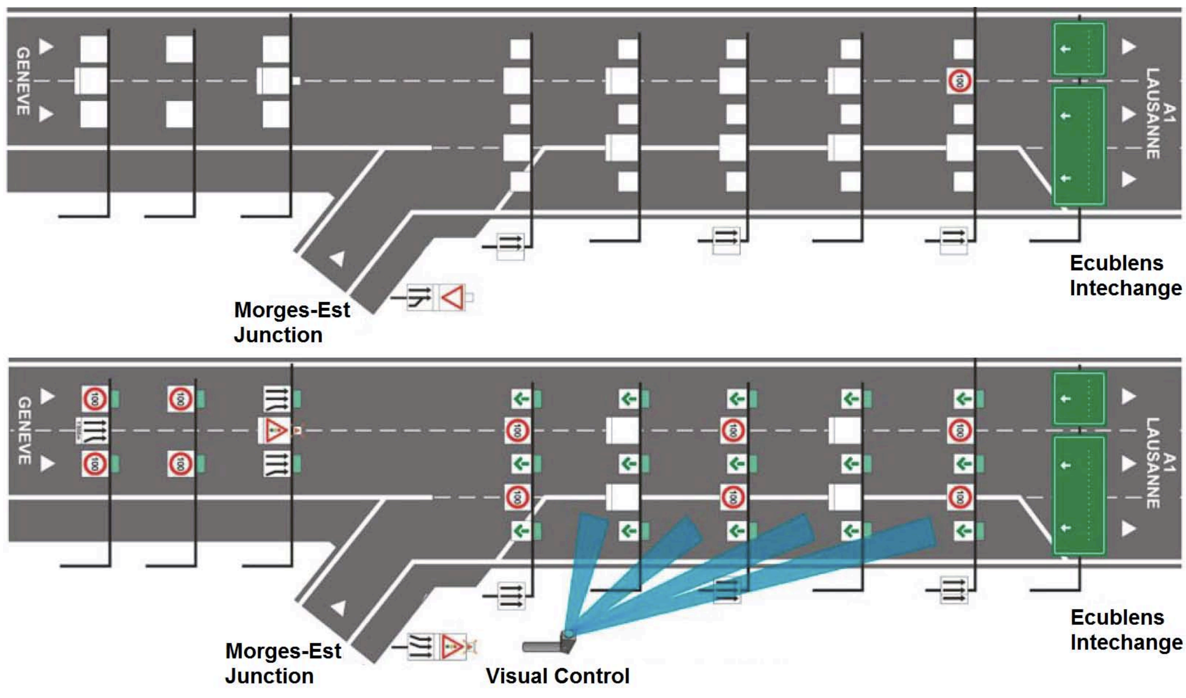

Short-term prediction models and calibration for managed lanes

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Abstract

Managed lanes systems are a recently developed traffic management scheme, aiming to alleviate the congested arteries. Hard shoulder management systems have been efficiently deployed in Europe, America and Asia. Furthermore, during the last few years, such systems have been implemented in Switzerland as strategies to address recurring peak hour congestion.

This study is focusing in optimizing a currently operational reactive emergency-lane-running system in a three-lane freeway site, located between Geneva and Lausanne (A1). Short-term prediction models were developed for this scope, i.e. to manage and potentially prevent saturation of freeway networks. A forecasting approach is presented, based on patterns for off- peak and rush-hour traffic conditions, in order to accurately capture and respond to traffic dynamics. Furthermore, the corresponding models have been implemented and calibrated with simulation methods. Different Active Traffic Management (ATM) strategies have been analyzed by applying different scenarios, and their impact on congestion occurrence and thus emergency lane operation, has been estimated. A sensitivity analysis has been pursued to assess the developed models.

Keywords
Prediction models, hard shoulder running, calibration

1 Introduction

The increase of traffic demand results in congested links at freeways. In order to avoid this phenomenon, Intelligent Transportation System (ITS) strategies have been developed as an alternative solution to the costly construction of new transportation infrastructure. One of the less expensive ITS technologies, in both financial and time terms, that has been recently emerged, is the managed lane system.

The objective of this research is to investigate the impact of a hard shoulder running system and its potential effects. Samoili *et al.* (2013a) introduced the Left Lane Flow Distribution Ratio (LLFDR) and estimated short-term prediction models using data from a hard shoulder running freeway link between Geneva and Lausanne. The Lane Flow Distribution Ratio (LFDR) is computed by the traffic flow per lane divided by the total flow per direction. A cluster analysis was also performed to derive the prevailing traffic regimes of the same study area (Samoili *et al.,* 2013b). The classification provides homogeneous groups that represent certain regimes. Regression models had been applied to the clusters, providing an improved insight of traffic conditions. The generalized linear models that have been developed, aim to predict the flow distribution per lane, using 3 and 9 minutes time intervals.

