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Testing energy and emissions assessment models: a highway case study in virtual reality

Silvio Cristiano[1,2*] ✉

[1]*Department of Design and Planning in Complex Environments, Università Iuav di Venezia, Ca' Tron, Santa Croce 1957, 30135 Venezia, Italy*
[2]*Department of Molecular Sciences and Nanosystems, Università Ca' Foscari Venezia, via Torino 155, 30172 Venezia Mestre, Italy*
[*]*Portions of this research were conducted when the author was at the Università degli Studi Roma Tre, with the Department of Engineering*
✉ *E-mail: silvio.cristiano@unive.it*

Abstract: The estimation of pollutants from road transport systems is examined, by comparing emission factors (EFs) calculated with static and dynamic methods. Information technology is used to test currently operational assessment models in the European Union. The negligibility of the effects of variation in speed is questioned: acceleration/deceleration imply use/dissipation of energy, and directly affect pollutants release. An investigation based on drive simulation is conducted, proposing increasing traffic flow conditions. Two scenarios are simulated: an existing highway before and after major modernisation works. Benefits and detriments of its renovation are also examined. Results are processed through recent European Environment Agency models and a system that continuously computes the operations of an engine. The correlation found between average speed and EFs is not representative. Instead, a good correlation is observed between increases in speed variation and increases of EFs. Synthetic parameters are proposed to support the analysis, based on intensity and duration of acceleration/deceleration events. EFs are substantially lower if calculated through the static models. The assumption that the effects of speed variation can be neglected is rejected: driving cycles due to traffic flow conditions are identified as crucial for realistically evaluating emissions. A need is detected to formulate correcting parameters.

1 Introduction

Road traffic plays a primary role in the plights of resource consumption and air pollution, the latter posing a significant threat to ecosystems and human health through the release of substances and energy. In the past decades, some emission-limiting measures have been adopted in many countries. However, petrol and diesel motor vehicles are still major responsible for the emission of nitrogen oxides (NO_X), particulate matter mass, carbon monoxide (CO) and unburned hydrocarbons, the effects of which are correlated with heart and cancer diseases [1], and estimated to entail over 7 million premature deaths a year [2].

According to the active International agreements (e.g. Geneva Convention on Long-range Transboundary Air Pollution, 1979; Kyoto Protocol, 1995), aimed at limiting the release of pollutants into the atmosphere within a given time period, the emissions generated by the various polluting sectors are estimated and predicted at a national and supranational level, while planning a country's strategy towards the achievement of the preset goals. The European Environment Agency (EEA) provides European Union (EU) Member States with a technical guidance to prepare national emission inventories [3] through a static model, called European Monitoring and Evaluation Programme (EMEP)/EEA. Static models take into consideration mean parameters, constant in time and space; emission factors (EFs) are computed as a function of the average speed adopted or predicted on a given road or infrastructure network.

An analysis of static models and their parameters illustrates the omission of a crucial variable: the variation in speed of vehicles in motion. In average speed models, the effect of the variation in speed is considered as negligible or secondary. This assumption can only be regarded as valid in some specific circumstances, i.e. low traffic volumes and constant speed. Recent studies demonstrated a direct correlation between high speed and exhaust emissions released [4] as well as between high speed and fuel consumed [5], by simulating freeway driving on smooth roads without traffic interference. Such results appear very close to what is assessed and predicted by the EMEP/EEA methodology [6]; however, they refer to conditions of low or no vehicular flows.

In this paper, the general representativeness of the EMEP/EEA model is thought to require adequate discussion, specifically for the real emissive levels in scenarios with medium and high vehicular flows and consequent inconstant speed [7, 8]. In fact, acceleration and deceleration imply use and dissipation of the energy provided by the engine, and directly affect fuel consumption [9–11] as well as the release of pollutant components [12]. Therefore, a need is observed for testing the possible limits of the currently active European official assessment models for road transport emissions. Since acceleration and deceleration are considered as crucial contributing factors to the phenomena of pollution and energy dissipation, the negligibility of the variation in speed of vehicles is brought into question.

Following the idea that driving styles can have a large effect on the energy consumption and the emissive levels of a vehicle [9, 13], static emissions assessment models are tested through experimental research in drive simulation: an analysis of the real driving cycles adopted by the users as a response to different traffic volumes is conducted. Such analysis is matched to the connected functioning of the vehicle engine, based on instantaneous parameters rather than on average speed, and simulated with the innovative software LMS AMESim (2012), continuously computing the operating conditions of the engine.

Both static and dynamic models are employed in simulating and evaluating traffic flows on a given Italian highway section as well as on its brand new alternative layout, inaugurated in December 2015. Simulation data are computed through the aforementioned LMS AMESim software (dynamic model), thus yielding emission rates associated with realistic driving behaviour due to traffic flows. Results are then compared with the EFs predicted through the application of the two most recent European EMEP methodologies (static models). By means of these evaluations and comparisons, efforts are put into shedding some light on the following questions: (i) ‘How accurate is the EU official model for the evaluation of CO and NO_X EFs from road transport in the presence of medium or high traffic flows and subsequently changing driving cycles?’; and (ii) ‘While planning successful transport strategies for energy saving and emission reduction, what benefits or detriments in fuel consumption and pollutants release can be expected following the modernisation of a major highway?’.

