Rational truck driving and its correlated driving features in extra-urban areas

Claire D’Agostino1 Alexandre Saidi2 Gilles Scouarnec3 and Liming Chen4

Abstract— Truck drivers typically display different behaviors when facing various driving events, e.g., approaching a roundabout, and thereby have a major impact both on the fuel consumption and the vehicle speed. Within the context where fuel is increasingly a major cost center for merchandise transport companies, it is important to recognize different driver behaviors in order to be able to simulate them as closely to the real data as possible during the truck development process. In this paper, we introduce, instead of economic driving, the notion of rational driving which seeks to decrease the average fuel consumption while respecting the transport companies' constraint, i.e., the delivery delay. Moreover, we also propose an indicator, namely rational driving index (RDI), which enables to quantify how good a driver behavior is with respect to the rational driving. We then investigate various driving features contributing to characterize a rational driver behavior, using real driving data collected from 34 different truck drivers on an extra-urban road section particularly representative of travel paths of trucks ensuring regional merchandise distribution. Given the fact that real driving data collected on an open road can differ in terms of environment, e.g., weather, traffic, we further study, through simulations on a digital representation of a roundabout, the impact of two major driving features, i.e., the use of coasting and crossing speed at roundabouts, with respect to rational driving. The experimental results from both real driving data and simulations show high correlations of these two driving features with respect to RDI and demonstrate that a good rational driver tends to decelerate slowly during braking periods (use of coasting) and have high crossing speed in roundabouts.

I. INTRODUCTION

Nowadays oil price is expensive and fuel is increasingly a major cost center for merchandise transport companies. In such a context, a highly desirable goal for these companies is to reduce their fuel consumption while keeping the commercial speed as high as possible. While vehicle, environment and driver all have an impact on the fuel consumption, we are interested in this study by the impact of driver behavior. Indeed, a test carried out by Maincent in 2005 [1] showed a gap from -11% to +14% in the fuel consumption between 33 different drivers on the same cycle while driving a same heavy vehicle in similar traffic conditions. This study thus suggests that drivers can play a major role on fuel economy through their driving style or behavior. While this result is very interesting for transport companies, it implies that drivers know how to drive more fuel efficiently while not decreasing their commercial speed.

A straightforward way to drive more fuel efficiently is the so called economical driving or eco-driving which refers to the energy efficient use of a vehicle, i.e., reducing the fuel consumption from road transport so that less fuel is used to travel the same distance. It is not the most appropriate driving style for merchandise transport companies. Indeed one rule of eco-driving is to drive more slowly in order to drive at appropriate speeds depending on the engine efficiency map for example. However truck drivers cannot be late because of their deliveries. It is also necessary for drivers to reach their next delivery point quickly because their working hours are regulated. In this paper, we introduce the notion of rational driving which seeks to decrease the fuel consumption while maximizing the authorized average speed. It implies that drivers, in adjusting their driving behavior, can reduce their fuel consumption without loosing time for their deliveries. But concretely how to reach such a rational driving for a driver in piloting a truck? We aim to answer this question in providing a quantitative measurement of rational driving and identifying some key driving features using real driving data collected from 34 different drivers on an extra-urban road section and through a focused study on extra-urban roundabouts by simulation, all of which are typical driving situations for a transport company ensuring regional distribution.

A. Related work

Related research work so far are mostly focused on economical driving. Lin et al. [2] categorized various factors impacting the fuel consumption into four classes: vehicle, road, environment and driver. The specific impact of the driving style or behavior on the fuel consumption can thus be studied in isolating the driver independent parameters and making them stable. Liiinatainen [3] followed this method and studied this question using data of comparable combinations of road, vehicle and time of the day.

