Towards linking driving complexity to crash risk

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Abstract

Complementary to classical road safety approaches aimed at improving infrastructure, there is growing evidence about the relationship between motorway crashes and traffic conditions. Unstable or congested flow can drastically increase cognitive workload for motorists which, combined with reduced freedom to perform needed maneuvers (e.g. lane changes), increases crash risk. While these conditions are usually described by macro factors such as average traffic speed, modern vehicle detection technologies allow analysis of individual vehicle behaviors (micro level). This paper discusses the value of refined detection and analysis methodologies to develop Intelligent Transport System based road safety improvement strategies.

Traffic performance is determined by random interactions between individual vehicles

Improving road traffic safety and efficiency on highly saturated urban motorways and high-volume arterials requires an understanding of the complex traffic phenomena such as unstable or congested traffic flow, including wide moving jams and of the mechanisms that can trigger them. Such phenomena increase crash risk. For example, as motorways approach capacity, there is an increasing number of interactions between individual vehicles that cause traffic to slow down, longitudinal oscillating waves to form, and lane change numbers to rise.

Along with a heterogeneous vehicle fleet comes an even more diverse driver population expressing numerous behaviours which influences interactions between vehicles and ultimately determines the overall traffic performance outcome of a system. Human behaviours include unique personal (instantaneous) choices of:

- Speed;
- Travel lane;
- When and where to change lanes;
- When to enter and/or leave the motorway; and
- Gear changing, mirror glancing, braking and acceleration actions to maintain their position within the traffic stream.

The human element creates complexity, and this creates human error

Drivers can perform certain simple tasks with relative ease with minimal chance of error. Higher speed driving (with lower traffic densities) on motorways does not always result in proportionally more crashes (i.e. higher crash risk) nor necessarily lead to increased congestion. However, as the number of vehicles per kilometre (i.e. density) rises there is an increasing number of inter-vehicle interactions with vehicle movements between different lanes (e.g. lane changes) or vehicles in the same lane performing abrupt braking or other manoeuvres. These interactions compound the driving task which with the reducing road space available (caused by rising volumes as well as numerous individual vehicle manoeuvres) requires considerably more skill and precision by the driver and additional collaboration between drivers to perform seemingly normal and simple tasks such as lane changing to gain advantage in the flow, to fill all motorway lanes to capacity, or to reposition the vehicle into the slow lane for a nearby exit.

As a result, there is growing evidence relating to the relationship between motorway crashes and traffic state (Golob, Recker & Alvarez, 2004; Hovenden, Zurlinden & Gaffney, 2018).

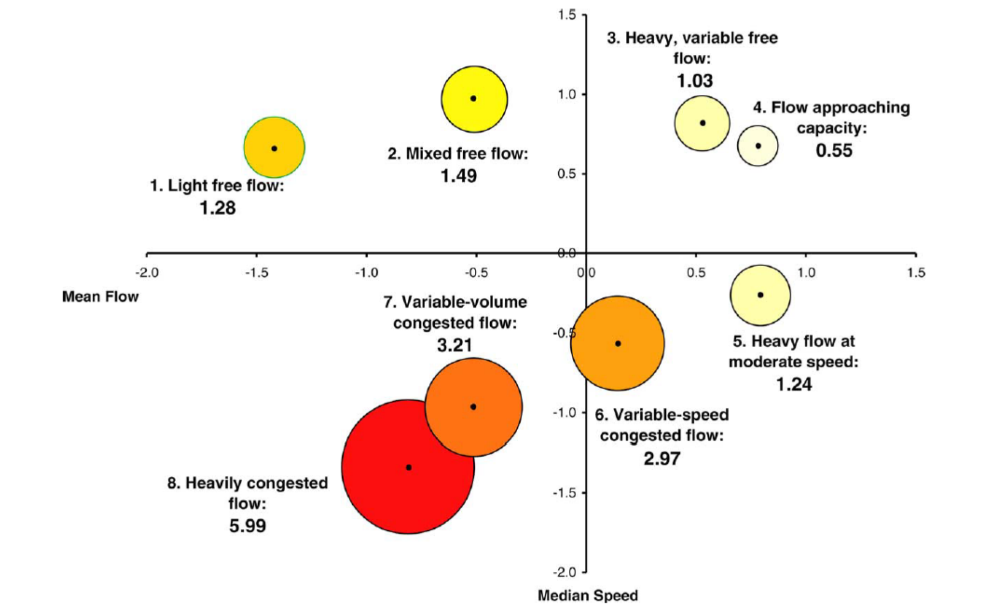

Fig. 6. Estimated total crashes per million vehicle miles of travel for the eight traffic flow regimes during a.m. peak hours, plotted in standardized speed–flow space.

Figure 1. Estimated Crash Rates / Types for Traffic Flow Regimes (Source: Golob et al., 2004)

New insights through new measurement technology

New insights into the mechanisms that cause unstable flow or congestion, including individual vehicle maneuvers, are now possible due to advancements in detection technology (e.g. infrared technologies), which provide richer, finer grained (vehicle events and smaller time periods) and more accurate data sets. This enables real-time control of numerous compounding and complex motorway phenomena and their triggers, e.g. through improved design limiting the number of needed lane changes or an improved Coordinated Ramp Metering Signal system, in turn improving road safety. Measurement and analysis of lateral movement data (i.e. lane changes) is also suitable to explain many of the phenomena linked to merging, diverging and weaving (e.g. reduced capacity).

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