In this research, the authors aim to evaluate different scenarios, in order to assess the efficiency of the system in an horizon of 5 and 10 years. In that scope, the AIMSUN simulator was used (Barceló and Ferrer, 1997), for 'optimistic' and 'pessimistic' scenarios. The section following the introduction describes the case study setup and Section 3 describes the calibration procedure that was followed. In Section 4 the results of the simulated scenarios are analysed and in Section 5 conclusions and recommendations are provided.

2 Case Study Setup

The study area is located in Switzerland, in a two lane per direction freeway between Geneva and Lausanne (A1) with average daily traffic 82,000 veh/h. In 2010, a semi-automatic managed lane system was implemented, with a variable speed limit (VSL) system that succours for maintaining the safety requirements, addressing the issue of recurrent traffic demand increase during peak hours. The opening and closing of the managed lane is defined by speed and density thresholds. According to the technical company that undertook part of the implementation of the system (RGR Ingénieurs Conseils, 2011), the definition of the traffic regimes (in six levels) is based on the speed-density fundamental diagrams that activate the hard shoulder running and the VSL enforcement. The thresholds differ for ascending and descending directions and are computed after two successive cycles of 9-minutes measurements (aggregated by 3-minutes aggregated data). The reason is laying in the mitigation of any potential oscillations of the system when traffic state is unsettled.

In the traffic dataset that was used for the research, are included per lane disaggregated traffic data, speed, heavy vehicles percentage and indications of the opening and closure of the shoulder lane, collected by radar sensors on beams placed every approximately 500 meters. The data were aggregated per t = 3 min intervals, before proceeding to the analysis.

3 Model Calibration

In order to assess the efficiency of the system, a model of the study area was firstly developed in the aforementioned traffic simulator (AIMSUN). The model was then calibrated using real data, and indicators have been computed, such as the left lane flow distribution ratio (LLFDR), the total flow and the average speed. A three minutes time step was considered for the analysis, in order to be in accordance with the time interval of the data. The parameters of the following categories were modified in the simulator: 1) vehicle's geometry, 2) drivers' behaviour, 3) infrastructure and 4) simulation environment. The vehicle parameters (maximum acceleration, normal deceleration, maximum deceleration, length, width) could be considered invariable since they were common for all the models (the existed and those created for the purpose of this research). The last three categories of the parameters could be modified accordingly:

Simulation environment
Minimum headway: This option is by default ignored by the simulator. In our case, it has been considered as the distance between the vehicles including the lead vehicle and depends on the speed; the driver adjusts the space between his and the lead vehicle, a distance that varies depending on the speed. The headway also depends on the traffic density. The minimum distance between the vehicles is applied when the cars are in a queue.

Simulation step: The parameter depends on the response time of the users, their ability to find a space to enter in the stream or to change lanes. This lower the value is, the more possible is that a driver will find the space to enter (the capacity of the section is increased), but it renders the simulation slower.

Infrastructure:

For each section of the freeway, the distance of each zone and the distance of the ramp can be defined. Zone 1 corresponds to the link where the user begins considering his next move (e.g. change lane). If the operation is impossible, the user does not proceed. Zone 2 is the area where the user reduces his speed or stops, in order to be positioned on the corresponding lane for his next turn. The ramp distance represent the links where the lane is considered to be operating as access lane to the freeway. The users who are not intending to turn to the next intersection will therefore leave the street, starting from this distance. These time-distances vary in space and depend on the speed at a given time. Moreover, each junction has a different configuration, while each section has been adjusted in order to have different values between each other.

Driver's behavior:

Headway (minimum): This distance corresponds to the space that the driver retains between his vehicle and the one in front, after its stop. This distance has been adjusted for the queues due to the traffic lights at the exits of Crissier, Morges East and Morges West.

Give-way time: It corresponds to the time that the user in a stop begins feeling impatient and attempts to force either his entering to the stream or to change lane, in order to be able to turn. This parameters was set to zero, since in high-speed network levels as the one in question, forced by speed the user acts aggressively to impose his will to change lane to the other users.

Overtaking percentage: This parameter determines the percentage of users that stay at the right (fast) lane for an overtake. This value was set to 0.

Imprudent lane changing: This parameter determines the frequency that the vehicles change lanes in an unsafe gap. Given the flow and speeds of the study area, a high value was set. Two sub-parameters need to be defined: the percentage imprudent lane changing (compared to the number of potential imprudent lane changes, it was set at 100%) and the sensitivity to imprudent lane changing (based on the deceleration of the following vehicle, it was set at 0.6, given that a value <1 is used for underestimation and >1 for overestimation). Both sub-parameters determine the imprudent lane changing, which is regulated by the headway.

Vehicle's speed: It is constantly computed and depends on the speed limit of the section, the acceptability of the user to the legal limit (multiplier of the legal speed limit) and the dynamics of the other users (function of the car-following model for two lanes and of the lane-changing model). The car-following model for two lanes it is only applied for the overtaking vehicles. Their speed is influenced by the average speed of the vehicles moving on the right lane. Two cases were considered depending on whether the vehicle overtakes on an acceleration lane or on a normal lane. Two values of the maximum difference of speed between the user who overtakes and the average speed of the users that are undertaken, are applied.

Overtaking and undertaking percentages: They influence the decision of the user to overtake the leading vehicle. The first is a multiplier of the user's speed. If the speed of the users vehicle is greater than the speed of the leading vehicle multiplied by the overtaking percentage, the leading vehicle will undertaken. After the overtaking maneuver, if the speed of the previously leading vehicle is lower than the speed of the previously following vehicle multiplied by the undertaking percentage, the vehicle will wait.

Sensitivity factor: This scaling factor defines the perception of the deceleration of the leading vehicle. It the values are lower than 1 then the vehicle follows an aggressive behaviour, else if the values are greater than1 then it moves safer. For the models of this study, this factor was set to 0.7.

The aforementioned parameters determine the following indicators:

Distribution of traffic flow
- Overtaking percentage
- Undertaking percentage

Average speed
- Sensitivity factor (affects the variability of speeds)
- Changes reckless (affects the variability of speeds)
- Maximum desired speed (affects the free flow speed)
- Speed acceptability (affects the speed when it is lower than the free flow speed)

Average speed and total flow rates
- Simulation step
- Minimum headway
- Time in zones (1,2, ramps) of the section

The results are computed after three replications, in order to mitigate the variance error of the simulation. Comparing the vehicle's speed at the hard shoulder, it is observed that they are close to the legal limit, while the average speed in other sections is below. This could indicate that users are more reluctant to keep a temporary speed limit than a permanent. This observation applies to both sections limited to 120 km/h and 100 km/h. Attention has been paid to the calibration of the section with the hard shoulder, resulted in a representative model which was used for the simulation of the scenarios that evaluate the efficiency of the system.

4 Scenarios

The scenarios that are analyzed, examine the operation of the hard shoulder in the future, assuming different cases of traffic evolution. Two categories of scenarios were investigated: the first is based on an optimistic evolution of traffic; the traffic maintains the rate of 2010, namely 2.2% per year. The second category of scenarios assumes a significant increase in 2013 (6.0% rate), followed by a more reserved traffic rise (2.4% per year). Both groups of scenarios were examined for two different time horizons: 5 years (2017) and 10 years (2022). This was performed in order to investigate if and from which year the hard shoulder system should be running for a longer period during the day, meaning that its efficiency is decreasing.

The first simulation was performed to investigate the suitable opening time of the hard shoulder (density greater than 35 veh/km for several successive 30 seconds cycles). The second simulation is performed so as to understand when the hard shoulder must be closed (traffic density less than 32 veh/km for several successive 30 seconds cycles). The last simulation served to verify that the hard shoulder was not closed too early by the operator. In order to assess the efficiency and the performance of the hard shoulder, the density, speed and lane flow distribution were analyzed during the peak hours. Figure 1 shows the traffic states at a given time.

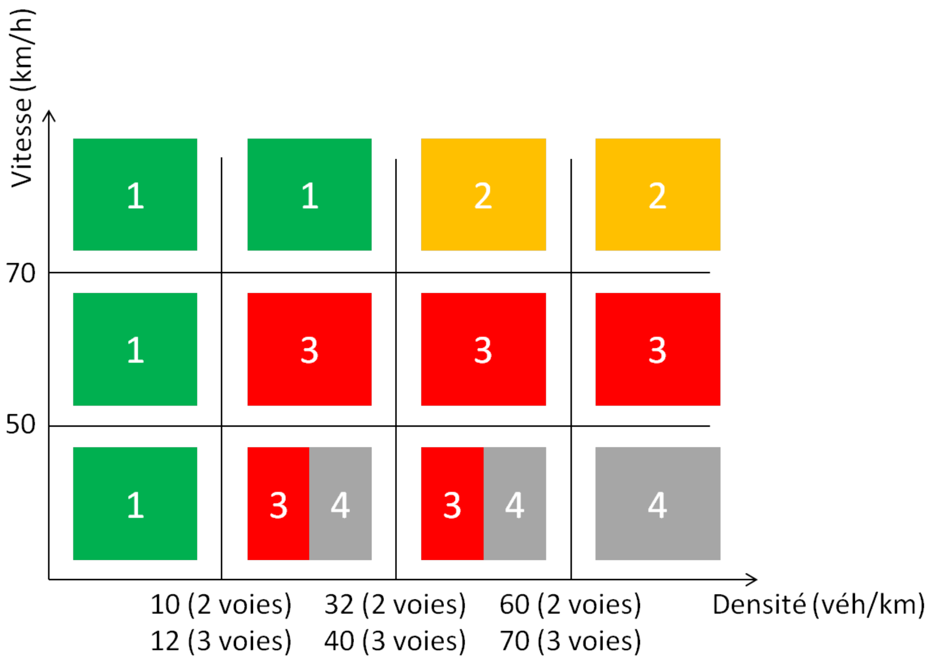
The travel time and the volume of CO emissions on the link that the system is operating, are being used for a qualitative and quantitative comparison of the different scenarios, and evaluate the sustainability of the system. For the direction to Geneva, the occupancy rate near the exit Morges-East allows to quantify the rise of the waiting queue at the traffic light and make conclusions about the adjustment of the its cycle.

