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Sustainability of large urban transport structures in terms of traffic and environment

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Abstract

The paper attempts to explain the impacts of large transport structures on the traffic quality and urban environment, in terms of the sustainability of these structures in the long term decades. Such effects can be expressed e.g. via travel time and speed, the length of congestions and time delays, number of stoppings, fuel consumption, location and amount of pollutants produced. The rating is based on the application of mathematical models working with data measured throughout the city, using strategic detectors and floating cars, or test drives. One of the models is the estimation of fuel overconsumption due to reduced travel speed e.g. in congestions, as well as a model determining the delay costs due to traffic situation. Models and measurement data enable to compare the situation before the construction and after implementation of the structures. The method is demonstrated in the case of the Blanka tunnel complex on City Ring Road, which was opened in September 2015.

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1. Introduction

There is no doubt that large transport constructions affect greatly both the quality of transport and the city environment. E.g. in connection with the completion of the tunnel complex Blanka in Prague (autumn 2015), traffic conditions have changed as well as transport related habits of drivers. The goal of the ongoing research is the

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systematic monitoring of changes in traffic not only in terms of traffic flow change, but in terms of sustainability where it is necessary to monitor changes in the quality of traffic. In the first stage of the research, a global transport model is being created, based on real measurement from strategic detectors. In addition to evaluating traffic at these spots, one part of the research is focused on evaluating the quality of driving on routes where there it is possible to choose between driving through a tunnel or on the surface.

This paper highlights the change of thinking that is increasingly reflected in connection with the tunnel constructions in the International Committee D.4 "Road Tunnel Operation" of PIARC World Road Organization and other similarly large transport constructions. Ten years ago, all efforts concentrated on constructing and technological issues, i.e. purely technical questions. The recent change of thinking is related to the concept of sustainability, where the scientific methods of investigating the social, environmental and economic impacts of tunnel construction in the long term horizon are used and thus the usefulness of the construction is evaluated.

2. Evaluation of sustainability

The principle of sustainability assessment is based on the creation of a global city model based on multiple methods of data measurement. Models and measured data enable to compare the situation before the implementation of construction and after commissioning. Mathematical models are working with data measured throughout the city, so far using strategic detectors and floating cars, or test drives. Above all detectors, categorization of traffic quality is introduced that is transformed into fuel consumption (expressed in financial equivalent). The proposed methodology allows to create a pricing model that expresses the travel costs along the network of detectors. Based on the evaluation of fuel overconsumption due to the inferior quality of service (e.g. due to congestion), it is then possible to create a pricing model for transportation.

2.1. Measured data processing and traffic quality categorization

In Prague, there are more than 150 profile strategic detectors, followed by section detectors and other detectors. A user software tool was designed for the analysis, in an accessible programming environment Tableau Desktop™ version 10 allowing visualization and further processing and interpretation of data [5]. The software also allows export of the final report to be viewed without linking to the original database. This tool was developed and implemented in a period of about two months. Classification of traffic quality (Level of Service, LOS) is set in four categories A-D of city traffic operation according to the speed:

- **A** – Slow-moving or stationary queue (speed below 10 kph);
- **B** – Saturated flow – rapidly moving queue (10-25 kph);
- **C** – Unstable state – clusters of vehicles without greater possibility of overtaking (25-45 kph);
- **D** – Free and almost free traffic flow (speed above 45 kph).

2.2. Global Pricing Model – The correlation between fuel consumption and traffic parameters

In dozens of articles models and computational methods are described for finding links between traffic parameters, vehicle parameters, external atmospheric conditions and the production of harmful substances, or the fuel consumption of vehicles. Grote [1] deals with the prediction of pollutants in cities, thus in complex topologies. Based on an extensive analysis of the literature, Grote shows that the more complex a model describing production of harmful substances is, the more probable a prediction error may be.

Practical field measurements [2] describe parameters influencing fuel consumption of the vehicle, and thus emissions. These are categories of vehicles, weight, engine power, aerodynamics and so on. Then there is the character of the roads, their quality, longitudinal gradients, width, altitude... Significant is the impact of weather, wind speed and direction, humidity... Finally it is inferred that the number of parameters changes so that they partially compensate each other (longitudinal positive and negative gradient, changes in the weather) or could not be more clearly expressed (vehicle categories).