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# Effects on speed and safety of point-to-point speed enforcement systems: Evaluation on the urban motorway A56 Tangenziale di Napoli

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ABSTRACT

In this paper, we evaluated the effects on speed and safety of the point-to-point (P2P) speed enforcement system activated on the urban motorway A56 in Italy. The P2P speed enforcement is a relatively new approach to traffic law enforcement that involves the calculation of the average speed over a section. To evaluate the speed effects, we performed a before–after analysis of speed data investigating also effects on non-compliance to speed limits. To evaluate the safety effects, we carried out an empirical Bayes observational before-and-after study.

The P2P system led to very positive effects on both speed and safety. As far as the effects on the section average travel speeds, the system yielded to a reduction in the mean speed, the 85th percentile speed, the standard deviation of speed, and the proportion of drivers exceeding the speed limits, exceeding the speed limits more than 10 km/h, and exceeding the speed limits more than 20 km/h. The best results were the decrease of the speed variability and the reduction of the excessive speeding behaviour. The decrease in the standard deviation of speed was 26% while the proportion of light and heavy vehicles exceeding the speed limits more than 20 km/h was reduced respectively by 84 and 77%.

As far as the safety effects, the P2P system yielded to a 32% reduction in the total crashes, with a lower 95% confidence limit of the estimate equal to 22%. The greatest crash reductions were in rainy weather (57%), on wet pavement (51%), on curves (49%), for single vehicle crashes (44%), and for injury crashes (37%). It is noteworthy that the system produced a statistically significant reduction of 21% in total crashes also in the part of the motorway where it was not activated, thus generating a significant spillover effect.

The investigation of the effects of the P2P system on speed and safety over time allowed to develop crash modification functions where the relationship between crash modification factors and speed parameters (mean speed, 85th percentile speed, and standard deviation of speed) was expressed by a power function. Crash modification functions show that the effect of speed on safety is greater on curves and for injury crashes.

Even though the study results show excellent outcomes, we must point out that the crash reduction effects decreased over time and speed, speed variability, and non-compliance to speed limits significantly increased over time. To maintain its effectiveness over time, P2P speed enforcement must be actively managed, i.e. constantly monitored and supported by appropriate sanctions.



## 1. Introduction

Drivers' speed inconsistent with the road environment is among the most significant crash contributing factors (Council et al., 2010; Hauer, 2009; Montella and Imbriani, 2014; Montella et al., 2010, 2011; Neuman et al., 2009; OECD, 2006; Yannis et al., 2013). Speeding is both driving faster than the posted speed limit as well as driving too fast for the prevailing weather, light, traffic and road conditions, but within the speed limits (Montella et al., 2013; NHTSA, 2012). The relation between speed and safety rests on two pillars: (1) the relationship between speed and the crash risk and (2) the relationship between speed and the crash severity. Higher speeds imply greater driving task difficulty and therefore greater crash risk. At higher speeds, the time to react to changes in the environment is shorter, the stopping distance is larger, the manoeuvrability is reduced, and it is more difficult to react in time and prevent a crash. However, the greater effect of speed is on the injury consequences of the crashes. The higher the collision

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speed, the more severe the consequences in terms of injury and material damage. This is because the energy dissipated in a crash goes up 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. Hence, higher speeds result in more severe injury.

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). The culture of speeding is so embedded that exceeding the posted speed limit is perceived as normal. Indeed, there is evidence that many drivers regard speeding as one of the least serious traffic offences (SARTRE, 2012). Thus, significant resources are dedicated to reducing speeding across the road network and new initiatives and technologies are continually being developed and trialled in an attempt to enhance speed compliance. These initiatives include public education campaigns, speed limit reviews, police enforcement, and fixed speed cameras. One issue of speed enforcement by spot speed cameras is that some motorists brake before passing a speed camera and then speed up to above the speed limit after they have passed it (De Pauw et al., 2014). Thus, a speed reduction is obtained only on a short section. This issue is overcome by the point-to-point (P2P) speed enforcement, named also average speed enforcement or section speed enforcement (Lynch et al., 2011; Soole et al., 2012, 2013), which is a relatively new technological approach to traffic law enforcement that has increased in use in a number of highly motorized 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 over a section and encourages compliance over a greater distance. Point-to-point enforcement involves the installation of a series of cameras at multiple locations along a road section. The average speed is calculated by dividing the distance between two camera sites by the time taken for the vehicle to travel between those two sites. If the corresponding average speed of a vehicle exceeds the posted speed limit for that road section, image and offence data are transmitted to a central processing unit from the local processor via a communication network. Indeed, with point-to-point enforcement a sanction is imposed only for an average speed exceeding the posted speed between the cameras, and not when the motorist has driven too fast when passing point A or point B. While there are capabilities for the back-office of a system to be fully automated, almost all current installations involve some degree of human verification to assess the validity of detected infringements. Validated offences are subsequently issued with an infringement notice and data on non-offending vehicles are typically erased.