Given a similar external environment, i.e., road, traffic, weather, what are the key driving features which enable the discrimination of one driving behavior from another one? Brundell-Freij et al. [4] identified seven factors which have significant effects on the fuel consumption and exhaust emissions. They are features related to acceleration, stop, speed oscillation, extreme acceleration, late gear changing

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3http://www.ecodrive.org/.
4http://www.energysavingtrust.org.uk/Travel/Driving
from 2nd and 3rd gear, engine speeds $> 3500$ rpm and moderate engine speeds in 2nd and 3rd gear. However, these features are related to car driving. They are thus not always adapted to the context of the truck. Indeed cars and trucks do not have the same range of values for the engine speeds and gear changing. Moreover the use of a robotized gearbox is a standard for trucks. For the study of truck driver behaviors, it is thus necessary to isolate the factors due to the driver, e.g., the use of the throttle, brake, from those due to the gearbox management and the vehicle (engine speeds, gear changing, fuel map...). Nevertheless, most of these driving features can still be used for the case of trucks, but with different thresholds, e.g., percentage of time where acceleration is greater than a threshold. Montazeri et al. [5] listed 19 driving features, including in particular most features already proposed in previous studies, e.g., those in [4]. In their study, they defined an effectiveness index (EI) to evaluate the impact of each driving feature with respect to the fuel consumption and concluded that the fuel consumption and exhaust emissions depend on energy, mean velocity and displacement more than other features. While the introduction of the EI indicator is original and interesting, it only considers the fuel consumption and emissions but ignores the average speed of a vehicle.

A rare work within a context similar to ours, i.e., truck driving on extra-urban roads, was made by Maincent [1] who proposed to characterize rational driving through several features: the anticipation of driving events, the use of the kinetic energy of the vehicle, the use of the right engine speed and finally the crossing speed on some road infrastructures, including in particular curves and roundabouts. However, the aim of Maincent's study was to analyze drivers’ mental road and the generalization of her conclusion is quite questionable as it is based on the analysis of driving data from four drivers.

B. The proposed approach and contributions

Our goal here is to study how different driving behaviors impact the fuel consumption and the average speed and thereby characterize the rational truck driving through a set of practical driving features. For this purpose, we first introduce an indicator, namely rational driving index, which enables to quantify different driving styles in terms of the driving rationality. We then select a set of state of the art driver dependent features within the truck context and experiment them for their discriminating skills in terms of driving behavior, using real driving data collected from 34 drivers who piloted a same truck on an extra-urban road.

Finally, we study, through a simulation tool, the impact of the two major driving parameters identified during the previous step, namely passing speed and deceleration, on the fuel consumption and the average speed when crossing a roundabout. Given the fact that France has the half of roundabouts worldwide [6], crossing a roundabout in an extra-urban environment is a driving situation particularly representative of merchandise transport companies which ensure regional distributions. Simulation is useful to evaluate the impact of one driving parameter at a time while fixing all the other ones. This is not possible when driving on a real open road where the environment keeps changing. The contributions of the paper are threefold:

- We define an indicator of rational driving instead of economic driving. This indicator, namely rational driving index, enables to measure how good a driver behavior is compliant with the rational driving which seeks decreasing the fuel consumption while maximizing authorized commercial driving speed for merchandise transport tasks;

- Using real driving data collected from 34 drivers who piloted a same truck on an extra-urban road with similar traffic conditions, we analyze a set of driver dependent features which contribute to characterize the driver behavior, in particular with respect to the rational driving;

- Using the two major features identified as particularly sensitive to the driver behavior, we further study and quantify, through simulations, their impact on rational driving, i.e., in terms of fuel consumption and average speed.

C. Organization of the paper

The rest of the paper is organized as follows. Section II defines our rational driving indicator. Section III presents the data collection and the measure of correlation between selected driving features and rational driving index. Section IV focuses on the simulation-based impact study of different driving behaviors on a representative roundabout. Finally in section V we will conclude and discuss the future work.

II. RATIONAL DRIVING INDEX

Maincent [1] defined the notion of rational driving as the full exploitation of the potential of the vehicle to drive more fuel efficiently while respecting the delivery delays. We go one step further in suggesting that one could achieve the economy of fuel consumption while maximizing the authorized average speed. This implies in particular that drivers can reduce their fuel consumption without loosing time to travel the same distance for their deliveries. Fuel consumption should not be the only parameter to be taken into account for a rational driving. In order to enable comparison between two driver styles in terms of driving rationality, we propose a rational driving index and make use of a coefficient used in [7]. In the subsequent, this Rational Driving Index is called $RDI$ and is defined as the ratio of the average speed on the fuel consumption for a given travel:

$$RDI = \frac{\text{Average speed (km/h)}}{\text{Average fuel consumption (L/100km)}}$$  \hspace{1cm} (1)

