Roadway Crashes: A Systems Approach to Understanding Causes

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Human factors and traffic safety scientists analyze the relative contributions of a host of potential causal factors to passenger vehicle and heavy vehicle crashes. Specifically, the individual and combined contributions of road user factors (e.g., age, impairment, inattention), vehicle factors (e.g., height, safety features, location of A-pillars), and environmental/roadway factors (e.g., functional class, geometrics, signs, markings, lighting) to a crash can be identified, assessed, and documented by the human factors specialist. Understanding how these inter-related factors contribute to driver confusion, misperception, errors, and subsequent crashes plays a critical role in assessing crash causality as well as the broader safety performance of intersections, road junctions, and highways. A rigorous approach to identifying the impacts of human factors on crashes will become even more valuable with the added complexities of modern advancements in transportation (e.g., connected and automated vehicles, motorized scooters and bikes for hire).

Critically, decades of crash data and models of human error make it clear that interactions between road users, vehicles, and the environment often lead to crashes. For example, a crash involving a vehicle striking a pedestrian doesn't typically happen just because a roadway is wet and lane markings are less than optimally visible; rather, it might happen to an older driver, driving at night, when answering a call on a cell phone. In these instances, crashes do not generally reflect the breakdown or occurrence of a single factor—as in models of crashes that refer to a broken link in a causal chain—but, rather, reflect a confluence of factors that occur more or less simultaneously. Fundamentally, applying human factors to investigate crash causality involves detailed analyses of the "who," "where," and "why" of crashes.

Addressing human factors considerations is especially valuable to state transportation agencies that have shifted away from a nominal approach to safety that relies on compliance with well-accepted design criteria and towards a substantive approach that relies on the data-driven quantification of the safety performance of a given roadway facility in terms of crashes. While the substantive safety approach offers flexibility and the opportunity to consider the broader context of a facility when making design decisions, it requires robust assessment and management of risk. Examining safety performance by analyzing the interactions between causal factors can yield compelling, science-based explanations for crashes. This approach is also sensitive to the many design trade-offs that challenge transportation agencies. In particular, highway safety professionals frequently face gaps in commonly used design handbooks and guidelines (e.g., A Policy on Geometric Design of Highways and Streets; the Manual on Uniform Traffic Control Devices). These gaps create uncertainties or "gray areas" when planning and designing a roadway, and when conducting regular safety audits, maintenance, and upgrades of the facility. These "gray areas" can, in turn, increase risk, making it more difficult for states to defend their design decisions when a crash occurs and claims emerge. For example:

- On a rural road, how will the installation of shoulder rumble strips (SRS) impact bicyclist safety given the available shoulder width? Bicyclists need separation from traffic, as well as sufficient gaps to cross rumble strips in advance of intersections and to avoid hazards. What are the expected safety outcomes of adding SRSs, including both the potential benefits of alerting cars who stray onto the shoulder and the potential risks to bicyclists?

- At a complex freeway interchange, where should guide signs be located and how should lane designations and destinations be displayed on these signs? Drivers should be able to quickly associate sign information with their current and desired lanes to safely position themselves well in advance of the roadway split. How well do different signing options (e.g., sign locations, layout of sign information, organization of multiple destinations on a sign) support driver expectations and performance, and what are the safety impacts of these options?
- In a busy urban environment, should a bus stop be located mid-block, or on the near- or far-side of an intersection? Trade-offs include: concerns about congestion and delays from stopped busses, impacts to sight lines, unsafe pedestrian behaviors like mid-block crossings, and the potential for rear-end crashes and conflicts with turning vehicles. What are the safety outcomes associated with the bus stop location options, and how can these outcomes be mitigated by the addition of striping, special signing, or bus turnouts?

Incorporating human factors research and analyses in the crash investigation process can provide a rich description of the primary and contributing factors to a crash. In addition to the basic crash reports and other supplementary information, relevant site data and historical crash data can be obtained and analyzed; this should include considerations of infrastructure elements upstream of the crash site. In particular, crash analyses should examine: (a) roadway and vehicle factors relevant to the crash, (b) requirements of the driving task imposed by these factors, and (c) capabilities and limitations of the road users involved in the crash relative to those requirements. As needed, targeted studies can be conducted to answer questions that remain once that the basic crash analyses and literature syntheses are complete.

Many state transportation agencies turn to independent third parties for human factors support. What sets Exponent apart from other firms is our ability to offer (1) a multi-disciplinary team of vehicle engineers, accident reconstructionists, biomechanists, and human factors scientists; (2) sophisticated modelling and simulation techniques; and (3) state-of-the-art testing facilities to support crash investigations and reconstructions. These resources provide a systematic and effective approach to assessing crash causality, determining whether and how the crash could have been avoided, and identifying what, if any, countermeasures could be implemented to avoid similar crashes in the future.

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John L. Campbell, PhD, CHFP, PMP

Human Factors

Senior Managing Scientist

Seattle

(425) 519-8719 | campbellj@exponent.com

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