To date, there are some evaluations of the system with encouraging positive findings. However, the system is not yet evaluated on a substantial scale (DaCoTA, 2012) and methodological limitations are noted across the majority of the published evaluations (Soole et al., 2012, 2013). Thus, there is a strong need for sound scientific evaluations. The P2P system was first introduced in the Netherlands where it operated in trial form in 1997 and then as a permanent installation in 2002. Currently, there are 11 permanent point-to-point speed enforcement locations on various motorways and rural roads. The number of casualties has halved on these sections (Olde Karter et al., 2005) and most drivers obey the speed limit. In the UK, P2P speed enforcement has increased considerably since its inception via a trial in 1999 in Kent and is now widely used. The overall result of average speed control is a conveyor belt type flow, with uniform speeds, little braking and larger headways (Collins and McConnell, 2008). P2P speed cameras established on corridors with a history of high crash rates have led to reductions in fatal and serious injury crashes. After the installation of P2P devices along a section of the A77 in southwest Scotland in 2005, a 19% reduction in all crashes was observed, with fatal crashes falling by 46% and serious injury crashes by 37% (Soole et al., 2012). In Australasia, P2P speed enforcement was introduced in 2007 in the State of Victoria. Currently, New South Wales has a total of 21 road segments enforced by P2P speed camera systems and a trial is being conducted in New Zealand (Soole et al., 2012, 2013). In Italy, the P2P speed enforcement system was introduced in 2006 and includes a total of 320 P2P speed camera sites which cover more than 2900 km of the motorway network. In 2012, the system has also been applied on three national expressways. Further installations of the system are planned also on regional and provincial highways. A recent before–after study showed that the vehicle speeds, and subsequently traffic flows, were sensibly homogenized (Cascetta et al., 2011). To evaluate the safety effectiveness of the system in an 80 km segment of the Motorway A1, an empirical Bayes observational before–after study was performed (Montella et al., 2012). The estimate of the total crash reduction was 31.2%, with a lower 95% confidence limit of 24.3%. The safety effectiveness decreased over time. The crash reduction was 39.4% in the first semester after the system activation while it was 18.7% in the fifth semester. Speed data before and after the system installation were not available.

To obtain a more comprehensive evaluation of the system, this study investigates both effects on speed as well as effects on crashes after the P2P system installation on the urban motorway A56 Tangenziale di Napoli in Italy. The remainder of the paper is organized as follows. Section 2 describes the P2P system operation, the geometric data, the traffic data, the speed data, and the crash data. Section 3 describes the methods used to perform the speed analysis and the safety evaluations. Section 4 presents effects on both speed and safety as well as crash modification functions which take into account the effects of speed on safety, followed by a discussion that places the results in the context of the highway engineering practice. The last section presents the conclusions.

## 2. Study data

### 2.1. Treatment site data

#### 2.1.1. Point-to-point speed enforcement system

The system is composed of steel gantries at the section entrance and exit, with one high resolution camera (1600 pixels × 1200 pixels) with infrared flash for each lane, mounted on the gantry. Due to the privacy legislation in Italy, only rearward facing cameras are used, given that face obscuration is not considered sufficient for the protection of personal information. Other components include inductive loop detectors for each lane placed under the road pavement in two cross-sections slightly downstream from the cameras, an optical fibre network to transfer the data, a central monitoring and data processing station managed by the police, and an automatic vehicle identification (AVI) system for video-based vehicle license plate recognition. Moreover, the system is equipped with a global position system which allows the time-synchronization of all the detection points.

Whenever a vehicle crosses over the inductive loop detectors, the variation of the electromagnetic field allows the detection of the vehicle and, simultaneously, the activation of the lane-related camera. Once activated, the camera records the date and time of activation and acquires 100 frames, with a frame rate of 25 fps, which are post-processed by the AVI software for vehicle plate recognition. When the same vehicle crosses the section exit gantry, the same operation is performed. As a result, vehicles are classified in six classes (1 – car, moped, caravan; 2 – light vehicle with a trailer; 3 – heavy duty vehicle with weight in the range