As it can be seen from the equation, the $RDI$ increases when the fuel consumption is reduced and/or when the average speed increases. The higher is the $RDI$ on a fixed travel, the better is the driver regarding the rational driving. Given a travel and similar exterior conditions, this index thus enables to sort drivers in terms of driving rationality, the best ones being those who reduce the fuel consumption of the vehicle without loosing time, or even gaining time.
III. IDENTIFYING THE MAIN FEATURES FOR RATIONAL DRIVING

While the rational driving index RDI enables to compare different drivers in terms of the quality of the rational driving, we do not know what are the main driving features which contribute to characterize such a rational driving. In this section, we aim to answer this question. For this purpose, we collected a set of real driving data from 34 different drivers on an extra-urban road and studied the correlation of several state of the art driving features with respect to RDI.

A. Driving data collection

In order to sort out the behaviors of drivers in terms of rational driving, we collected a database of real driving data from 34 different drivers in approximately the same driving conditions, i.e., using the same vehicle on the same road with similar traffic conditions. Specifically, 34 drivers were asked to drive a Renault Trucks D-wide vehicle as illustrated in Fig. 1. It is a Heavy Multi-Purpose vehicle, representative of vehicles for a regional distribution usage. The vehicle was equipped with a robotized gearbox, two sets of engine retarders (exhaust and compression) and loaded to 14.5 tons. The drivers were asked to drive normally but without using kick-down and cruise control, and always keeping the robotized gearbox in auto mode. These instructions were delivered with the aim to isolate the driver features from those of the vehicle with respect to the impact on fuel consumption. Indeed, when using the robotized gearbox in auto mode while excluding the cruise control usage, all the drivers must control the vehicle speed only with throttle pedal, brake pedal and retarders. We also chose a representative road of regional distribution, i.e. mainly urban or extra-urban road with a few stops. The drivers drove several times on the indicated path of 6 km distance, and we finally collected 75 runs on the selected section. In-vehicle driving data were recorded using three sensors, namely GPS data (latitude, longitude etc.), CAN data (vehicle speed, fuel consumption, brake pedal etc.) and video data synchronized to the CAN-data logger. The video was employed to select similar runs and remove those presenting high density traffic for instance.

B. Rational driving related driving features

At this point, we had the driving data of 75 different runs by 34 different drivers on the selected road of 6 km distance. Given the fact that the exterior conditions were approximately the same, the drivers were thus sorted according to their RDI which gave hints on their ability to drive rationally. As it was expected, the distribution of RDIs presented in Fig. 2 looked like a Gaussian distribution. Few drivers had a very low or very high RDI while the most of them had a RDI close to the average RDI value. This RDI distribution enabled us to separate intuitively the drivers into three different classes according to their driving rationality, namely good, medium and bad rational drivers. But still we did not know which driving features could contribute to a rational driving. Our study on previous works highlighted several state of the art features with respect to the rational driving. How are they really correlated to the RDI indicator that we introduced here? To answer this question, we listed several state of the art driving features in the first column of Table I and adapted them to the truck context, e.g., the threshold of acceleration for evenly driving was modified to an appropriate value. We then computed their Pearson’s correlation coefficient with its corresponding RDI that we display in the second column. The Pearson’s coefficient measures the linear dependence between two variables, giving a value between +1 and −1 inclusive, where +1 is total positive correlation, 0 is no correlation, and −1 is total negative correlation. It is defined by:

\[
\rho_{X,Y} = \frac{\text{cov}(X,Y)}{\sigma_X \sigma_Y} = \frac{E[(X - \mu_X)(Y - \mu_Y)]}{\sigma_X \sigma_Y}
\]

where \(\rho_{X,Y}\) is the Pearson’s coefficient between \(X\) and \(Y\), \(\text{cov}(X,Y)\) is the covariance between \(X\) and \(Y\), \(\sigma_X\) is the standard deviation of \(X\), \(\mu_X\) is the mean of \(X\) and \(E\) is the expectation.

