SLOVENSKO DRUŠTVO ZA ZNANOST V PROMETU

IN

FAKULTETA ZA POMORSTVO IN PROMET
UNIVERZE V LJUBLJANI

10. MEDNARODNO POSVETOVANJE O PROMETNI ZNANOSTI

10TH INTERNATIONAL CONFERENCE ON TRAFFIC SCIENCE

12)

ICTS 2006

PROMET IN GLOBALIZACIJA

TRANSPORTATION AND GLOBALIZATION

ZBORNIK REFERATOV

CONFERENCE PROCEEDINGS

6. – 7. DECEMBER 2006
PORTOROŽ, SLOVENIJA

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

656(063)(082)(086.034.4)

MEDNARODNO posvetovanje o prometni znanosti (10 ; 2006 ; Portorož)
Promet in globalizacija [Elektronski vir] : zbornik referatov = Transportation and globalization : conference proceedings / 10. mednarodno posvetovanje o prometni znanosti = 10th International Conference on Traffic Science - ICTS 2006, 6.-7. december 2006, Portorož, Slovenija ; [organizirala] Slovensko društvo za znanost v prometu in Fakulteta za pomorstvo in promet Univerze v Ljubljani ; [uredniki Marinna Zanne, Daša Fabjan, Peter Jenček]. - Portorož : Fakulteta za pomorstvo in promet, 2006

ISBN-10 961-6044-80-X
ISBN-13 978-961-6044-80-6
1. Gl. stv. nasl. 2. Vzp. stv. nasl. 3. Zanne, Marina 4. Fakulteta za pomorstvo in promet (Portorož) 5. Slovensko društvo za znanost v prometu
230290688

Založila: Fakulteta za pomorstvo in promet Portorož, 2006
Uredniki: Marina Zanne, Daša Fabjan, Peter Jenček
Naklada: 150 izvodov

SPEED-FLOW REGRESSION MODELS FOR INTERRUPTED TRAFFIC STREAM: A CASE STUDY

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ABSTRACT

This paper describes a regression "speed-flow" developed within the 2U2SBILOSAT (Uniform Urban Street Segment BImodal Level Of Service Analysis Tool) calibration process. The defined models are a result of the evaluation of a wide range of measurements' data processed by mathematical and statistical methods.

The results revealed that the "speed-flow" curves are useful tool in traffic operational performance evaluation and bimodal (passenger cars and heavy vehicles) Level Of Service assessment and analysis.

1 INTRODUCTION

Models of the relationship between the basic flow parameters resulting from traditional traffic counts are an approximation in order to reflect the quality of the traffic flow. Each mode in the heterogeneous traffic flow has its own strengths and weaknesses concerning capacity, flexibility, energy consumption, safety and environmental impact. The Level Of Services-LOS associated to different traffic conditions as well as different vehicle modes can be defined using these models. For the description of the characteristics and the quality of traffic flow several methods can be found in the international literature. Highway Capacity Manual - HCM, is the primary tool used for capacity and LOS analysis and the design of highway (rural and urban) facilities.

In the following sections analysed urban street network and traffic conditions are presented, relevant literature is reviewed and summarized. As it is recommended in a waste majority of literature, a real-life data has been used.

The objective of this paper is to develop and present speed-flow regression models for passenger cars and heavy vehicles in the interrupted traffic stream. In particular, a relationship between parameters is investigated based on empirical data, which relationship has so far been ignored in the HCM method.

2 LITERATURE REVIEW

Several research papers and authors have focused on the issue for basic flow parameters relationship modelling. A time-dependent speed-flow model modified form of Davidson's function, referred to as Akcelik's function in the literature [1], has been used in the Highway Capacity Manual-HCM travel speed model for urban street [2]. Namely, these are called uninterrupted flow models applicable to mid-block travel conditions. Skabardonis & Dowling (1997) recommended a separate curve called "Updated BPR Curve", for arterials speed determining [3]. More recently, Akcelik's time-dependent speed-flow model based on queuing theory concepts [4], has been used to develop alternative versions of the HCM speed-flow models for urban streets. The model developed by Centre for Transportation Studies-CTS in Singapore requires only two input parameters: intersection spacing and minimum signal delay. The CTS model is useful for planning applications as it does not require the input of detailed signal timing data. Details of this study are given in Fan et al. (1995) and Lum et al. (1998). There has been a wealth of European researches into traffic flow modelling. In Hungary for example, developed speed-flow curves are in function of the vehicle type and considering whether it runs freely or in a platoon [5].

3 MEASUREMENTS AND DATA ASQUISING

Since, the general objective of this paper is to develop and present speed-flow regression models for passenger cars and heavy vehicles separately in the interrupted traffic stream, the measurements and data squishing were established on the urban street network under study, (figure 1) by conducting two different studies.

- **Speed study**: Travel time and vehicle delay case study (a method of an average passenger and heavy vehicle);
- **Volume study:** Passenger cars and heavy vehicle flows case study.

On the base of volumes and speed measured, the following data were determined:

- Signalized intersection approach through lane volumes per vehicle types
- Mid-block urban street volumes per direction as well as per vehicle types
- Average travel speed for passenger cars
- Average travel speed for heavy vehicles

The analysed urban street network, (figure 1). consists of several arterials (Urban streets number 1,2,4) and collector streets (Urban streets number 3,5). It's a quite dense central business district network which design standards and technical conditions are not significantly improved during the past decades.

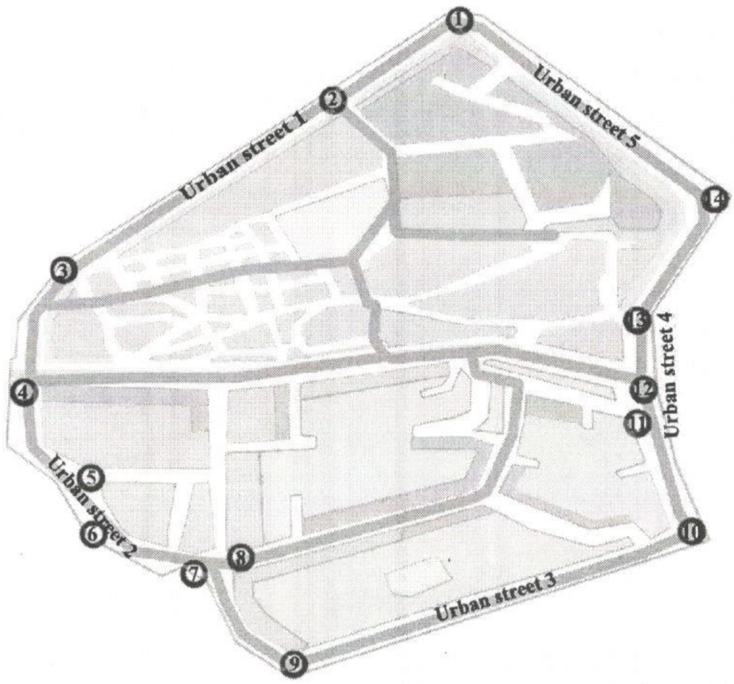

Figure 1: Analysed urban street network

3.1 Speed study

Aiming to define average vehicle travel speed a detailed studies for running times, travel times and delays has been performed. Based on the general purpose, which means to develop a speed – flow curves, separately for passenger cars and heavy vehicles, a passenger test vehicle and heavy test vehicle were used. They were running on the sections under study at the sae peak hour, as well as traffic conditions. According to the literature reviewed, exactly six (6) test runs for both directions has been made.

3.2 Volume study

Considering a reference literature (MUTCD), study was performed in a peak hour with 15-minutes tabulation periods. Data were counted manually, with fourth (40) people counters at the fourteen (14) locations, (see figure 1), four (4) signalised intersections (see figure 1, locations 1, 3, 9, 10) and ten (10) driveways (access points). Depending upon the study purpose, data were classified into vehicle types, directions and turning movements.

4 RESULTS: DEVELOPED SPEED-FLOW REGRESSION MODELS

The speed-flow regression models $S_A = f(q,q')$ was determined by using the least squares method, and multiple regression method. It has been obtained for Passenger Cars-PC and Heavy Vehicles-HV separately for each of the urban streets. It's parabolic in shape and is as shown in Eq. (1) below.

$$S_A = a + bq + cq'^2 \quad (1)$$

Where:

S_A - average travel speed (km/h)

q - approach through lane volume (input urban street volume), (veh/h)

q' - mid-block volume / direction (output urban street volume), (veh/h)

a, b, c - regression function parameters

The parameters of regression functions as well as the speed-flow relationship coefficients of corelation are shown in Table 1 for passenger cars and in Table 2 for heavy vehicles.

Table 2: The parameters of regression functions and the coefficients of corelation for speed-flow relationship for PC

Analysed Urban Street N°	*Regression Function Parameters*			*Corelation Coefficient*
	a	*b*	*c*	*R*
Urban Street 1	24.07	-1.073	0.993	0.861
Urban Street 2	57.70	-0.112	-0.072	0.925
Urban Street 3	48.52	0.238	0.349	0.627
Urban Street 4	52.39	-0.056	-0.081	0.950
Urban Street 5	54.20	0.506	-0.651	0.707

Table 2: The parameters of regression functions and the coefficients of corelation for speed-flow relationship for HV

Analysed Urban Street N°	*Regression Function Parameters*			*Corelation Coefficient*
	a	*b*	*c*	*R*
Urban Street 1	17.56	-0.074	0.044	0.940
Urban Street 2	38.47	-0.076	-0.047	0.925
Urban Street 3	32.43	0.159	-0.234	0.759
Urban Street 4	34.78	-0.037	-0.054	0.918
Urban Street 5	36.01	0.338	-0.434	0.707

Namely, each regression speed-flow model presents a so called surface, consisting of geometric and traffic characteristics which in a way has an impact on the average vehicle travel speed as a primary LOS Measure Of Effectiveness-MOE, as well as on the input and output urban street volume values.

Speed-flow relationships (surfaces) are prepared and presented in Teechart Office for Windows and Linux. Taking into consideration measured or observed traffic data (input and output 15-minutes hourly volumes), curves were fitted onto the points represented into the 3D charts, (figure 2-6).