Opening hours of the hard shoulder

Following the simulations, it is observed that in all scenarios the evening closing hour of the hard shoulder is the same as in the base year (2012) (Table 1). It may therefore be concluded that the current evening closing hours are extended and thus earlier closure of the hard shoulder would not have a negative impact on the traffic conditions. On the contrary, late morning closing to Geneva could be explained by the queue generated at the exit Morges-East.

Regarding the scenarios with a time horizon of 5 years, the results show that the morning opening time should be extended by 30 minutes from the base year time. The morning closing and evening opening times should remain as in 2012. In the direction to Lausanne, in the optimistic scenario, the opening and closing time of the morning are identical to those of 2012 and the opening time of the evening should be advanced by 10 minutes. However for the pessimistic scenario, the opening hour of the hard shoulder should be extended by 40 minutes, since the

Figure 1: Traffic states based on density and speed thresholds.
1-Green: Free flow, 2-Yellow: Dense flow, 3-Red:Bound flow, 4-Grey:Congestion



Source: (Dumont, 2013)

Morges-East exit is problematic; the flow instability that is formed requires the earlier opening and later closing time rather than those currently applied.

The scenarios of a time horizon of 10 years, denote that in the direction to Geneva the opening hour is the same as in the 5-year scenario. On the contrary, the morning closing time should be delayed by 30 minutes and the evening opening time should be extended by 30 minutes. Towards Lausanne, the morning opening time is suggested to be advanced approximately 20 minutes and the closing to be delayed one hour. Traffic conditions deteriorate in the afternoon, which requires an earlier activation of the system: 12h40 for the optimistic scenario, and 11h40 for the pessimistic.

Table 1: Scenarios analysis according to time horizons and system's activation hours

Base-case

	Morning peak		Evening peak	
Direction	Geneva	Lausanne	Geneva	Lausanne
Opening hour	6h59	7h11	15h56	15h57
Closing hour	9h05	9h07	19h21	19h22

Optimistic scenario - 5 years horizon

	Morning peak		Evening peak	
Direction	Geneva	Lausanne	Geneva	Lausanne
Opening hour	6h30	7h11	15h56	15h20
Closing hour	9h05	9h20	19h21	19h22

Optimistic scenario - 10 years horizon

	Morning peak		Evening peak	
Direction	Geneva	Lausanne	Geneva	Lausanne
Opening hour	6h25	6h45	15h25	12h40
Closing hour	9h30	10h30	19h21	19h22

Pessimistic scenario - 5 years horizon

	Morning peak		Evening peak	
Direction	Geneva	Lausanne	Geneva	Lausanne
Opening hour	6h59	6h55	15h56	12h50
Closing hour	9h05	9h30	19h21	19h22

Pessimistic scenario - 10 years horizon

	Morning peak		Evening peak	
Direction	Geneva	Lausanne	Geneva	Lausanne
Opening hour	6h30	6h45	15h25	11h40
Closing hour	9h30	10h30	19h21	19h22

Density and speed

Regarding the scenarios for a 5-year time horizon, the density and speed do not present a high variability. A small incident, such as a sudden braking, will not have high impact on the traffic stability. The potential instability created will be temporary, rapidly absorbed and it will not cause congestion. Nevertheless, the 10-year scenarios, indicate a large variability of the values of the observed parameters'. Even a minor incident will have a significant effect on the traffic stability; dense to bound flow will be observed, as well as frequent capacity drops and waiting queues at the ramps.