As it can be seen from Table I, while being non null, none of these driving features displays a high Pearson’s coefficient. It is thus not that obvious to conclude on their strong correlations. This result could be expected since the driving data were collected on an open road. The environment was thus similar but not always equal, especially concerning weather or traffic. Wind and rain for example have an impact...
on the fuel consumption because they increase the drag force opposed to the vehicle motion. However, Table I suggests five driving features with higher Pearson’s coefficient that we list in the first column of Table II. How good are they to discriminate the three driver classes that we previously introduced? We display in the second column of Table II the difference between the average values of the good driver class and the bad driver class with respect to the average value of the medium driver class for each of these 5 driving features. As it can be seen from Table II, good drivers use on average more coasting, i.e. they tend to have more time where they use the kinetic energy of the vehicle only (they use neither the throttle pedal, nor the brake, nor the retarders). While driving more evenly with less high acceleration periods, good drivers also tend to brake in average less than the medium and bad rational drivers. Finally, they have a higher speed when crossing a roundabout. This fact suggests that they better anticipate than other drivers, and thereby loose less the velocity, i.e., the kinetic energy of the vehicle. As a result, they inject less fuel in the accelerating phase which follows the roundabout. All these discoveries are coherent with the intuitive rules of rational driving and are thus promising. However, how important is each of these driving features for rational driving? We further quantify the impact of two major driving features, namely the coasting time and the crossing speed, when crossing a roundabout, using simulations.

<table>
<thead>
<tr>
<th>Driving features</th>
<th>Pearson’s coefficient between the driving feature and RDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of coasting time (%) [1]</td>
<td>0.13</td>
</tr>
<tr>
<td>Number of braking events [4]</td>
<td>-0.42</td>
</tr>
<tr>
<td>Number of retarders events [4]</td>
<td>-0.05</td>
</tr>
<tr>
<td>Percentage of time where the position of the throttle pedal is 100% (%) [4]</td>
<td>-0.10</td>
</tr>
<tr>
<td>Percentage of time evenly driving (%), i.e. [Acceleration] &lt; 0.2 m/s² [4]</td>
<td>0.31</td>
</tr>
<tr>
<td>Percentage of time with extreme acceleration (%), i.e. [Acceleration] &gt; 0.6 m/s² [4]</td>
<td>-0.32</td>
</tr>
<tr>
<td>Average speed in roundabout (km/h) [1]</td>
<td>0.38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Driver type</th>
<th>Feature</th>
<th>Lowest RDI drivers</th>
<th>Medium RDI drivers</th>
<th>Highest RDI drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage of coasting time</td>
<td>-22.0</td>
<td>0</td>
<td>+14.3</td>
</tr>
<tr>
<td></td>
<td>Number of braking events</td>
<td>+7.8</td>
<td>0</td>
<td>-13.3</td>
</tr>
<tr>
<td></td>
<td>Evenly driving</td>
<td>-4.4</td>
<td>0</td>
<td>+6.5</td>
</tr>
<tr>
<td></td>
<td>Sudden speed change driving</td>
<td>+8.4</td>
<td>0</td>
<td>-7.3</td>
</tr>
<tr>
<td></td>
<td>Average speed in roundabouts</td>
<td>-13.7</td>
<td>0</td>
<td>+20.8</td>
</tr>
</tbody>
</table>

Fig. 3. View of the selected roundabout and the driving direction.

IV. SIMULATION-BASED IMPACT STUDY OF DRIVING FEATURES WHEN CROSSING A ROUNDBOUGHT

The last section shows that the five driving features help to discriminate drivers in terms of rational driving. But how important are they in terms of impact to rational driving? In this section, we aim to provide insights to this question using simulations. Indeed, the simulation gives us the possibility of quantifying the impact of one variable, e.g., a driving feature, over another one, e.g., fuel consumption, while fixing all the other variables. This is not possible in real driving experiments in open environments. Specifically, we chose to evaluate the impact of two of the previous five driving features, namely the coasting time and the crossing speed in roundabouts. While the coasting time is related to one of the main rules of rational driving, the crossing speed in roundabouts impacts the average speed for transport companies. Besides, roundabouts are a very common road infrastructure in Europe that drivers face frequently.