Acceleration and deceleration in the presence of different levels of traffic interference are evaluated in order to assess their significance to the emissive phenomenon. In view of neglecting the acceleration and deceleration implications in the estimation of EFs, the limits of the targeted static model for assessing pollutant emissions are investigated. Some parameters are also proposed, which are able to analyse simulated and continuously recorded data as well as associated emissive trends. Following the test of the EMEP/EEA methodology, a need for correcting its formulas for CO and NO_X EFs is finally inspected, and possible directions for future advancements are suggested.

The experimentation is based on a real-time drive simulation in virtual reality; therefore no on-road data are employed in this study. Emerging intelligent transport systems (ITS) technologies have made real-time monitoring possible on many European roads in recent years, through sensors and devices, allowing for studies on traffic flow conditions and consequent estimations of energy consumed and emissions released [14]. On-board software and devices are being implemented on some vehicles in order to enhance the adoption of energy- and emission-efficient driving cycles [15, 16]; networks are also being used (e.g. VANETs, Vehicular *Ad hoc* Networks), allowing for vehicle-to-infrastructure and vehicle-to-vehicle communication [17].

2 Case study and methodology

As a case study for the simulation of driving cycles in different traffic flow conditions, the CO and NO_X impacts of a real highway section are evaluated before and after major modernisation works; this helps both analysing two diverse highway configurations (category A freeways with two 3.25 m lanes and three 3.75 m lanes) and forecasting possible advances or worsening in the contribution to atmospheric pollution following road capacity enlargement in a non-urban environment.

The targeted road is the Italian highway A1, in its section between Barberino and Florence, whose layout has recently been substantially changed due to its connection and integration into the modification A1-var, with its cross-section extending from two to three lanes, and with wider shoulders. The choice of the vehicle and its power source starts from the analysis of the most common technologies. Considering the EU [18] and the USA vehicle fleet [19], a passenger car is chosen for the simulation, with a Euro III gasoline engine. Gasoline represents more than 52% of road vehicle power sources in Europe and India, and the prevailing power source in China, Japan and the United States of America. On the basis of the same statistics, the Euro III technology is adopted as an intermediate one. Given the nature of a highway, no modal alternatives are taken into consideration for this study.

The proposed experimental research is based on instantaneous parameters. Punctual factors significant of a vehicle’s motion are preliminary investigated: traffic volumes – influencing the traffic flow conditions on a given road section – and the geometric features of the infrastructure – inducing velocity modulation as a response to steep longitudinal slopes and narrow horizontal bending radii. Since such factors can coexist on the same infrastructure, they need to be studied separately in order to distinguish their respective contributions. This research is meant to be limited to the investigation of the effects of traffic volumes. So, the chief criterion for the choice of a highway as a case study is essentially its being a road infrastructure whose geometric features are not supposed to affect driving conditions. The expected lack of effects of the geometric features is verified both theoretically and experimentally for the simulation scenarios [20].

The experimental research uses virtual reality, and includes both the accurate construction and the output analysis of a drive simulation. The users’ behavioural analysis in drive simulation is based upon recent software STISIM Drive (2012). The reliability of the hardware instruments is assured by previous experimentations [21, 22]. The simulation is realistic due to the fact that the driving simulator is installed inside a real vehicle. The image of the road scenery is simulated and projected onto three panels – placed frontally and front laterally – able to grant a visual angle equal to 135°. The regulating software allows for the accurate registration of a series of motion parameters characteristic of each trial. Event data are registered and saved every 0.3 s, and include: time; longitudinal distance; longitudinal speed; cross-speed; longitudinal acceleration; cross-acceleration; vehicle curvature; roadway curvature; vehicle angulations; roadway angulations; steering wheel angulations; opening of throttle valve; pressure on the brake pedal; gear; vehicle lateral position; and vehicle deviation relative to the x-, y- and z-axes.

Two road configurations A and B represent the targeted highway section, respectively, before and after major modernisation works. For each configuration, increasing traffic flow conditions are simulated. Since configurations A and B present different capacities, due to their different cross-sections, traffic conditions are determined according to their level of service, i.e. groups of homogeneous traffic flow conditions as per the directions of the *Highway Capacity Manual* [23]. In this study, increasing traffic flow conditions are organised in groups as follows:

- low inter-vehicular interference: level of service A–B;
- medium inter-vehicular interference: level of service C;
- high inter-vehicular interference: level of service D.

In configuration A, low, medium and high levels of inter-vehicular interference correspond to flows of 1400, 2000 and 2600 vehicles per hour (vph), respectively. In configuration B, they are associated with flow values of 1850, 3400 and 4650 vph, respectively.

These six simulation scenarios are repeated with the same conditions for all drivers. A homogeneous sample of voluntary drivers is selected, and made aware of the test’s functioning: 20 people, of which 10 men and 10 women, ranging from 20 to 50 years old, with a mean age of 30. They all hold a driving licence, and had driven 8,000 km in the 12 months before the test. Among them, no psychophysical disorder is registered during or after the driving test. According to a statistical method, based on the stability of the parameters and here applied to the convergence of the velocities adopted by test drivers [24], the number of the drivers is considered statistically significant. The experimental output data are validated statistically through the Chauvenet’s criterion [25], which leads to reject data from four drivers. The remaining data are validated again, and are still significant.

