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Evaluating the combined effect of ramp metering and variable speed limits on the French A25 motorway

Simon Cohen[a*], David Gil[b], Zoi Christoforou[c], Régine Seidowsky[a]

[a]*University Paris-Est, COSYS, GRETTIA, IFSTTAR, F-77447 Marne-la-Vallée, France*
[b]*Cerema Nord Picardie, 44 Ter, rue Jean BART, 59019 LILLE Cedex, France*
[c]*Laboratoire Ville Mobilité Transport, Ecole des Ponts ParisTech, 6-8 Avenue Blaise Pascal, Champs-sur-Marne 77455, France*

Abstract

Despite the large body of literature on active traffic management (ATM) and post hoc evaluation, few are the studies assessing the impact of a combination of ATM strategies implemented in the field. In this paper, we present and evaluate the innovative implementation of a speed regulation scheme combined with local ramp metering. The evaluation is based on field data and the assessment criteria include travel time, travel time variability, capacity and level of service (LOS) under three regimes: (i) no control, (ii) ramp metering, and (iii) ramp metering combined with variable speed limits. Our findings confirm that ramp metering is beneficial to users and suggest that the combination of ATM measures further extends these benefits. However, travel time savings, travel time reliability improvement, and LOS gains are limited to the regulated section and do not affect downstream sections.

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Keywords: ramp metering; variable speed limits; post hoc assessment; travel time; level of service

1. Background

Urban population grows while public investments in transportation infrastructures decrease. The development of efficient road management tools is on the top of the agenda of both operators and the policy

*simon.cohen@ifsttar.fr

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makers. Active traffic management (ATM) strategies are proven, cost-effective operational measures that smooth traffic flows and increase motorway throughput during peak hours. The most well-known ATM strategies are: (i) ramp metering (RM), (ii) variable speed limits (VSL), (iii) managed lanes and, secondarily, (iv) incident detection. All four have been extensively used in motorway management schemes. Transportation agencies evaluate positively their effectiveness in terms of travel time reliability, congestion mitigation, air quality improvement, and road safety enhancement. In the US, Transportation Research Board (TRB) reports that ATM experience has been positive overall and that some of these strategies can be deployed in work zones to improve operations impacted by construction (NCHRP, 2014). A scanning study in Denmark, England, Germany, and the Netherlands revealed that quantified benefits obtained may vary from 3 to 7% for average throughput during congestion, 3 to 22% for overall capacity, 3 to 30% for primary incident reduction, and as much as 50% for secondary incident reduction (Mirshahi et al., 2007).

Numerous researchers studied the effects of ATM strategies either using field data or simulation techniques. For example, Lee et al. (2005) observed driver responses to ramp metering and the consequent traffic flow oscillations using a microscopic traffic simulation model. The simulation concerned a 14.8 km section of I-880 in Hayward, California and a hypothetical isolated on-ramp network. Results showed that ramp metering reduced crash potential by 5–37% compared to the no-control case. A second microscopic traffic simulation model was developed to evaluate traffic conditions under variable speed limits (Lee et al., 2006). The authors report a potential 5–17% crash decrease by temporarily reducing speed limits when crash potential exceeds a pre-specified threshold. Bhouri et al. (2013) used field data instead and assessed the ramp metering impact based on two indicators: traffic flow and travel time reliability on the A6W motorway in Paris. The results indicate a net enhancement in terms of travel time reliability and average travel time. Nissan and Koutsopoulos (2011) also used field data to statistically evaluate the impact of advisory VSL on motorway capacity and LOS. They found no significant impact on traffic conditions both immediately after the implementation and several months later.

On the contrary, few authors evaluate combinations of different ATM strategies and even fewer use field data to do so. Carlson et al. (2014) propose an integration of local RM with mainstream traffic flow control enabled via VSL and evaluate results using a macroscopic traffic simulator. Kamel et al. (2009) propose a control algorithm for the coordination of RM and VSL. They use the METANET macroscopic model to evaluate results and conclude that the proposed coordination improves the performance of the freeway traffic network. One of the scarce research efforts on combined effects of ATM strategies using field data can be found in Haj-Salem et al. (2014). Field trials were conducted between February and October 2008 using the ALINEA control strategy for ramp metering combined with the occasional use of hard shoulders during peaks. The reported results indicate that the coordination improves traffic conditions in a significant way compared to ramp metering only. In particular, mean speed increased by 12% and total time spent on the network decreased by 4.4%. To the best of our knowledge, the combined effect of RM and VSL strategies has not been evaluated so far using field data.

The objective of this paper is to present and evaluate an innovative implementation of simultaneous RM and VSL on a French motorway. In order to quantify the impact of ATM strategies, we statistically compare three data sets collected in situ under different control schemes: (i) no-control (NC), (ii) RM only, (iii) RM and VSL. The assessment is made upon two main criteria: (i) travel time (TT) and TT variability, and (ii) level of service (LOS). This research is useful to both researchers and operators as it provides new insight on the interest of implementing several ATM strategies on the same motorway section.

The remainder of this paper is organized as follows: section 2 offers a description of the site and the implemented strategies along with the data used; section 3 includes the evaluation for TT and LOS; section 4 summarizes major findings and presents ongoing research.