A. Selection of a representative roundabout and its representation on the simulation tool

The input of the simulation tool is a road which depicts a roundabout. Therefore we had to find a real roundabout representative of extra-urban driving and to create its digital equivalent. The road where we carried out the data collection includes several roundabouts. We selected one of them according to several criteria, i.e., low traffic, high visibility, same road type before and after the roundabout (i.e., extra-urban road), and straight direction, such that drivers only needed to concentrate on their driving and did not need to pay attention to road signs, traffic or turning directions. The third roundabout was the best compromise with respect to these criteria. Fig. 3 gives a Google Earth picture [8] of the selected roundabout and shows the driving direction of the selected infrastructure. We had to characterize the selected roundabout in order to build its digital representation through several parameters, e.g., the diameter of the roundabout, and the distance with the previous and the next roundabout. The diameter of the selected roundabout is 47 meters which is an average value, because some drivers cut the corner on the turn whereas others drove on the outside of the turn. This averaged diameter enabled us to compute the maximum speed to get through this roundabout. The maximum lateral acceleration tolerated for this Heavy Multi-Purpose vehicle is

\[
A_{max} = 0.4 \times g
\]
where \( g \) is the Earth’s standard surface gravity in \( m/s^2 \). This value is the limit before rollover for that truck. In this case, the maximum speed to get through this roundabout is

\[
S_{\text{max}} = \sqrt{A_{\text{max}} * R}
\]

(4)

where \( R \) is the radius of the roundabout. It gives:

\[
S_{\text{max}} = 34.6 \text{ km/h}
\]

(5)

The distances with the previous and the next roundabouts are 1810 and 2940 meters, respectively. We imposed the initial and final speed at 0km/h in order to concentrate our study only on the selected roundabout. Once given all these characteristics, we were able to build the digital representation of this roundabout as illustrated in Fig. 4. This will be the input of the simulation tool.

B. Simulating driver behaviors on the digital roundabout

The simulation tool includes three components, namely the vehicle, the road, and the driver, all of which impact mainly the fuel consumption and the average speed as illustrated in Fig. 5. For a given vehicle, the driving features whose impact we aim to evaluate on rational driving are the crossing speed and the deceleration, respectively. Therefore we tested different target deceleration values on the driver side, and various roundabout crossing speeds on the road side.

The different parameters of various essays on the simulation tool are listed as follows:

- The cruising speed: 60km/h, 70km/h or 80 km/h. It describes the cruising speed that the driver wants to reach and to keep between the roundabouts. On this road the legal speed limit is 80km/h. However, we observed that the drivers rather targeted a cruising speed between 60 and 80 km/h. We tested these three cruising speeds to comply with real driving behaviors and to evaluate the impact of the selected driving features with respect to rational driving given an input cruising speed;

- The passing speed: 0, 15, 17, 18, 20, 22, 24, 34.6 km/h. 0km/h is the extreme speed value illustrating the case where the driver must stop at the roundabout because he did not anticipate correctly for example. 34.6 km/h is the theoretical maximum speed that the vehicle can reach when turning in the roundabout as we calculated previously. The other speeds are representative of the real measured data;

- The configuration where the roundabout is not simulated. In this case, drivers do not need to brake. They only have to keep the cruising speed for the whole distance. The results achieved in this configuration can be used as reference values, e.g., to quantify the impact of the roundabout itself;

- The deceleration by braking: -0.6, -0.8, -1.2, -2 m/s². These values are representative of real measured data. These values enable an interpretation of driving styles: the lower is the deceleration, the more the driver uses coasting.

All combinations of previous four variables were simulated. Table III illustrates some of these combinations. They are representative of different driving behaviors in terms of cruising speed, crossing speed and deceleration. Run 1 corresponds to a typical behavior with the mean crossing speed and the mean deceleration. It is used as reference behavior. All the other runs, i.e., 2 through 5, deviate from this reference run.

C. Impact of the simulated driving features on \( RDI \)

For each run over the digital representation of the 4.8km road section, we measured the simulated fuel consumption and average speed in order to compute the corresponding \( RDI \). Fig. 6 illustrates several results from these simulations. As for real runs, simulated driver behaviors were sorted according to their \( RDI \). Table IV gives average speed, fuel consumption and \( RDI \) results for the five examples runs.

### Table III

<table>
<thead>
<tr>
<th>Run number</th>
<th>Cruising speed</th>
<th>Roundabout</th>
<th>Crossing speed</th>
<th>Deceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80</td>
<td>Yes</td>
<td>20 km/h</td>
<td>-0.8 m/s²</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td>No</td>
<td></td>
<td>-1.2 m/s²</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>Yes</td>
<td>34.6 km/h</td>
<td>-0.6 m/s²</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>Yes</td>
<td>0 km/h</td>
<td>-2 m/s²</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td>Yes</td>
<td>15 km/h</td>
<td>-0.8 m/s²</td>
</tr>
</tbody>
</table>

Fig. 5. The main simulation parts in the simulation tool. Arrows represent exchange of data between driver, vehicle and road.

