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Mini Review

Road Safety in Brief

Anna Granà*

Department of Engineering, University of Palermo-Polytechnic School, Italy

***Corresponding author:** Anna Granà, Department of Engineering, University of Palermo-Polytechnic School, Italy.

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Road safety issue has been the subject of study for many years and with each passing day transportation engineering expands this research area since it is a social matter of absolute priority. The expression road safety is frequently used in the current vocabulary of road users (as drivers or pedestrians), and road professionals (as technicians, designers or managers), given that the repeated occurrence of fatal, injury and property damage crashes compromise the use of highways, streets and intersections and the safety of the general community. Hauer [1] argues that the road safety concept may be related to a property of the real-world road units as road segments, intersections, vehicles, and users; each road unit may be involved in crashes and crashes may happen on it. When we think of ways to improve road safety, the associations conjuring up are the reduction in crash frequencies and risky road driving situations. Crashes are random events, rare when compared to the millions of vehicles on the roads, events not reproducible a posteriori, almost never observable if not when they have happened; although many risky road situations continually happen on units (road segments and intersections) of the road network, they don't always result in crashes [2]. Engineering countermeasures for reducing crashes require to learn more about what may cause them but drawing conclusions on the causes is no easy task since it includes uncertainties. Figure 1 shows that each movement on road is an element of the operation of the road system, whose different interacting components can present operating anomalies (both sudden and protracted over time) which, in turn, can give rise to situations of potential danger or at worst to crashes. The figure also shows the risk factors associated with each component of the road system (Figure 1).

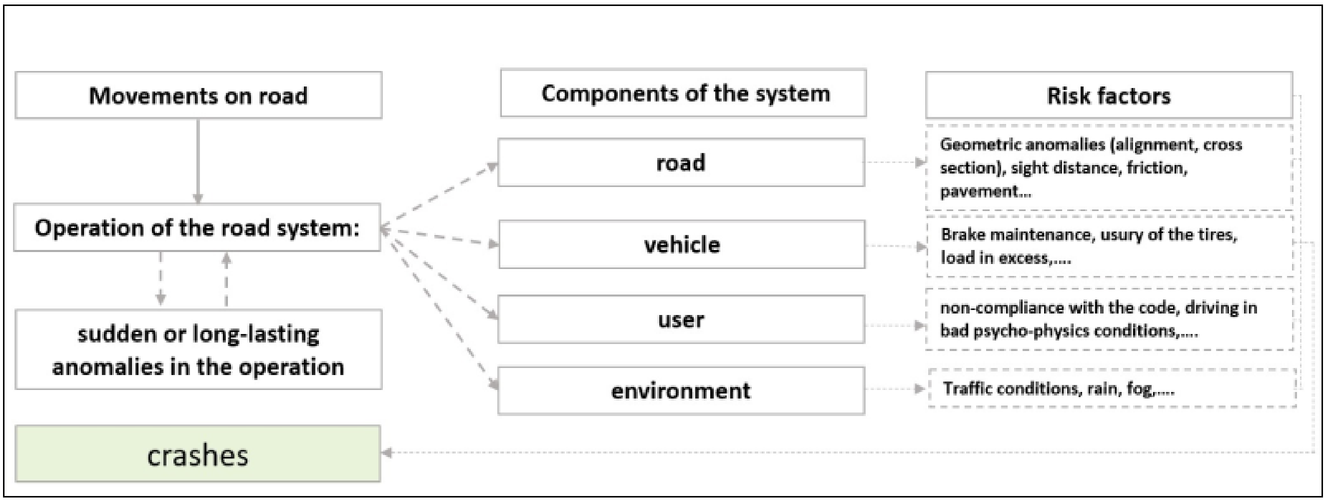

Figure 1: The components of the road system by road safety point of view.

