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Traffic indicators, accidents and rain: some relationships calibrated on a French urban motorway network.

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Abstract

The purpose of this paper is to study the link between the occurrence of injury road accidents, the prevailing traffic conditions, and the occurrence of rain. This is useful for assessing, before its implementation, the safety impact of a new traffic management. Traffic conditions were extracted from a one year traffic database which covers 150 kilometres of two or three lanes urban motorways near the city of Marseille, in the south of France. 208 loop detectors provide the individual speeds, headways, arrival times and lengths of vehicles. Based on this information, thirteen aggregated traffic variables were constituted every six minutes, such as the average speed, occupancy, short time headways and a few combinations of speed, relative speed and time gaps.
292 injuries or fatal accidents occurred on the network during the same year. The French accident database provides their characteristics - location, time and type of accidents, meteorological conditions and other parameters addressing the infrastructure, the driver and the vehicle. The rain occurrence is provided, every six minutes, from a meteorological station.
A set of safety performance functions were estimated, each one giving the risk of injury accident by vehicle-kilometre according to the level of one traffic variable and according to the occurrence of rain. Generally based on logistic regression models, analyses were carried out separately by lane and for two types of accidents -single vehicle accidents and crashes between vehicles. Some relations linking accidents with traffic variables are significant: the occurrence of single vehicle accidents is related to the speed on the fast lane; the occurrence of multiple vehicle accidents is related to occupancy.

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Keywords: Traffic data; accident; rain;surrogate data; traffic indicators; urban motorway;risk, safety performance function, logistic regression

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1. Introduction

The assessment of a new traffic management, before its implementation, requires to assess the impact of the future values of the traffic variables on accidents. The aim of this paper is to establish the relations which quantified this impact. For safety reasons, a driver adapts his speed, relative speed, time gap and lane, according to the infrastructure (bends, slopes, intersections), traffic conditions (speed of the vehicle ahead or on the adjacent lane, density) and weather conditions. Indeed the performances of vehicles and drivers decrease on slopes and bends, and some danger may come from close vehicles. Despite this adjustment, the accident rate remains related to infrastructure, (Venkataraman et al., 2011), weather (Brodsky and Hakkert, 1988), (Bergel-Hayat et al., 2013), and traffic conditions: Golob et al. (2004) found different accident rates according to the type of crash and traffic conditions, to the temporal variations in volume and speed; Abdel-Aty et al. (2005) used traffic conditions as accident precursors; (Park and Saccomanno, 2007) highlighted speed variation. According to Nilsson (1984) or Elvik (2013), the risk is a continuous power function of the speed; it is an exponential function according to Hauer (2009) and Elvik (2014).

Relations between traffic conditions, infrastructure elements and accidents are discrete or continuous. Discrete relations provide the risk by vehicle-kilometer and by class. According to the authors, a class may combine traffic, weather and infrastructure conditions. Making a discrete relation "continuous" is possible by varying the thresholds defining the classes- see (Aron et al., 2013). This paper focuses on continuous relations. When appropriate, they give a quick understanding of the risk and might be included in simulations or in traffic management algorithms.

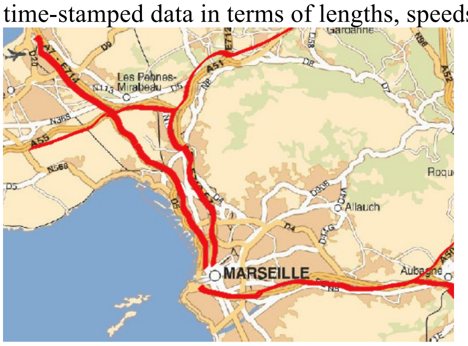
The role of speed in road safety has been demonstrated. "Speed" refers to different quantities: the speed limit at a national level, on a network, on a particular section; speeds of individual drivers recorded at particular points, or their distribution on a route; average speed on a spatial range; temporal average at a given point, by lane, or for all lanes. According to what "speed" is, the analytical pattern, the numerical values, the relevance of models vary.

In the following, we present the data in section 2 and then some continuous models, which relate the risk to different traffic indicators (section 3). We give in section 4 the relationships which proved to be significant; we discuss their limits in section 5. Section 6 is the conclusion and perspectives. Numerical results are in the Appendix.

2. Traffic, Accident and Meteorological Data

2.1. Traffic Data

CEREMA, the French centre for studies on risk, mobility and environment, collected, from June 2009 to May 2010, time-stamped data in terms of lengths, speeds of vehicles on the “Marius” network.



This network is 150 km-long. It consists in the urban parts of motorways A7, A50, A51 and A55 (in red on the Figure) around Marseille. The sections have either two lanes per direction (here called middle and slow lanes) or three lanes (fast, middle and slow lanes); 104 available traffic stations by direction, (one station every 750 meters) are available on the main carriageway and on the ramps. Missing data being not too numerous, the traffic pattern based on available data is assumed to be representative. The traffic counts and the distance between sensors lead to the estimation of 1.5 billions of vehicle-kilometres. 5,3% vehicles travel during rain, and 15% during night time (defined here between 8PM to 6AM).

Fig. 1. The Marius urban motorway network, near Marseille (France); A weather station is located in Marignane airport, at North-West.

2.2. Accident Data

The French Police collects the characteristics of all road fatalities and injury accidents. A few characteristics are used here - date, hour, minute, accurate location, number of implied vehicles, atmospheric conditions.