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Influence of vehicle driving parameters on the noise caused by passenger cars in urban traffic

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ABSTRACT

In this work, a sample of vehicles has been instrumented to measure of variables that influence vehicle noise emissions in Madrid. A circuit reproducing a normal travel pattern in large city is traveled by a fleet of vehicle models representing the fleets of cars in a European city. A sample of drivers covers the test track under different traffic conditions. Driving parameters and noise emitted have been recorded in each test and average values have been extracted. These data have been analyzed to define the noise emissions produced by a vehicle in real driving conditions and to identify the noisiest driving behaviors.

1. Introduction

About 20% of the EU population are estimated to suffer noise levels considered to be unacceptable, and another 45% to live in areas where noise can cause serious annoyance (Affenzeller and Rust, 2005). On average, about half of the noise in urban areas is produced by road traffic, and this has become a cause of social tension between economic development and quality of life in some places. Despite the efforts made to reduce the noise emissions of individual vehicles, noise disturbance is not diminishing largely because of the growth of the vehicle fleet.

Current abatement legislation in Europe is based on the noise level of a vehicle according to test procedures in Directive 70/157/EEC (European Economic Community, 1970). If a vehicle exceeds the maximum level established, it is approved for use. The maximum noise level depends on the category and type of the vehicle and has been declining gradually with updates of the Directive. Given traffic growth, however, his reduction has done little to reduce the overall traffic noise (Sandberg, 2001). One reasons for this is that the test does not properly represent the noise level emitted by a car in real driving conditions but is rather based on specified, specific conditions.

To determine noise emission levels in real driving conditions, we initially establish the parameters that cab influence on noise emission (Ochieng et al., 2004) and then take a representative sample of vehicles and drivers to represent average driving behavior based on a route that approaches average driving condition in large cities (Ericsson, 2000).

The drivers behave as they usually do with one exception, an expert driver who drives aggressively to allow comparison of such behavior with normal driving parameters and noise emissions. This allows identifying of driving behavior that has particularly adverse effects on vehicle noise and parameters that could be used to detect this.

2. Methodology

Passenger car vehicles representative of the current Spanish fleet are studied for their noise contribution (Asociación Nacional de Fabricantes de Automóviles y Camiones, 2009). The following vehicles are examined: B-segment vehicles (com-

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Table 1
Characteristics of selected vehicles.

Vehicle	Segment	Engine type	Engine size (cm^3)	Vehicle mass (kg)	Tire size
Seat Ibiza	B	Diesel	1598	1170	185/60 R14
Seat Ibiza	B	Gasoline	1390	1049	185/60 R15
VW Golf	C	Diesel	1968	1314	205/55 R16
Opel Astra	C	Gasoline	1598	1373	205/55 R16
Audi A4	D	Diesel	1968	1475	215/55 R16
Mercedes C180	D	Gasoline	1796	1485	225/40 R18

pact cars) that amounted to 30% of the Spanish fleet in 2010; C-segment vehicles (midsize cars), 29% of the fleet; and D-segment vehicles, 15% of the fleet. Other segments have a much smaller impact on urban traffic and are no included.

For each segment, a diesel engine model and a gasoline engine model have been selected. Brands and models have been chosen after analyzing the vehicle sales registration statistics. Table 1 summarizes their characteristics:

The test path has been selected according to:

- *Representativeness*: According to (Banister et al., 2000) over 75% of the EU population live in urban areas and around 20% of all miles traveled are urban trips. The circuit is thus representative of the average urban journey that a driver takes in his daily activities (commuting, shopping, etc.) These types of trips account for about 80% of trips in large cities. The average trip on urban roads is between 8 and 12 km.
- *Traffic density*: Traffic levels in the selected area are high but not outside of the range of many cities.
- *Noise emissions level*: The selected area, taken from the *Strategic Noise Map of the Madrid City* (Ayuntamiento de Madrid, 2006), embraces zones afflicted with high traffic noise levels.

Carabanchel, the circuit selected in Madrid, is divided into zone according to noise nuisance (Fig. 1) based on day equivalent continuous noise levels (Fig. 1). The test track has a day equivalent continuous noise level of between 70 and 75 dB (A) and traffic a density of 20,000–40,000 vehicles per day. It includes roads with a variety of speed limits, generally 50 km/h, but some sections are limited to 30 km/h. Half of it involves two-lane two-ways streets, and the other 50% runs through four-lanes, two-ways streets. The circuit is 8500 m long and has 25 traffic lights and three roundabouts. Tests are carried out using the different drivers randomly. Drivers perform the circuit taking into account traffic conditions and the tests are carried out different times (morning and afternoon) and on several days of the week. They involved 21 drivers, selected to cover a range of driving skills (Jackson et al., 2006);

- Five men, with more than 5 years of driving experience (Driver category A).
- Five men, with less than a year of driving experience (Driver category B).
- Five women, with more than 5 years of driving experience (Driver category C).
- Five women, with less than 1 year of driving experience (Driver category D).
- One professional driver (to simulate aggressive driving) (Driver category E).

The professional driver deliberately drove aggressively to try to reduce travel time. He drove fast and selected gears lower than normal to increase the acceleration of the vehicle when making continuous lane changes. The rest of the drivers drove in their same usual way taking into account traffic conditions.

In terms of technology, a microphone was placed inside the engine space, near the inlet valve, and a second close to the rear wheel, opposite the exhaust pipe (Robertson et al., 1998).

3. Results

A vehicle's speed is recorded when it is in motion along with stopped time to calculate its average speed. The difference in average speeds of drivers by category is only around 7% compared to the aggressive driver that is around 20%. No significant differences is found in the average speed for vehicles by driver category, including the "aggressive" driver, indicating vehicle types does not greatly influence average speed when driving. Taking all drivers and vehicles, and assuming they represent a normal distribution, with driver *E* excluded from the calculation, the average value of the "normal" drivers is 29.7 km/h[1] whereas it is 37.7 km/h for the aggressive driver.

The novice drivers, categories C and D, are 7% slower when driving larger vehicles than more experienced drivers, and men with more experience (category A) are significantly faster than other categories across all vehicles. On the other hand, the variation of speed is 30% less for the standard drivers than for the aggressive one reflecting the smoother driving. Standard drivers use second and third gears most, with the aggressive driver preferring first and second.

[1] To average 29.7 km/h it is necessary to exceed the speed limit at least 17% of the time.