Temporary distribution of traffic conditions

The results of the 5-year scenarios in both directions reveal an increase of the dense traffic conditions, though without increase of the bound or congested states. Concerning the direction to Geneva, a dense state is observed for the half of the peak hour period, while to Lausanne, 33% of the volume is circulating under a dense state in the morning hours, while during the evening this percentage is even higher (50% at the Morges-East entry and 67% in Preverenges). The 10-year scenarios show that the congestion states are increased in both directions, and are more pronounced in the Geneva direction. Congestion is formed in the morning and afternoon for the 20% of the time period between 6am and 10am in the morning and 3pm and 8pm in the evening. For the direction to Lausanne, the frequency of this state is lower (2-3% of the time between 6am and 10am) and appear only during the morning rush hour. The congestion occurs due to the lane changes (Morge-East exit at the Geneva direction, and the interchange of Ecublens of the Lausanne direction). Nevertheless, the model could possibly overestimate the congested periods to the Geneva, due to a less efficient representation of the real traffic flow distribution. Indeed, 20% of the vehicles should be moving to the hard shoulder when open, 40% to the middle and 40% to the left (Samoili *et al.,* 2013a). However, the model underestimates the distribution to the middle and left lanes and overestimates the percentages in the hard shoulder.

Travel time

The travel variance was also examined. Table 2 shows the average variances in travel times comparing the scenarios with the base-case, from 6am to 10am, and from 3pm to 8pm. In the 5-year scenarios, the variances are between 15% and 20%, though in the 10-year scenarios, the variances are greater (between 15% and 20%), which is justified by the accumulated yearly variance.

Table 2: Travel time variance between the scenarios and the base-case scenario

	Morning peak		Evening peak	
Direction	Geneva	Lausanne	Geneva	Lausanne
Optimistic 5-years	17.4%	15.8%	15.2%	16.1%
Pessimistic 5-years	17.2%	19.4%	16.1%	17.3%
Optimistic 10-years	31.9%	31.2%	28.4%	18.2%
Pessimistic 10-years	15.5%	33.1%	17.6%	32.9%

Spillback at the Morges-East exit

The results of the 5-year scenarios show that a queue is generated at the Morges-East exit, which begins being problematic during the morning rush hour with values reaching 200 meters. Concerning the 10-year scenarios, the queue is increasing at 300 meters and lasts more than 2 hours. It is therefore mandatory to adapt the traffic increases for the next 5 years. On the other hand, in the evening rush hour, the queue is similar to the base-year. It does not exceed the 50m length and does not last more than 5 minutes maximum.

Pollutant emissions

The resulted CO emissions allow a qualitative comparison of the scenarios. The emissions assessment, normalised by the volume of traffic, was computed so as to be related to the traffic growth. When the variance of pollutant emissions becomes more significant than the traffic increase, the efficiency of the hard shoulder is decreasing. The output of all scenarios results in the conclusion that the emissions generated to the Geneva direction are greater than those to Lausanne.

Table 3: Emissions variance between the scenarios and the base-case

	Morning peak		Evening peak	
Direction	Geneva	Lausanne	Geneva	Lausanne
Optimistic 5-years	7.4%	0.4%	6.2%	1.3%
Pessimistic 5-years	5.5%	0.3%	7.1%	1.2%
Optimistic 10-years	52.0%	4.4%	15.4%	6.0%
Pessimistic 10-years	47.3%	6.0%	16.8%	6.9%

5 Conclusions and recommendations

In this study, the efficiency of a hard shoulder running freeway as a traffic regulation system is investigated. The case study that is assessed is the Morge-Ecublens part of the Geneva-Lausanne freeway in Switzerland. By examining an "optimistic" and a "pessimistic" scenario, the authors are trying to forecast the changes in the traffic conditions and measure the variance of travel and environmental indicators for the next 5 and 10 years.

The system can be assessed by analysing the traffic evolution between the operating and not-operating periods within the day. Concerning the impact of the hard shoulder on travel times, it has been observed that the most significant gains in terms of time are when the system is activated during the morning peak hour. Moreover, the link with direction to Lausanne direction is more benefited than the respective one to Geneva. This is presumably due to the effect of bounding the speed limit lower than the legal when the hard shoulder is open, which is not set in accordance by the traffic flow. However, both directions are benefited during the weekends.

The future efficiency of the hard shoulder was assessed by projecting the current situation in the future. In that scope, a model was developed in the micro-simulation platform AIMSUN (Barceló and Ferrer, 1997), and several scenarios were examined under two groups: an optimistic and a pessimistic for 5 and 10 years time frame. The results indicate that the hard shoulder will fulfill its major role, namely to preserve the emergence of congestion at low frequency, with the condition that the activation time the system will be extended. The system's performance remains satisfactory, since the proportion of the dense traffic regimes remains in similar levels as in the base-year. Based on the scenarios prediction for 2022, the efficiency of the hard shoulder will be reduced for the direction to Lausanne and it will be more significant towards Geneva, with lane changes as the main cause of the appearance of this effect. Concerning the link with direction to Lausanne, the congestion regimes last for 1 to 2% of the rush hour time. Moreover, the hard shoulder is open longer within the day. It is noted that safety issues may be arisen, since the absence of the functional hard shoulder during the activation of the system will be proved to be prejudicial. To the Geneva direction, it is observed that the proportion of time that the links are congested will reach 25% during the rush hour.

It should be noted that the results of the micro-simulation scenarios are based on assumptions imposed on the modeling area. It was considered that the an existing bottleneck in Crissier has been resolved. The results give an approximate image of the remaining sustainability of the traffic management system. Traffic evolution assumptions have been considered for the simulation of the scenarios in time. Finally, the analysis is focused on the increased percentage of traffic and not the individual daily traffic.

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A Appendix

Figure 2: Time vs. Density - morning peak hour.
The blue line represents the observed values and the red the simulated

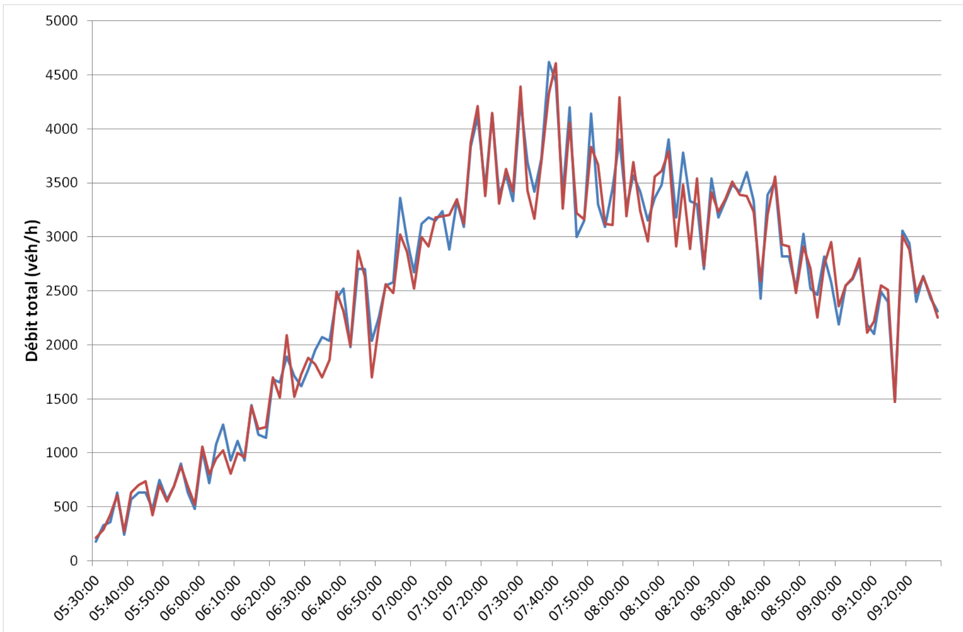

Figure 3: Time vs. Speed - morning peak hour.
The blue line represents the empirical values and the red the simulated

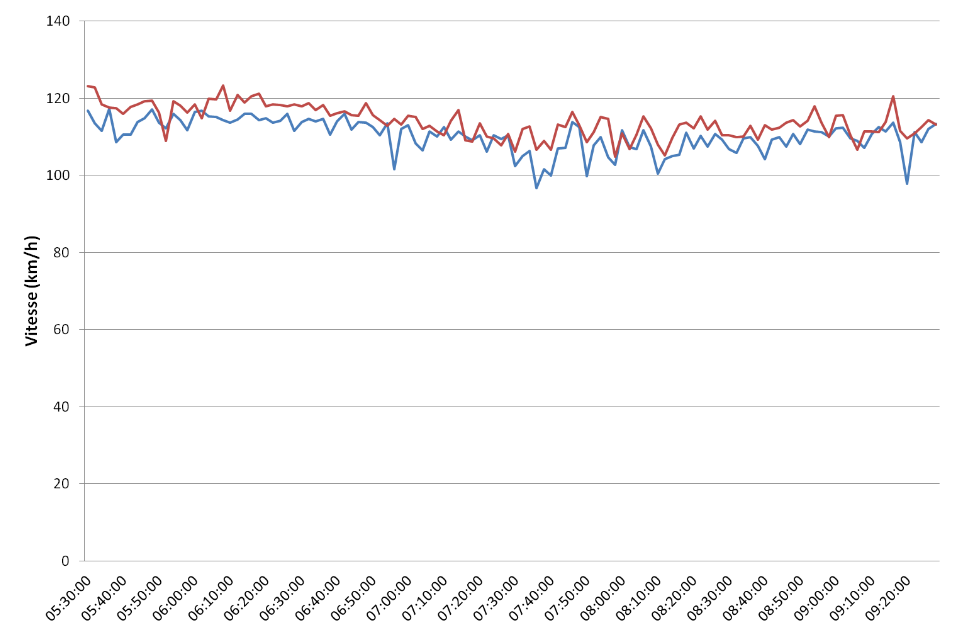

Figure 4: Lane flow distribution.
Green: left lane, Red: median lane, Purple: Hard Shoulder.
Dotted lines: simulated values, Continuous lines: empirical values