Validated data from registration are computed through the dynamic software LMS AMESim, and compared with the expected EFs calculated through the EMEP/EEA static model for the targeted vehicle: a light-weight gasoline-powered passenger car. The LMS AMESim dynamic software reproduces the methodology imposed by major International regulations in terms of emissions testing for the validation of new vehicle engines. This software simulates the functioning of an engine during the motion of a vehicle and measures fuel consumption and EFs based on the type of engine and transmission, the opening of the throttle valve, and the pressure on the brake pedal.

3 Results and discussion

After being validated and computed, the output data are analysed in order to observe the EFs according to the two assessment models, in addition to the different driving behaviours adopted by the sample drivers in the various scenarios and traffic flow conditions. As a preliminary observation, the velocities adopted by the test drivers

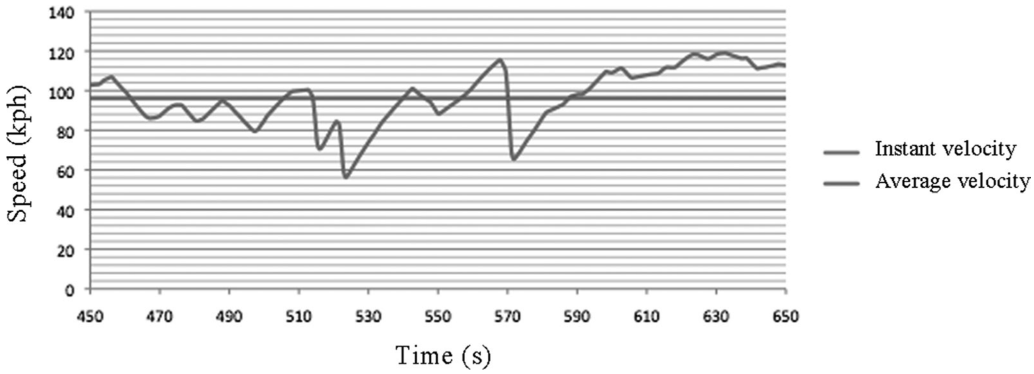


Fig. 1 *Example of difference between average and instantaneous speed (extract from one of the tests)*

tend not to be constant. On the contrary, instantaneous speed is generally significantly different from average speed on a given scenario (Fig. 1); differences increase with the level of vehicle interference.

The first analysis on the output data represents the study of the correlation between speed and EFs; the dynamic model points out how average speed cannot be considered descriptive of the emissive phenomenon. Dynamically calculated EFs are confirmed to be independent from average speed, and their values are five to ten times higher than those predicted by the static model (Fig. 2).

Instead, a fair correlation trend can be observed between the increase of the EFs and the increase of the variation in speed, expressed as root-mean-square deviation (RMSD). However, no significant statistical correlation is found, since the R^2 factor for the linear regression is lower than 0.5. This is ascribed to the fact that small but frequent fluctuations around mean speed imply relatively high EFs, yet resulting in a low RMSD. A need for other synthetic indicators is then detected.

The second analysis focuses on the drivers' behaviour in the six different scenarios and traffic flow conditions, and is followed by the study of the relation between driving styles and EFs. As a preliminary step to this phase, the possible relation between the road geometric features and the registered speed is investigated: as per the initial hypothesis, no statistical correlation between geometry and velocity is found in the whole experimentation. Also, the speed-flow curves of the scenarios present a good correlation with the theoretical speed-flow curves suggested by the Highway Capacity Manual [23]: the R^2 of the standard speed-flow curve applied to the output data of the two configurations A and B is 0.84 and 0.80, respectively. This confers adequate representativeness to the present research.

For each configuration, output data are organised and grouped according to their homogeneous flow over capacity rate (*F/C*). First, the opening percentage of throttle valve is investigated: in both configurations, its mean value is around 50%, while its RMS deviation starts increasing 34 and 30% passing from a medium to a high level of traffic interference, respectively, for configuration A and B. In configuration B (new highway with higher capacity), energy/fuel consumption is higher for low vehicle interference and for high vehicle interference. These data suggest how fuel consumption increases with high vehicle interference ($F/C \geq 0.70$) or when high speed is adopted (over 130 kph, i.e. minimal vehicle interference); though, this fact is not sufficient to find significant correlation with the EFs. Consequently, some synthetic parameters are proposed, based on acceleration and deceleration, and able to express adequate correlation between speed variation and emissions.

