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Crashes and crash-surrogate events: Exploratory modeling with naturalistic driving data

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ABSTRACT

There is a need to extend and refine the use of crash surrogates to enhance safety analyses. This is particularly true given opportunities for data collection presented by naturalistic driving studies. This paper connects the original research on traffic conflicts to the contemporary literature concerning crash surrogates using the crash-to-surrogate ratio, π . A conceptual structure is developed in which the ratio can be estimated using either a Logit or Probit formulation which captures context and event variables as predictors in the model specification. This allows the expansion of the crash-to-surrogate concept beyond traffic conflicts to many contexts and crash types.

The structure is tested using naturalistic driving data from a study conducted in the United States (Dingus et al., 2005). While the sample size is limited (13 crashes and 38 near crashes), there is reasonable correspondence between predicted and observed crash frequencies using a Logit model formulation. The paper concludes with a summary of empirical results and suggestions for future research.

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1. Introduction

1.1. Background

There has been considerable research conducted over the last 40 or more years concerning the development of crash surrogates for assessing traffic safety (e.g. Perkins and Harris, 1967; Datta, 1979; Hauer, 1982; Hydén, 1987; Chin and Quek, 1997; Shankar et al., 2008; Tarko et al., 2009; Jovanis et al., 2010; McGehee et al., 2010; Guo et al., 2010). The goal of surrogate research is driven by the perceived need to conduct safety analyses (e.g. identification of sites with promise of improvement or evaluation of safety countermeasure effectiveness) more quickly (before a large number of crashes occur) and with more data than are typically available from law-enforcement-reported crash records (Datta, 1979; Grayson and Hakkert, 1987; Archer, 2004).

Only recently has a consensus emerged concerning the definition of a crash surrogate. The definition is based on the relationship (Hauer, 1982; Hauer and Gårder, 1986; Davis et al., 2008; Tarko et al., 2009): Number of crashes expected to occur on an entity during a certain period of time (λ) = number of crash surrogates occurring on an entity in that time (c)* crash-to-surrogate ratio for that entity (π). Mathematically,

$$\lambda = \pi * c \tag{1}$$

Here we take the liberty of using the more current term, "surrogate", instead of the original term "conflict". Eq. (1) must hold for any meaningful crash surrogate. And hence, Eq. (1) is the conceptual foundation for this crash surrogate analysis. Eq. (1) provides a definitional link between the expected number of crashes, λ ; the number of observed surrogate events, *c*; and the crash-conflict conversion factor, π . If one can develop a method to estimate π and observe the number of conflicts, *c*, then one may be able to use conflicts to estimate expected crash frequency.

While there is some agreement concerning surrogate definition, several other issues remain relatively understudied including methods to identify crash surrogates, tests for the validity of crash surrogates, and the use of crash surrogates to assess road safety. While many crash surrogate have been proposed and studied, much of the crash surrogate research has historically been focused on traffic conflict technique (TCT) applied at intersections. The exploration of crash surrogates thus begins with a review of this early research followed by a description of our conceptualization of crash surrogate analysis. The paper then tests the conceptualization empirically, followed by conclusions and lessons learned for future research.

1.2. Traffic conflict studies—the foundation for crash surrogate analysis

The most well-known and studied crash surrogate is the traffic conflict. In the first conflict study (Perkins and Harris, 1967), conflicts were defined based on evasive actions taken by drivers

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