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Point-to-point speed enforcement systems: Speed limits design criteria and analysis of drivers' compliance

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ABSTRACT

Point-to-point (P2P) speed enforcement is a relatively new approach to traffic law enforcement. Its technology allows vehicles whose average speed exceeds the speed limit over the controlled section to be fined. It therefore encourages compliance over distances longer than those where spot enforcement policies have been in place.

In this paper, a procedure for consistently setting speed limits with such enforcement systems is proposed. Such a method has been applied to design the speed limits on two motorways in the district of Naples, Italy, where P2P enforcement systems became operational in 2009 and 2010. The speed limits, which were set using the Italian geometric design standard to assess vehicle stability and stopping sight distance, have been compared with those provided by using well-known international standards.

The impact of the newly designed speed limits and of the P2P enforcement system on drivers' speeding behaviour has been quantified for each highway section and vehicle type. In fact, accurate measurements of the average travel speeds of each vehicle crossing the enforced sections, before and after the activation of the system, were available. The migration from the old speed limits with spot speed enforcement to the new approach resulted in a notable increase in drivers' compliance to the speed limits with a remarkable decrease in both the average of individual speeds and in their standard deviation.

In addition, the analysis of 3 years of data shows that a gradual adaptation of drivers' behaviour to the system took place. In particular, a decreasing compliance to the speed limits points to a non-optimal system management. Finally, the results of a revealed preference survey allowed us to make a behavioural interpretation regarding the significantly different impacts measured on the two motorways.

1. Introduction

Travelling at too high speed for the road environment is considered to be a major factor contributing to road crashes (Aarts and van Schagen, 2006; Hauer, 2009; Montella and Imbriani, 2015; Montella et al., 2010, 2011, 2015; Neuman et al., 2009; OECD, 2006; Yannis et al., 2013). Speeding is not simply driving faster than the speed limit; it is also driving within the speed limits but too fast for the prevailing weather, light, traffic and road conditions (Montella et al., 2013; NHTSA, 2012).

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Speeding is an aggravating factor in all crashes. The relation between speed and safety depends on two fundamental aspects: the relationship between speed and the crash risk and the relationship between speed and the crash severity. Higher speeds imply greater difficulty in driving task and therefore a greater crash risk. At higher speeds, the time to react to changes in the environment is shorter, the stopping distance is greater, and the vehicle's manoeuvrability is reduced. However, the greatest effect of high speed is on the consequences of the crashes. The higher the collision speed the more severe the consequences in terms of injury and material damage. This is because the energy dissipated in a crash increases with the square of collision speed. At a higher impact speed, more energy is released when colliding with another vehicle, road user or obstacle. Part of this energy is absorbed by the vulnerable human body. Furthermore, also speed variability affects safety. The greater the speed variability, the greater the crash frequency (Aarts and Van Schagen, 2006; Montella et al., 2015) and the crash severity (Yu and Abdel-Aty, 2014a, 2014b).

Despite understanding that speeding is a high-risk behaviour, speeding is common and is seen as normal and socially acceptable by many drivers (Fleiter et al., 2010). Indeed, there is evidence that many drivers regard speeding as one of the least serious traffic offences (SARTRE, 2012). For this reason, significant resources are dedicated to reducing speeding across the road network and new initiatives and technologies are continually being developed and trialed in an attempt to increase speed compliance. These initiatives include public education campaigns, speed limit reviews, police enforcement and fixed speed cameras.

One issue regarding speed enforcement by speed cameras is that some motorists brake before passing a speed camera and then speed up again after they have passed it. Thus, a reduction in speed is obtained only on a very short section of a road. This issue can be overcome by the employment of point-to-point (P2P) speed enforcement, also known as average speed enforcement or section speed enforcement (Lynch et al., 2011; Soole et al., 2012, 2013), which is a relatively new approach to traffic law enforcement that has increased in use in a number of highly motorised countries in the last decade. Unlike traditional spot-speed enforcement, which measures the speed of a vehicle at one point, point-to-point enforcement involves the calculation of the average speed of each vehicle over a section and therefore encourages compliance over greater distances. Point-to-point enforcement involves the installation of a series of cameras and detectors at multiple locations along a stretch of road. At each monitoring location, for every crossing vehicle, the P2P system captures an image of the vehicle's number plate and records its passing time. Automatic number plate recognition, using high-definition infrared digital cameras and optical character recognition software, is then used to identify and track each vehicle crossing the monitoring locations. The average speed of each vehicle travelling between two consecutive monitoring sites is calculated by dividing the distance between the sites by the time taken for the vehicle to cross the section between the sites. In principle, an offence is committed when the vehicle's average speed exceeds the speed limit in at least one of the monitored sections (and not when the vehicle is driving too fast at a particular location).

Though P2P speed enforcement systems are in use in many places around the world, there is no established method as regards the setting up of suitable speed limits for the sections enforced by such a system. Current methods provide speed limits which may vary along the road, but in the case of a P2P enforcement system, a unique speed limit for an entire section of the road has to be set. The adoption, for the entire section, of the speed limit value for which all critical design-speed-related criteria are met at any location along the section may result in speed limits that appear inconsistent and are ignored by the majority of drivers. A way of establishing speed limits capable of balancing safety concerns and drivers' travel expectations is clearly needed, therefore. Such a balance cannot be achieved, however, if the impact of such a system of enforcement on the compliance of drivers to the speed limits is not taken into account.

This paper proposes a procedure for setting speed limits consistent with P2P enforcement systems. The method has been applied to the establishment of speed limits on two motorways in the district of Naples, Italy where a P2P enforcement system became operational in 2009 and 2010. In order to thoroughly understand the method, the designed speed limits, which were set using the Italian geometric design standard to assess vehicle stability and stopping sight distance, have been compared with those that would been provided by using well-known international standards.

The impact of the speed limits and of the P2P enforcement system on drivers' compliance has been quantified for each highway section and vehicle type based on accurate individual vehicle speed measurements available before and after the implementation of the system. Furthermore, the availability of vehicle speed data from the system for 3 years after its activation allowed us to trace the evolution in time of drivers' compliance to the speed limits, i.e., how drivers adapted to the system. To the best of our knowledge, no similar analysis has been carried out in the previous literature.

In addition, as driver compliance on the two motorways turned out to be notably different, a revealed preference survey was conducted in order to try and interpret this fact.

The remainder of the paper is organised as follows: Section 2 presents a brief state-of-the-art description of speed limit design criteria and the effects of the point-to-point speed enforcement. Section 3 describes the system in operation at the study sites. Section 4 describes the proposed methodology for setting the speed limits. Then, Section 5 describes the application of the methodology to the case studies of the two Italian motorways – the A56 "Tangenziale di Napoli" and the A3 Naples-Salerno. Speed data, along with results of the interviews regarding drivers' perception of the speed limits, are presented in Section 6. Finally, a short discussion that places the results in the context of highway engineering practice and brief conclusions are presented in Section 7.