Longitudinal acceleration and deceleration are examined through the combination of their intensity (m/s^2) and duration (s), which originates new parameters: time–acceleration per kilometre (TA) and time–deceleration per kilometre (TD). These parameters are based on the discrete integral of the longitudinal acceleration as a function of time, defined as quantity of acceleration (QA) and quantity of deceleration (QD), respectively:

- $QA_{k,n} = \sum (\Delta t_i \times a_{L\ i})_{k,n}$, for $a_L > 0.0$ m/s^2 (m/s);
- $QD_{k,n} = \sum (\Delta t_i \times |a_{L\ i}|)_{k,n}$, for $a_L < 0.0$ m/s^2 (m/s);

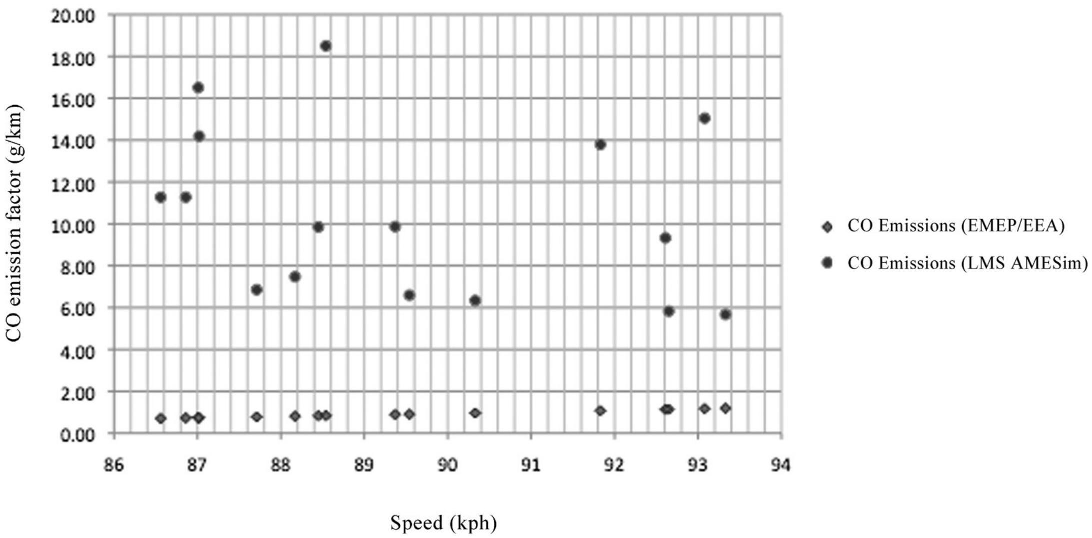


Fig. 2 *Difference between predicted and simulated EF values*

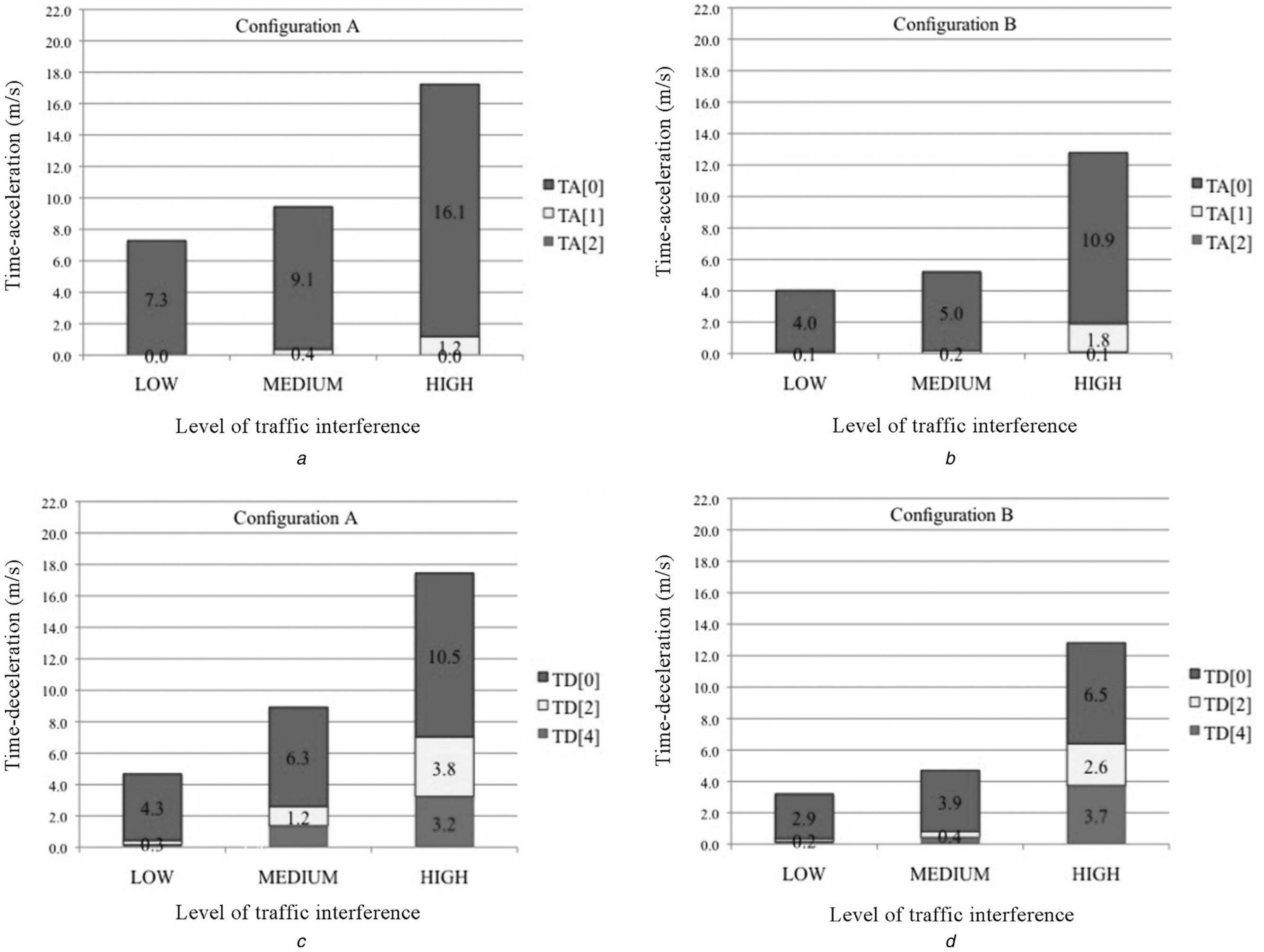


Fig. 3 *TA (a, b) and TD (c, d) values in configurations A and B*

with:

- k progressive longitudinal acceleration event on a given road section n;
- i generic moment of a longitudinal acceleration event k;
- Δt_i discrete duration (s) of a generic moment i;
- $a_{L\ i}$ longitudinal acceleration (m/s^2) at moment i.

Three threshold values (x) are proposed for describing the quantity of acceleration $QA_{[x],k,n}: x=0,\ x=1$ and $x=2$, respectively, corresponding to: $0.0 < a_L < 1.0\ \text{m/s}^2$; $1.0 \le a_L < 2.0\ \text{m/s}^2$; and $a_L \ge 2.0\ \text{m/s}^2$.

Three threshold values (y) are proposed for describing the quantity of deceleration $QD_{[y],k,n}$: $y=0,\ y=2$ and $y=4$, respectively, corresponding to: $0.0 > a_L > -2.0\ \text{m/s}^2$; $-2.0 \ge a_L > -4.0\ \text{m/s}^2$; and $a_L \le -4.0\ \text{m/s}^2$.

This way, deceleration is divided into a transition status $y=0$ when longitudinal acceleration is interrupted, and inertia leads acceleration to assume negative values; a proper deceleration status $y=2$; and a braking phase $y=4$. Therefore, quantities of acceleration and deceleration per threshold are so defined

- $QA_{[0],k,n} = \sum (\Delta t_i \times a_{L\ i})_{k,n}$, for $0.0 < a_L < 1.0\ \text{m/s}^2$ (m/s);
- $QA_{[1],k,n} = \sum (\Delta t_i \times a_{L\ i})_{k,n}$, for $1.0 \le a_L < 2.0\ \text{m/s}^2$ (m/s);
- $QA_{[2],k,n} = \sum (\Delta t_i \times a_{L\ i})_{k,n}$, for $a_L \ge 2.0\ \text{m/s}^2$ (m/s);
- $QD_{[0],k,n} = \sum (\Delta t_i \times |a_{L\ i}|)_{k,n}$, for $0.0 > a_L > -2.0\ \text{m/s}^2$ (m/s);
- $QD_{[2],k,n} = \sum (\Delta t_i \times |a_{L\ i}|)_{k,n}$, for $-2.0 \ge a_L > -4.0\ \text{m/s}^2$ (m/s);
- $QD_{[4],k,n} = \sum (\Delta t_i \times |a_{L\ i}|)_{k,n}$, for $a_L \le 4.0\ \text{m/s}^2$ (m/s).

Total quantity of acceleration $QA_{[T],k,n}$ indicates the sum of the various quantities of acceleration related to different acceleration events k on a same road section n. Similarly, $QD_{[T],k,n}$ expresses deceleration events.

$$QA_{[T],k,n} = \sum QA_{[x],k,n} \quad (\text{m/s});$$
$$QD_{[T],k,n} = \sum QD_{[y],k,n} \quad (\text{m/s}).$$

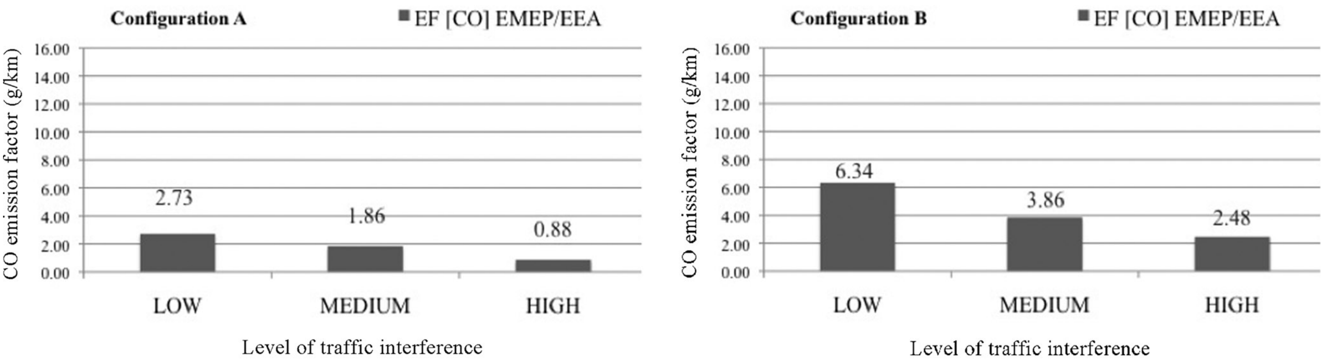
TA and TD are finally calculated through homogenisation on a comparative distance of 1 km

$$TA_{0,n} = (D_c/D_n) \times \sum QA_{[0]k,n};$$
$$TA_{1,n} = (D_c/D_n) \times \sum QA_{[1]k,n};$$
$$TA_{2,n} = (D_c/D_n) \times \sum QA_{[2]k,n};$$
$$TD_{0,n} = (D_c/D_n) \times \sum QD_{[0]k,n};$$
$$TD_{2,n} = (D_c/D_n) \times \sum QD_{[2]k,n};$$
$$TD_{4,n} = (D_c/D_n) \times \sum QD_{[4]k,n}; \quad (m/s)$$

with:

- D_n distance (km) of the targeted road section;
- D_c comparative distance: $D_c = 1$ km.

Parameters TA and TD, referring to different thresholds, can be summed up in a same road section n; total TA_T and total TD_T are



a *b*

Fig. 4 *CO EFs calculated through the EMEP/EEA static method*

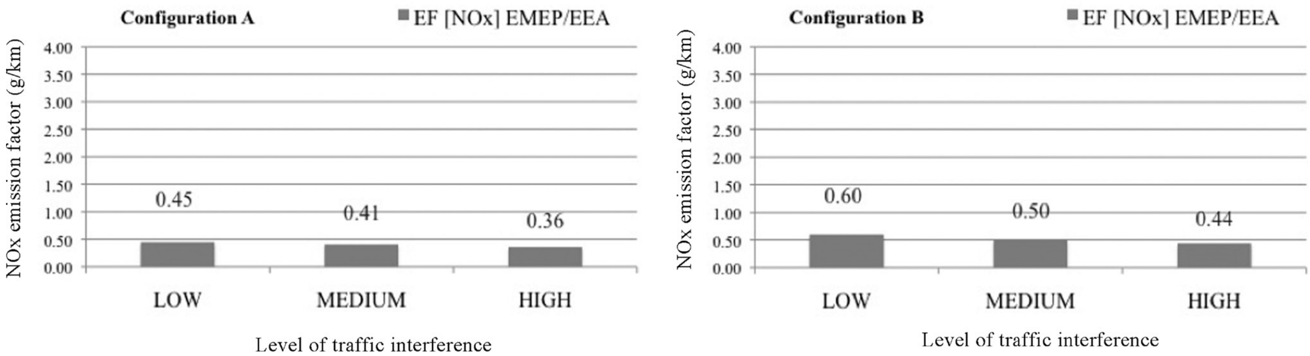
a Configuration A (old 2-lane highway)
b Configuration B (renovated 3-lane highway)

so defined

$$\mathrm{TA}_{\mathrm{T},n} = \sum \mathrm{TA}_{x,n} \quad (\mathrm{m/s});$$

$$\mathrm{TD}_{\mathrm{T},n} = \sum \mathrm{TD}_{y,n} \quad (\mathrm{m/s}).$$

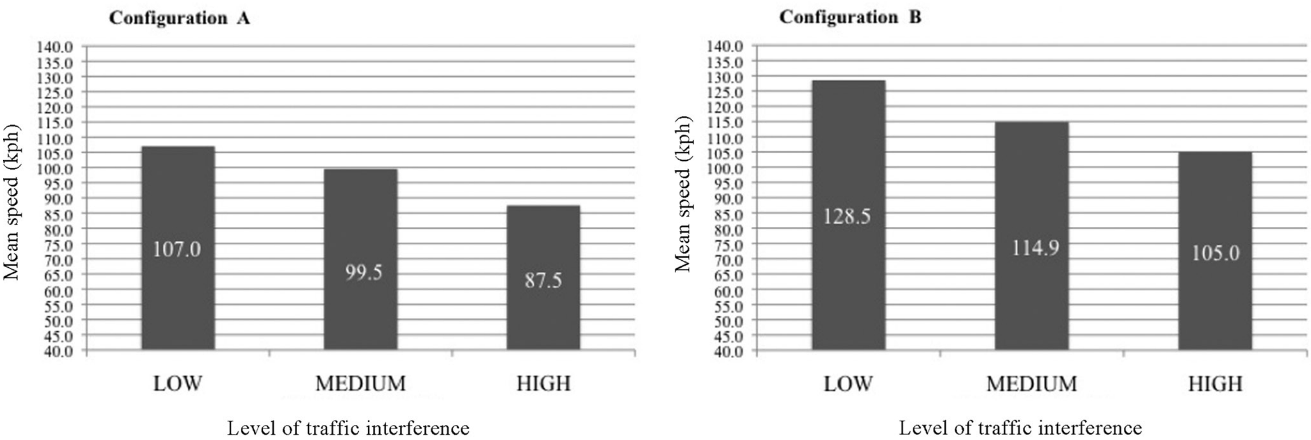
In both configurations A and B, TA values (Figs. 3*a* and *b*) significantly increase from medium to high vehicular interference conditions, with values that are approximately twice higher than average values related to low and medium interference. Similarly, TD values (Figs. 3*c* and *d*) are lower for lower vehicular interference, and increase with higher fluxes, especially for components $\mathrm{TD}_{[4]}$ that are associated with the braking status. TA and TD values suggest that significant variation in longitudinal speed happens in both configurations A and B, especially for *F/C*