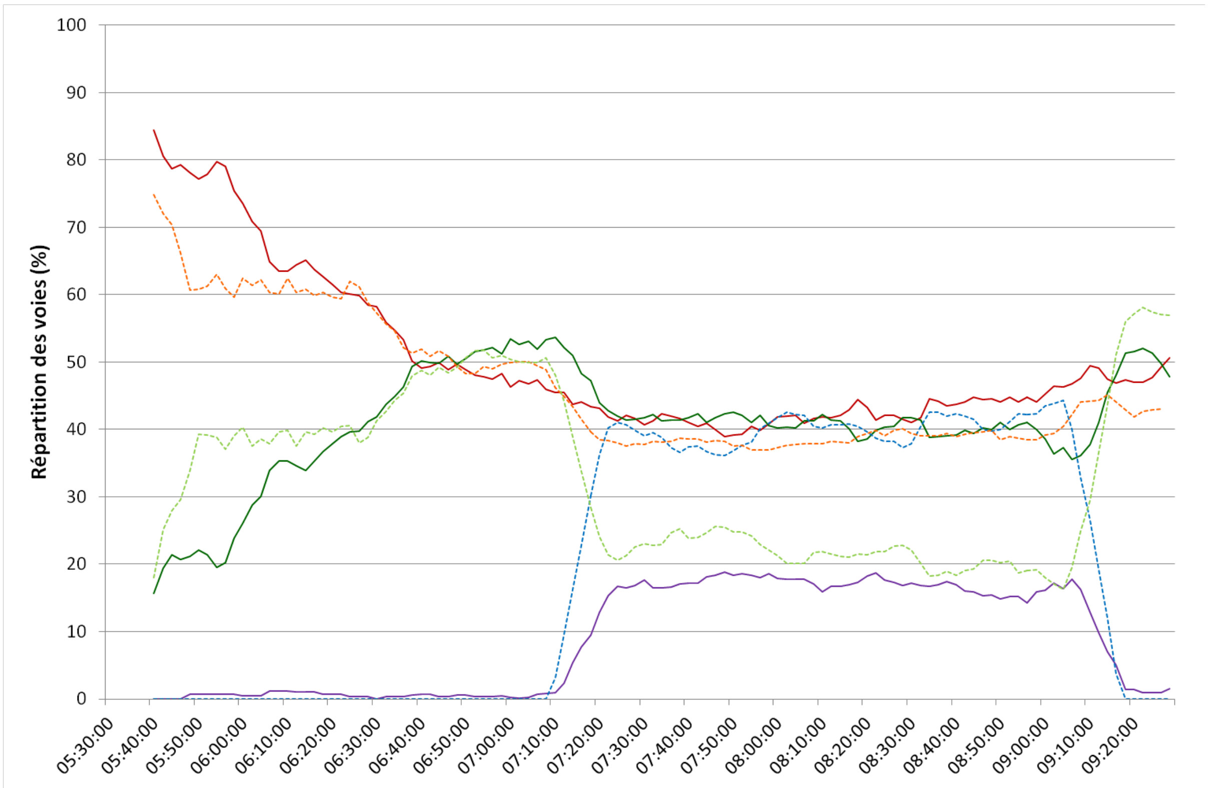

Figure 5: Simulated values for morning peak hour

	Default value	Morning peak hour	
		Direction Geneva	Direction Lausanne
Overtaking percentage	94 %	90 %	30 %
Undertaking percentage	99 %	99 %	90 %
Sensitivity factor	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1	Mean = 0,95 St.Dev.= 0 Minimum = 0,95 Maximum = 0,95
Imprudent lane changing	100 %	100 %	100 %
Sensitivity for imprudent lane changing	1,1	0,6	0,95
Max desired speed (km/h)	Mean = 140 St.Dev.= 12,9 Minimum = 58 Maximum = 210	Mean = 130 St.Dev.= 12,9 Minimum = 90 Maximum = 140	Mean = 130 St.Dev.= 12,9 Minimum = 90 Maximum = 140
Speed acceptance	Mean = 1,1 St.Dev.= 0,1 Minimum = 0,9 Maximum = 1,3	Mean = 1,15 St.Dev.= 0,05 Minimum = 0,95 Maximum = 1,2	Mean = 1,1 St.Dev.= 0,05 Minimum = 0,95 Maximum = 1,2
Simulation step (sec)	0,5	0,5	0,5
Min distance between vehicles (sec)	Mean = 0,85 St.Dev.= 0,46 Minimum = 0,1 Maximum = 2	Mean = 0,85 St.Dev.= 0,46 Minimum = 0,1 Maximum = 2	Mean = 0,71 St.Dev.= 0,46 Minimum = 0,5 Maximum = 2
Sensitivity factor for HV	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1
Imprudent lane changing for HV	100 %	100 %	100 %
Sensitivity for imprudent lane changing for HV	1,1	0,6	1
Max desired speed for HV (km/h)	Mean = 92 St.Dev.= 12,3 Minimum = 75 Maximum = 129	Mean = 92 St.Dev.= 12,3 Minimum = 75 Maximum = 129	Mean = 92 St.Dev.= 12,3 Minimum = 75 Maximum = 129
Speed acceptance for HV	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1	Mean = 1,1 St.Dev.= 0,05 Minimum = 0,95 Maximum = 1,2	Mean = 1,1 St.Dev.= 0,05 Minimum = 0,95 Maximum = 1,2
Min distance between vehicles for HV (sec)	Mean = 1,02 St.Dev.= 0,46 Minimum = 0,1 Maximum = 2	Mean = 1,02 St.Dev.= 0,46 Minimum = 0,1 Maximum = 2	Mean = 1,02 St.Dev.= 0,46 Minimum = 0,1 Maximum = 2
No. of considered vehicles of car following model for 2 lanes	4	10	10
Distance max (car following for 2 lanes) (m)	100	100	100
Max speed difference (km/h)	50	10	10
Max speed difference for on-ramp(km/h)	70	10	10
Time reaction at stop (sec)	1,35	1	1
Time reaction at traffic light (sec)	1,35	1	1
Model for on-ramps	Cooperative mode looking gaps upstream	Cooperative mode looking gaps upstream	Cooperative mode looking gaps upstream