Fig. 4. Selected roundabout model for simulation. a) is the speed target vs. distance. On b), the black point represents the final stop. c) is the road-type. And d) is the slope vs. distance signal.
Fig. 6. Speed vs. distance signals from the simulations for the selected five runs. We can observe the different cruising speeds, crossing speeds (at 1810m) and the deceleration values.

TABLE IV
EXAMPLES OF SIMULATION RESULTS. THE CONDITIONS OF EACH RUN ARE PRESENTED IN TABLE III

<table>
<thead>
<tr>
<th>Run number</th>
<th>Gap with the reference average speed (%)</th>
<th>Gap with the reference fuel consumption (%)</th>
<th>RDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2.886</td>
</tr>
<tr>
<td>2</td>
<td>+16.5</td>
<td>-17.9</td>
<td>4.094</td>
</tr>
<tr>
<td>3</td>
<td>-5.8</td>
<td>-18.3</td>
<td>3.326</td>
</tr>
<tr>
<td>4</td>
<td>-2.8</td>
<td>-2</td>
<td>2.886</td>
</tr>
<tr>
<td>5</td>
<td>-19.3</td>
<td>-17.8</td>
<td>2.836</td>
</tr>
</tbody>
</table>

TABLE V
CORRELATIONS BETWEEN THE TESTED DRIVING FEATURES AND THEIR RDI MEASURED IN TERMS OF PEARSON’S COEFFICIENT

<table>
<thead>
<tr>
<th>Varying driving feature</th>
<th>Fixed driving features</th>
<th>Average correlation with RDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average deceleration</td>
<td>Cruising speed, Crossing speed</td>
<td>0.79</td>
</tr>
<tr>
<td>Crossing speed</td>
<td>Average deceleration, Cruising speed</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Run 1 is used as reference. For each run, the gaps with the reference average speed and the reference fuel consumption are at the second and third column of the Table, respectively. The corresponding RDI is at the last column.

1) Impact of the average deceleration: For a fixed couple of crossing speed and cruising speed, the only varying parameter is the average deceleration. Table V gives the Pearson’s correlation coefficients between the tested driving features and their corresponding RDI. As it can be seen from that table, average deceleration shows a strong correlation with RDI, displaying a Pearson’s correlation coefficient as high as 0.79, when fixing all other driving features, i.e., cruising speed and crossing speed. Furthermore, as illustrated in Table IV, we discovered that the lower is the absolute value of average deceleration, the higher is the RDI. For example, run 3 displays a small deceleration and depicts a high RDI. These results thus confirm that using coasting, i.e., having a lower deceleration during the braking phase, is an important driving feature of rational driving.

2) Impact of the crossing speed: For a fixed couple of average deceleration and cruising speed, the only varying parameter is the crossing speed. As it can be seen from Table V, as compared to average deceleration, crossing speed displays an even higher Pearson’s correlation coefficient with RDI, while fixing the average deceleration and cruising speed. Furthermore, as illustrated in Table IV, the experimental results show that the higher is the crossing speed on the roundabout, the better is the RDI. These simulation results further confirm the correlation between crossing speed and rational driving that we discovered using real driving data.

3) Summary: For each of the two driving features tested in simulation, namely average deceleration and crossing speed, the correlation was found very high with RDI. This conclusion holds for three different cruising speeds tested in simulation. The simulations enabled us to isolate and quantify the impact of one driving feature with respect to rational driving while fixing all the other ones. The simulation results further confirm the global trends that we observed on real driving data.

V. Conclusion

In this paper, we introduced the concept of rational driving which seeks to decrease fuel consumption while not decreasing or even increasing the average driving speed. This is in clear contrast with the popular economical driving. Furthermore, we defined an indicator, namely RDI, for rational driving index, which enables to quantify how good a driving behavior is on a given travel path. We then studied various driving features related to rational driving and studied their impact using real driving data and simulations, in particular the use of coasting and crossing speed at roundabouts. In our future work, we are willing to study the impact of other driving features. We also want to implement a cost model which takes into account the benefit of fuel economy balanced with the cost of the loss of time.

REFERENCES