a *b*

Fig. 5 *NO_x EFs calculated through the EMEP/EEA static method*

a Configuration A (old 2-lane highway)
b Configuration B (renovated 3-lane highway)



a *b*

Fig. 6 *Mean speed levels in different traffic flow scenarios*

a Values recorded in configuration A (old 2-lane highway)
b Values recorded in configuration B (renovated 3-lane highway)

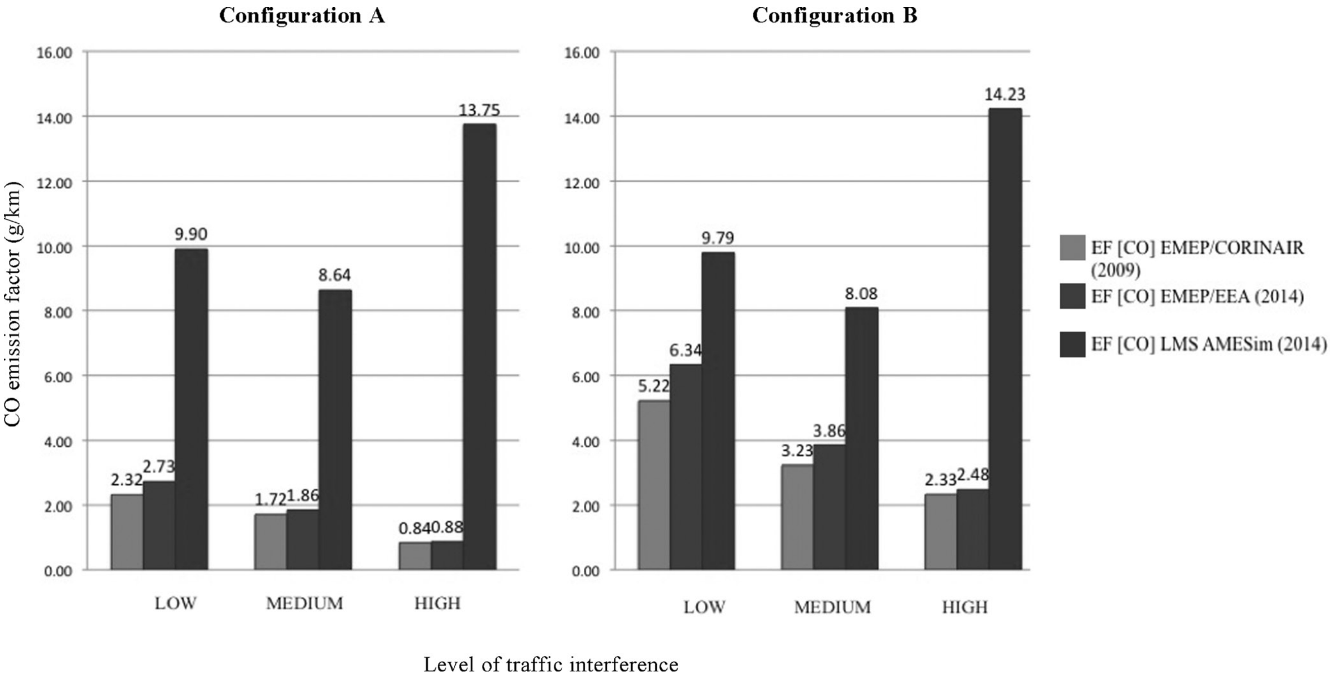


Fig. 7 *Carbon monoxide EFs*

ratios higher than 0.75. In high vehicle interference conditions, the higher dissipation of energy implies a higher energy demand.

The EFs for NO_X and CO are first computed with the EMEP/EEA model (2014). A correlation between EFs (Figs. 4 and 5) and mean speed (Fig. 6) can be noticed. In fact, mean speed (V) is an essential parameter in the formulas of this model

$$\mathrm{EF}_{[\mathrm{CO}]} = 0.0037V^2 - 0.5215\,\mathrm{V} + 19.127; \qquad (1)$$

$$\mathrm{EF}_{[\mathrm{NO}x]} = 7.55 \times 10^{-05}V^2 - 0.009\,\mathrm{V} + 0.666; \qquad (2)$$

Since a Euro III light-weight gasoline passenger car is simulated, the relative prescribed reduction factors for $\mathrm{EF}_{[\mathrm{CO}]}$ and $\mathrm{EF}_{[\mathrm{NO}x]}$ are applied: 48 and 79%, respectively to (1) and (2).

These EFs are then compared with the ones computed through the dynamic software LMS AMESim. CO EFs are also calculated through the EMEP/CORINAIR model [26], which was previously used (2003–2009) within the EMEP programme. For NO_X, the dynamic model shows values from 2.5 to 4 times higher than the static model does, both in configurations A (old 2-lane highway) and B (new 3-lane highway). However, neither of the two models predicts any significant variation in the release of NO_X after modernisation.

More interesting is the case of the CO emissions. On the one hand, the EMEP static models underestimate the releasing rates of CO two to five times. On the other hand, the dynamic model suggests a different trend (Fig. 7): the static models predict a reduction in the CO EFs as traffic interference increases (i.e. as average speed decreases, according to speed-flow curves); the dynamic model presents a reduction in EFs only from low to medium traffic interference, while assessing the highest levels of emissions when traffic flow conditions are high.

According to Xue *et al.* [4] and Ke *et al.* [5], a partial significant contribution of higher speed values to the release of CO is accepted as probable. In particular, comparing the new highway (configuration B) to the old highway (A), the first allows keeping on average higher velocities (Fig. 6). These velocities partially explain why more CO emissions are predicted by the static models for configuration B. Similarly to the NO_X EFs, an underestimation is considered possible also for COs. This said, the contribution of the interfering traffic flow implies an exponential increase in the EFs. Conversely, static models do not highlight this phenomenon. The need for a correcting parameter is here detected, in order to keep track of the emissions released with medium and high traffic interference. A correction, able to predict more reliable CO EFs, could be expressed by adding a term EF(*F/C*) to the formula (1), with EF(*F/C*) dependent on traffic flow conditions. A correction is considered to be necessary also to balance the underestimations noticed in (1) for the EF associated with speed

$$\mathrm{EF}(V) = \alpha\,\mathrm{EF}(V)_{\mathrm{EMEP/EEA}} \qquad (3)$$

A correcting parameter EF(*F/C*) is here designed starting from this experimentation, composed of an exponential factor and a reducing linear factor, both dependent on traffic flow conditions

$$\mathrm{EF}(F/C) = \beta(F/C) + \gamma \mathrm{e}^{[\delta(F/C)]} \qquad (4)$$

- $\beta < 0$, in order to mitigate the effect of the exponential function for low F/C values;
- $\gamma > 0$ and $\delta > 0$.

For the case study in Configuration B (new highway), a formula can be extracted starting from the CO EFs predicted through the dynamic model, and the N/C ratios recorded during the drive simulations. Coefficients α, β, γ and δ are here associated with the following numbers

$$\alpha = 1.45; \quad \beta = -1.6; \quad \gamma = 0.2; \quad \delta = 4.75.$$

Though, these parameters can be only referred to the present study. More experimentation would be needed in order to find accurate values able to represent emissions in other circumstances.

4 Conclusions

This paper compares EFs from road transport calculated with both static and dynamic models. A research in virtual reality is conducted to simulate driving with different levels of traffic interference. Simulated roads represent a real highway section before and after major renovation works.

Results show that the EFs predicted through the EMEP methodologies (static models) are not accurate if compared with the ones simulated in virtual reality and computed through the dynamic model: in particular, NO_X and CO EFs are substantially lower if calculated through the static models, especially in the presence of medium and high traffic volumes. In fact, the dynamic model assesses increasing fuel consumption and emissions release with medium and high traffic interference. As per the initial hypothesis, the dynamic model confirms the significance of the velocity variability. On the other hand, driving cycles are identified as crucial. As per the comparison of the emissions in the two simulated configurations, i.e. before and after the modernisation works, it can be observed that a reduction in pollutant emissions in the post-operam phase – though feeble (−7%) – is only registered in conditions of medium inter-vehicular interference, while no significant change can be detected in case of low and high traffic flow; this is ascribed to a balance between the increase in the maximum speed achievable, and the wider cross-section. Furthermore, these data all refer to the emissions (g/km) of a single vehicle, whereas more vehicles are expected and simulated on the renovated infrastructure.

Some synthetic parameters are proposed to support the analysis: they are based on acceleration and deceleration, and thus able to express a correlation between the drivers' behaviour and the pollutant emissions released. These parameters can be used as a testing tool for the analysis of more drive simulations regarding emission assessment models.

The need for correcting parameters, able to correct the EU official estimation formulas, is also one of the findings of this research. Correcting parameters should take into account the variations in fuel consumption and in emissions release, which are associated with the variation in speed. On the basis of the data of this experimentation, a possible structure is proposed; though, more experimentation is needed for their definition and validation. Future researches could employ on-road real-time data, in order to complete the investigation here illustrated.

The significance of the relation between medium/high traffic flow conditions and pollutant emissions, observed in this study, can be considered a valuable decision-support information; when levels of inter-vehicle influence become critical, intervention is not only required to upgrade the road's level of service, but also to reduce its environmental impact and energy consumption. To do so, critical traffic levels could be detected by employing emerging technologies such as VANETs or other sensor and devices installed on the roadside, with on-board cruise control systems helping reducing energy consumption and emissions release even with low traffic interference. In a wider frame, a need is noted for successful and long-lasting ecologically compatible transport strategies to go beyond the expansion paradigm for private motorised mobility, since enlarging infrastructures can only mitigate and postpone critical emission situations of a single vehicle, while affecting atmospheric pollution in view of a higher demand created.

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