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Enhancing Driver Performance: A Closed Track Experiment

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Abstract

Signalized intersection operations are important for urban mobility, safety, travel times and environmental issues. Saturation flow rate and start-up lost time are two of the most important parameters when it comes to calculating signalized intersection capacity. Consequently, it is not surprising that countless studies have aimed towards estimating saturation flow rates and start up lost times at signalized intersections. Reports on saturation flow rates reveal large variations between different cities and countries. Values of 1800-2000 veh/h are common, but ranges from 1500-2500 veh/h have been observed. Driver performance is often regarded to be a result of the prevailing conditions, such as intersection geometry, grade, vehicle attributes, percentage of heavy vehicles and weather. Population characteristics, degree of familiar drivers (commuters) and traffic pressure are other factors that are reported to affect flow rates and lost times. As a result, most traffic management strategies are not aimed towards enhancing driver performance. This paper takes a different approach: How can we enhance driver performance, and more specifically; to what extent can behavior change increase signalized intersection capacity? The potential efficiency gains are studied by conducting a field trial on a closed track. Unlike other studies, this paper examines individual driver performance as well as overall traffic flow.

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Keywords: driver behavior; signalized intersections; saturation flow rate; driver performance

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1. Introduction and motivation

It is reasonable to believe that in most cases, there is a gap between optimal and prevailing driver behavior. When it comes to traffic safety, several measures have been implemented in order to reduce this gap. The Norwegian design manual for traffic signals states that heavy vehicles, incline, lane width and other vehicle- and pedestrian movements may affect the saturation flow rate (Norwegian Public Roads Administration, 2014). Driver attention and motivation is not mentioned.

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Field observations have been carried out at three different signalized intersections (four different movements) in Trondheim, Norway. The results indicate that even very different movements seem to have similar headway distributions, once scaled to eliminate differences in the mean values. The slowest 10 % of the vehicles use almost 20 % of the green time, while the fastest 10 % only use about 5 % of the green time. In all four cases, the most efficient half of the drivers use only 35-40 % of the green time, leaving 60-65 % for the slowest half of the drivers. Only 1.3 % of the observed vehicles were heavy vehicles.

The observations support the idea that a significant amount of drivers display inefficient driver behavior. In one of the intersections (Sluppen), 70 % of the 30 phases included drivers with headways exceeding 3 seconds. Almost half of the phases included drivers with headways exceeding 3.5 seconds. Visual inspection of these headways clearly show that most are caused by lack of attention or motivation. A study of platoons of 20 consecutive vehicles revealed that in this same intersection, the average intra-platoon headway (for each group of 20 vehicles) ranged from 1.85 seconds to 3.0 seconds. The average headway for all vehicles was 2.3 seconds, due to narrow lanes and sharp turns.

The video footage from real life traffic revealed that drivers with large headways display at least one of the following two behavior types; long reaction time or insufficient acceleration. The results from the subsequent closed track experiments show that these inefficient behavior types can be eliminated by instructing and motivating the drivers.

2. Literature review

The saturation flow rate, *s,* is the most important single parameter for signalized intersection capacity (Akcelik, 1981) (Long, 2007). It is inversely proportional to the saturation time headway (h_s):

$$h_s = \frac{3600}{s} \quad (1)$$

The saturation time headway may also be expressed in terms of the reaction time (t_x), the jam spacing (L_{hj}) and the saturation speed (v_s) (Akcelik R. , 2008):

$$h_s = t_x + \frac{L_{hj}}{v_s} \quad (2)$$

In order to increase the saturation flow rate, one needs to influence the drivers' reaction time, jam spacing and/or saturation speed.

Anticipation of future events is a key factor in safe and efficient driving. Stahl, Donmez & Jamieson (2013), following a comprehensive discussion on the subject, define anticipatory driving in the following way:

Anticipatory driving is a high level cognitive competence that describes the identification of stereotypical traffic situations on a tactical level through the perception of characteristic cues, and thereby allows for the efficient positioning of a vehicle for probable, upcoming changes in traffic.

In accordance with the task analysis of driving by McKnight & Adams (1970), they categorize the situations based on the type of cues that may trigger the recognition of the situation in question; *Natural environment*, *Road Environment/Infrastructure* and *Other Traffic Participants*. Of course, the categories are not to be seen as mutually exclusive.

Recognizing a bottleneck in the network requires experience and knowledge: The traffic situation must be observed in order to understand the system state. The system state must be interpreted and evaluated, and an ultimate goal be identified. This goal may be converted to a target state, which requires the definition of a task. Finally the procedure necessary to obtain the target state and ultimate goal may be executed. With anticipatory driving, some shortcuts in this decision ladder may be created, as seen in Figure 1: