Abstract

From Theory to Practice – Modern Freeway Traffic Analysis

Werner Brilon[1]

Ruhr-University Bochum, Germany

Traffic analysis methods for freeways – both from the practical point of view (like HCM 2010) and on the background of theory based methodologies - treat investigations of stretches of freeways and of elements of intersections as separate approaches. They do not consider the interaction between both kinds of elements. In reality problems on freeway do, however, arise mainly in the metropolitan areas where the interaction between adjacent freeway elements determine the capacities at bottlenecks. Thus, the evaluation of interaction effects is of crucial importance for the determination of adequate freeway system layout.

Moreover, the conventional guideline-oriented methodology considers only the evaluation for one peak hour. Another limitation is the fact that guidelines operate only with one set of parameters for capacity and speed-flow curves. In reality there is, however, a large variability of freeway traffic flow characteristics where performance is differing both form place to place and over time. Finally, one handicap is also that the deterministic models do not handle performance assessment for times of temporary oversaturation.

Therefore, theoretically sound methods for the evaluation of traffic performance for freeway facilities should include:

- Integrated models for the interference of freeway sections and elements of intersections (like weaving sections, on- and off-ramps) and interchanges over longer parts of the freeway network.
- Realistic models for closely separated intersections and variable number of lanes.
- Response to driver's strategies regarding choice of lanes and speeds.
- Flexibility to allow for site specific traffic flow characteristics.
- Analysis of transient dynamic effects including oversaturation.
- Performance estimated under freeway lifetime aspects or, at least, over one year.
- Assessment of traffic reliability.
- Trade-off between freeway performance and cost of infrastructure, maintenance, and operation, including effects of oversaturation.
- Utilisation and integration of theoretical concepts which are available for these different aspects

To address these targets several projects have been performed in Germany in recent years both on the background of research and practical application as well. The paper gives an overview about these projects and the experience gained.

The projects mentioned in the paper can be characterized as following:

- Decision about the optimal layout for widening a 10 km long section of the autobahn A7 in the north of the city of Hamburg from 3 lanes to 4 lanes with additional auxiliary lanes between the closely separated intersections.

---

[1] Prof. (em.) Dr.-Ing. Werner Brilon - Ruhr-University Bochum - D – 44780 Bochum, Germany
werner.brilon@rub.de

- Decision of the minimal configuration of the autobahn A620 in the centre of the city of Saarbruecken with conversion of the existing urban motorway into a tunnel together with a rearrangement of interchanges.
- Assessment of plans to modify the joint guidance of A45 and A66 over 4-lane weaving sections of 2 km length for both directions with a variation of different on-ramp configurations.
- Research for different ramp metering algorithms (ALINEA versus pre-active algorithms).
- Research on closely separated motorway interchanges.

Of course, these projects will not be described in each detail. Instead, the methods which have been applied are compared:

- Deterministic calculations by guideline methods (using HBS, the German HCM)
- Microscopic simulation using the program system BABSIM. Analysis was based on an exploration of the local driving characteristics at each site which resulted to capacities larger then guideline figures. Therefore, there must be procedures to calibrate the simulation model to fulfil locally observed macroscopic parameters. This is a way to represent traffic performance – especially in areas with closely separated exits and entries – over a couple of hours. Limits and restrictions of model composition are mentioned. Here e.g. the need for a remarkable model flexibility must be mentioned, since parameters of driver behaviour may change within very short distances. Also the non-stationary driver behaviour is an essential to model typical effects like random breakdown. On the other hand microscopic simulation models do never cover the whole range of real life traffic flow variability.
- For purposes of comparison also the US-program FREEVAL has been applied to some cases. To get realistic results, a rather low capacity had to be applied. Unfortuntely, it reveals only deterministic performance parameters for one time period.
- Macroscopic analysis in form of a cell-transmission-type model: The model is extended to a whole year analysis (WAY) with cells of small dimensions both in space and in time.

  The whole year analysis is based on the stochastic concept of freeway capacity. It applies a rather simple macroscopic model of traffic flow where the parameters are treated as random variables with predetermined distribution functions. Their means and standard variations are based on the analysis of large samples of macroscopic data. E.g. the capacity itself is treated as a Weibull-distributed variable. The effects of accidents, incidents, and weather can be included using stochastic approaches based on literature and on local experience. For each run a set of realizations for capacity, incidents etc. is generated by random numbers. Also the traffic demand over a longer period, e.g. one year is modelled based on existing studies of traffic demand patterns over time including daily, weekly, and yearly patterns as well as random fluctuations.

  Confrontation of demand and capacity provides quantitative insights for traffic performance at each instant in space and time. The distribution of traffic states over space and time is modelled by a specific cell transmission model which is fully described in the paper. The model offers the potential to be run for extended parts of the freeway network for a whole year within short computer time (some minutes) on a normal PC. Thus, it is possible to repeat this kind of calculation for several years within reasonable time to estimate an average pattern of traffic performance over the year.

  The results encompass time consumed by road users, number and durations of congestions, amount of drivers concerned by congestion, etc. These are figures which can be compared to funds which are needed to establish a specific set of infrastructure extensions as well as

of organizational improvements. For each run the influencing effects like accidents, weather etc. can be switched on and off to study the impact of these factors. The paper describes this model in some detail.

For the application of these models a couple of conditions had to be accounted for, especially the relations of capacity distributions to the size of cells – both in space and in time. The theory behind these relations is discussed in the paper. Also some more, still undefined theoretical questions should be answered in the future.

The method is extended to a state-wide freeway performance assessment tool (complex computer program) which has been developed to estimate delays to drivers on the freeways all over the state. The model takes into account: random capacities of all freeway sections, impact of accidents, incidents, weather (only rain), and – of course – freeway layout. By changing the layout in detail the effects of these modifications can be evaluated. Here, also details of freeway operation – like strategy of workzone arrangements, incident treatment, etc. – can be entered into the system to study improvements in organization and their impacts for freeway performance. Thus, this tool establishes a WYA for a 2000 km long freeway network.

The paper, of course, can not describe all the projects mentioned in detail. Only some remarks and examples for results are given. The paper is more concentrated on the conclusions for the combined application of instruments for freeway traffic assessment. As one basic conclusion for practice, the combination of all three kinds of methods should be applied for responsible decisions in freeway planning, design, and operation. On the other hand, each kind of method has also some shortcomings – based on basic essentials and on unexplored features of the specific method. Thus, also a need for further developments is pointed out.