A (Figueira et al., 2005). The former consists in calculating and comparing benefits and costs of a project, decision or policy. Benefits and costs are expressed in monetary terms, and are adjusted for the time value of money. The latter involves a comprehensive, multiple – dimensional analysis of transportation projects. It allows for taking into account many evaluation aspects (criteria) and satisfying subjective, frequently contradictory interests and expectations of different stakeholders. The objective of MCDM/A – based evaluation of transportation solutions / projects is to balance the existing trade-offs and generate a compromise output.

In MCDM/A analysis the following parameters and characteristics are used to evaluate the considered transportation solutions (Caliskan, 2006, Zak & Thiel, 2001): comfort of travel, accessibility, travel time and travel costs, noise & pollution levels, investment costs & profitability, safety, etc.

In some cases the final decision regarding the selection of specific projects must be carried out as a group – oriented decision process (Saaty & Peniwati, 2008). In such a case a group of individuals is responsible for the finally selected decision or course of action. The choice from available alternatives is made collectively.

In this paper the authors present an original methodology of designing and evaluating transportation solutions/ projects implemented in an urban transportation system. The proposed approach is based on the application of combined theories of traffic macro-simulation, MCDM/A and GDM. A case study associated with the redevelopment of a major street in a medium – sized city is demonstrated. The transportation variants are designed heuristically with the use of traffic simulation and evaluated according to the principles of MCDM/A and GDM methodologies. The decision problem considered is formulated as a multiple criteria ranking problem. In the MCA phase different multiple criteria methods are tested. The authors presents the results of computational experiments leading to the selection of the most desirable transportation solution for a selected segment of the major municipal artery.

The paper is composed of 5 sections and a list of references. The 1st section introduces into a topic considered and provides basic definitions. Section 2 focuses on the methodological background of the research. It characterizes traffic simulation, MCDM/A and GDM. The considered decision problem is defined in section 3. Computational experiments are demonstrated in section 4, while final conclusions are drawn in section 5.

2. Research methodology

2.1. Traffic simulation

Traffic simulation (Hillier, Lieberman, 2001) is “a computer program that uses mathematical models to conduct experiments with traffic events on a transportation facility or system over extended periods of time”. It can describe the entire transportation system (e.g. urban, regional or national) or its selected part or component, such as: several intersections, a motorway segment and/or a roundabout. The simulation model consists of two mutually interrelated components, i.e.: information on demand that characterizes the passengers’ travel needs and information on supply that describes transportation network. Depending on their accuracy and scope the simulation models can be divided into (Liebermann & Rathi, 1997): micro- meso- and macro-simulation models.