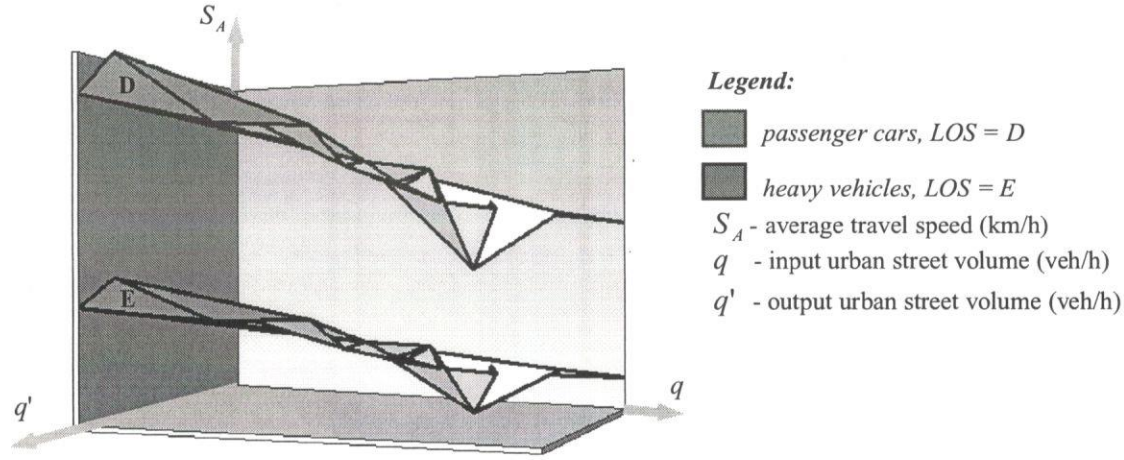

Figure 2: Speed-flow regression model for PC and HV on the Urban Street 1

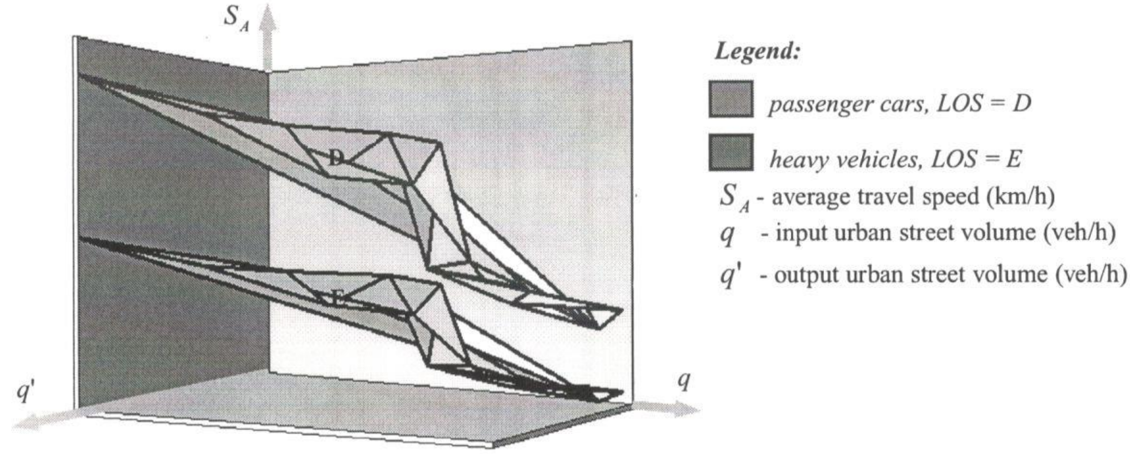

Figure 3: Speed-flow regression model for PC and HV on the Urban Street 2

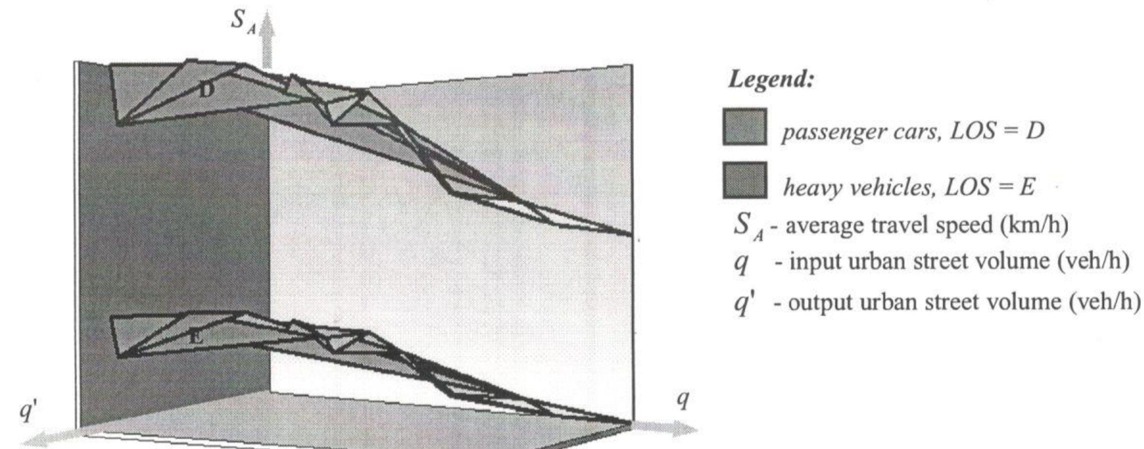

Figure 4: Speed-flow regression model for PC and HV on the Urban Street 3

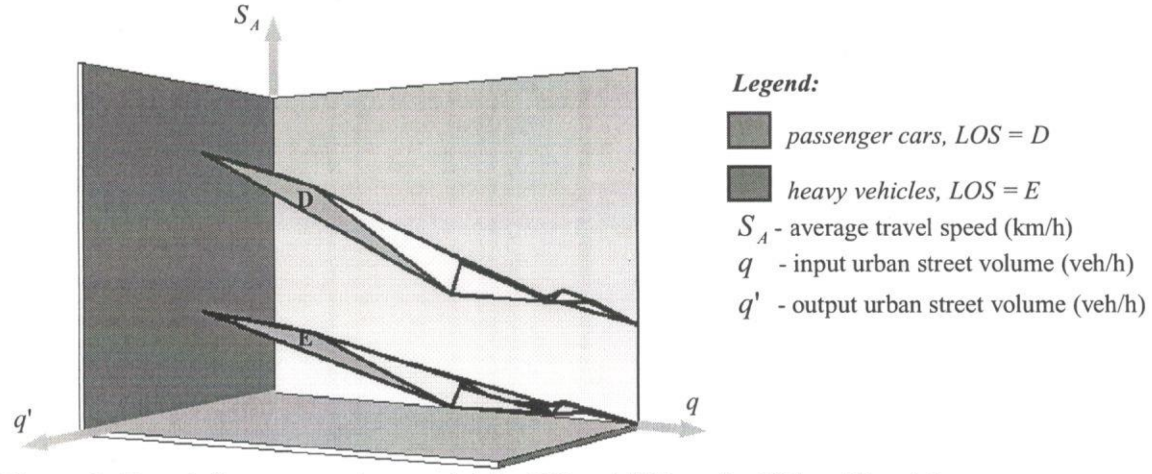

Figure 5: Speed-flow regression model for PC and HV on the Urban Street 4

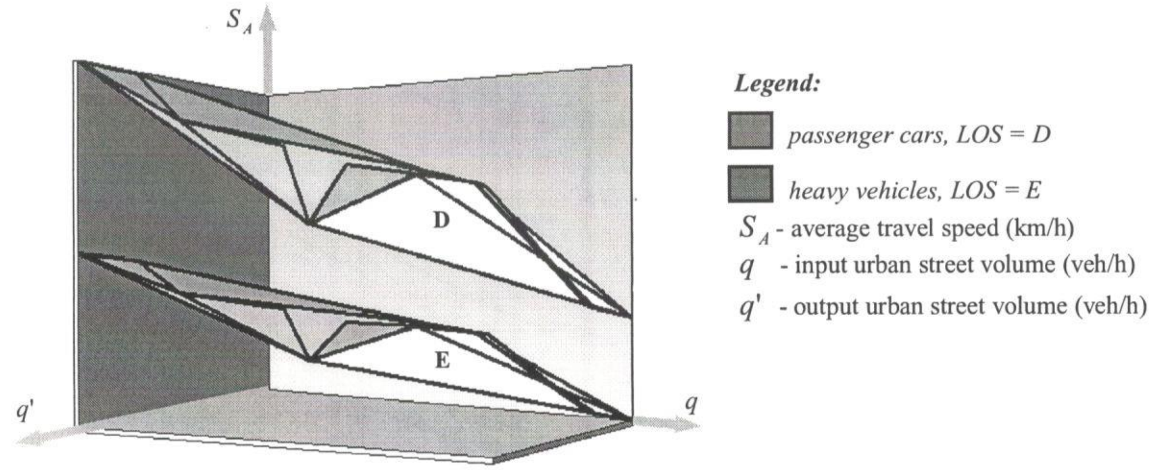

Figure 6: Speed-flow regression model for PC and HV on the Urban Street 5

5 CONCLUSIONS

For the speed-flow regression models development, as well as for the Uniform Urban Street Segment BImodal Level Of Service Analysis Tool for Windows - 2U2S BILOSAT verification, validation and calibration process, an extensive analysis of the real system has been done (streets in an urban zone of interest). Several parameters with a significant influence on the capacity and LOS of urban streets have been suitably measured, analysed and modelled. According to the waste majority of literature this work presents that the hourly traffic volume and the average travel speed calculated from traditional data of traffic counts could be related only approximately to the quality of the traffic flow.

Since, the drivers appreciate the quality of traffic flow (LOS) on the base of their actual impressions on the situation experienced nearby which differ for different geometric and traffic conditions, in the case study PC's and HV's category (traffic mode) were distinguished.

To reflect the relationship a parabola determined by the method of the least square was fitted to the data, and moreover presented as a 3D surface's for PC's and HV's separately, demonstrated that the urban street geometric and traffic conditions has it's weak or significant impact on the LOS felt by the vehicle modes. The results revealed that the "speed-flow" curves are useful tool in traffic operational performance evaluation and bi-modal (passenger cars and heavy vehicles) LOS assessment and analysis.

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