However, road safety is linked to the crash frequency: a road on which many crashes occur compared to another road where fewer or no crashes happen is considered unsafe. Engineering countermeasures can have different effects on safety and security. It is possible that a treatment carried out to increase the safety potential of the components of the road system (the road infrastructure, the user, the vehicle) will cause an unexpected increase in the number of road crashes. Although the relationship between safety and security is interesting, transportation engineers need to measure road safety for each type of infrastructure and to assess the effectiveness of treatments in terms of safety improvements. There are therefore numerous objectives and targets, interventions and measures, policy areas and professionals involved in an integrated vision of road safety [3]. With no claim of being exhaustive, one can remember different approaches to address the road safety problems. Preventive approaches are Road Safety Audits that have been introduced in 1980s in UK as a systematic and formal examination of safety performances of (existing or new) roads or intersections by a multidisciplinary team independent from the design team. The basic objectives of Road Safety Audits are to assess potential road safety issues of the road entities under examination from the point of view of all road users, and to identify opportunities for improvements in safety through recommendations on measures to reduce or eliminate the problems identified by the team. Road Safety Audits can be done at various stages of road design from preliminary to detailed design stages, prior to and after road opening. However, potential safety concerns should be considered prior to advance to the subsequent stage of the design process or construction works [4]. Crash predictive approaches have been developed with the purpose of determining the effect of road and intersection design on the crash frequency [5,6]. Several studies have been made and research efforts have been sustained to better understand the relationship between crashes and one or more explanatory variables concerning traffic and, in some cases, geometric characteristics of roads or intersections. Given that historical crash data are the basis of analysis, the availability of updated crash databases is held essential in the regression analysis applied to develop crash prediction models. However, crash collection needs not only a long observation time, but also further information on the drivers' behavior before the crash, the causes behind it, traffic and road conditions at the time of the collision, and so on. Technique of Generalized Linear Models (GLM) has been recognized able to offer a soundly-based approach for analyzing crash data and fitting Safety Performance Functions (SPFs), while Generalized Estimating Equations (GEEs) have been also used to examine the temporal correlation of crash data that can affect the reliability of the SPF estimates [7,8]. SPFs are used to predict crash frequency for a given set of site conditions; the predicted crashes can be used alone or combined with the crash history of a specific site in order to estimate its safety performance under various conditions. In this view, the Empirical Bayes method estimates the expected long-term crash experience, which is a weighted average of the observed crashes at the site under examination and the predicted crashes from a SPF; it is well-know that EB method corrects the regression-to-mean bias. The EB method is used in the Interactive Highway Safety Design Model [9].

The predicted crash frequency that SPFs calculate is used for various activities which are typical of the project development process, including network screening, comparison among countermeasures, and project evaluation [10]. The Highway Safety Manual presents a calibration procedure to reflect local conditions; the Highway Safety Manual identifies the base conditions for each SPF and provides crash modification factors when the conditions at the site of interest differ from the average conditions. In order to overcome the difficulty to observe crash situations and other lacunae in the crash data, traffic conflict techniques have been used to analyze the road situations through more easily observable traffic conflicts than crashes [11]. Differently from statistical methods used to analyze crash data and develop crash prediction models, traffic conflict technique allows us to study the road situations and to observe traffic conflicts. A traffic conflict study is, indeed, a systematic method of observing and recording traffic conflicts, and enabling the analysis of other events associated with safety and operations of road and intersections [12]. Proactive methods for safety analysis of road units have been through a lot of change lately. There is high potential for a road safety analysis to provide appropriate information since traffic simulation models incorporate the traffic conflict techniques [13]. Simulation-based surrogate safety measures have also been the subject of recent research [14]. As it is well known surrogate measures of safety encompass safety measures that do not rely on crash data and are applied to assess the safety performance of any road unit using vehicle trajectories files exported from microscopic traffic simulation models. In recent years, the Surrogate Safety Assessment Model (SSAM) software has caught attention of transportation engineers and it has been used considerably in professional practice as an approach to road safety assessment. The SSAM processes trajectory outputs generated by traffic microsimulation models, detects traffic conflict events examining vehicle-to-vehicle interactions, and classifies the conflicts by type; the SSAM estimates the surrogate measures of safety for pairs of vehicles that are involved in a traffic conflict [15]. Recent studies have highlighted that assessment of road safety performance through the surrogate measures of safety can depend on the microscopic traffic simulation model used for the analysis; the built of the road unit model in simulation environment and the subsequent simulation can affect the generation of the trajectory files from microsimulation. Thus, calibration of these models should be carefully considered so as not to compromise their ability to reproduce the real-world traffic conflicts; see e.g. [16]. Future developments can include studies focusing on the relationship between crashes and simulated traffic conflicts, and the use of surrogate measures as a sound basis for comparing safety performance of different road and intersection design layouts; automated safety analysis based on reliable assessment tools using surrogate measures of safety can be useful to deliver timely estimates to adapt to the technological safety-affecting advancements in intelligent infrastructures and connected vehicles.

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Conflict of Interest

No conflict of interest.

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