Figure 6: Simulated values for evening peak hour

	Default values	Evening peak hour	
		Direction Genève	Direction Lausanne
Overtaking percentage	94 %	90 %	30 %
Undertaking percentage	99 %	99 %	90 %
Sensitivity factor	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1	Mean = 0,95 St.Dev.= 0 Minimum = 0,95 Maximum = 0,95
Imprudent lane changing	100 %	100 %	100 %
Sensitivity for imprudent lane changing	1,1	0,8	0,95
Max desired speed (km/h)	Mean = 140 St.Dev.= 12,9 Minimum = 58 Maximum = 210	Mean = 125 St.Dev.= 12,9 Minimum = 90 Maximum = 140	Mean = 130 St.Dev.= 12,9 Minimum = 90 Maximum = 140
Speed acceptance	Mean = 1,1 St.Dev.= 0,1 Minimum = 0,9 Maximum = 1,3	Mean = 1,1 St.Dev.= 0,05 Minimum = 0,95 Maximum = 1,2	Mean = 1,1 St.Dev.= 0,05 Minimum = 0,95 Maximum = 1,2
Simulation step (sec)	0,5	0,5	0,5
Min distance between vehicles (sec)	Mean = 0,85 St.Dev.= 0,46 Minimum = 0,1 Maximum = 2	Mean = 1,1 St.Dev.= 0,46 Minimum = 0,5 Maximum = 2	Mean = 0,71 St.Dev.= 0,46 Minimum = 0,5 Maximum = 2
Sensitivity factor for HV	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1
Imprudent lane changing for HV	100 %	100 %	100 %
Sensitivity for imprudent lane changing for HV	1,1	0,8	1
Max desired speed for HV (km/h)	Mean = 92 St.Dev.= 12,3 Minimum = 75 Maximum = 129	Mean = 92 St.Dev.= 12,3 Minimum = 75 Maximum = 129	Mean = 92 St.Dev.= 12,3 Minimum = 75 Maximum = 129
Speed acceptance for HV	Mean = 1 St.Dev.= 0 Minimum = 1 Maximum = 1	Mean = 1,1 St.Dev.= 0,05 Minimum = 0,95 Maximum = 1,2	Mean = 1,1 St.Dev.= 0,05 Minimum = 0,95 Maximum = 1,2
Min distance between vehicles for HV (sec)	Mean = 1,02 St.Dev.= 0,46 Minimum = 0,1 Maximum = 2	Mean = 1,02 St.Dev.= 0,46 Minimum = 0,1 Maximum = 2	Mean = 1,02 St.Dev.= 0,46 Minimum = 0,1 Maximum = 2
No. of considered veh., car following model for 2 lanes	4	10	10
Distance max (car-foll. for 2 lanes) (m)	100	100	100
Max speed difference (km/h)	50	10	10
Max speed difference for on-ramp(km/h)	70	10	10
Time reaction at stop (sec)	1,35	1	1
Time reaction at traffic light (sec)	1,35	1	1
Model for on-ramps	Cooperative mode looking gaps upstream	Cooperative mode looking gaps upstream	Cooperative mode looking gaps upstream