Journal of Safety Research 49 (2014) 1

Contents lists available at ScienceDirect

Journal of Safety Research

journal homepage: www.elsevier.com/locate/jsr

Editorial

Letter from the Editors

The *Journal of Safety Research* is pleased to publish in this special issue the proceedings of several papers presented at the 4th International Conference on Road Safety and Simulation convened at Roma Tre University in Rome, Italy, October 2013. This conference serves as an interdisciplinary forum for the exchange of ideas, methodologies, research, and applications aimed at improving road safety globally.

Conference proceedings provide the opportunity for research in its formative stages to be shared, allowing our readers to gain early insights in the type of work currently being conducted and for the researchers to receive valuable feedback to help inform ongoing activities. This conference in particular offers an array of research topics not often covered by this journal from researchers practicing in over 11 countries. As is common with publishing conference proceedings, the papers published in this issue did not go through the normal *JSR* review process. Each paper included in this issue did meet the Road Safety and Simulation conference review requirements. They reflect varying degrees of scientific rigor, methodological design, and groundbreaking application.

The proceedings published in this special issue of *JSR* draw from the following road safety research sectors represented at the conference: driving simulation, crash causality, naturalistic driving, and new research methods.

It is our hope that the publication of these important proceedings will stimulate vigorous dialogue, rigorous research, and continuing innovative initiatives and applications, leading, ultimately, to fewer traffic fatalities, injuries, and crashes.

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18 February 2014

http://dx.doi.org/10.1016/j.jsr.2014.02.001
0022-4375/

Journal of Safety Research 49 (2014) 105–112

Contents lists available at ScienceDirect

Journal of Safety Research

journal homepage: www.elsevier.com/locate/jsr

On the required complexity of vehicle dynamic models for use in simulation-based highway design

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ARTICLE INFO

Article history:
Received 21 October 2013
Accepted 4 March 2014
Available online 24 April 2014

Keywords:
Friction
Modeling
Simulation
Highway safety
Vehicle dynamics

ABSTRACT

Introduction: This paper presents the results of a comprehensive project whose goal is to identify roadway design practices that maximize the margin of safety between the friction supply and friction demand. This study is motivated by the concern for increased accident rates on curves with steep downgrades, geometries that contain features that interact in all three dimensions — planar curves, grade, and superelevation. This complexity makes the prediction of vehicle skidding quite difficult, particularly for simple simulation models that have historically been used for road geometry design guidance. *Method:* To obtain estimates of friction margin, this study considers a range of vehicle models, including: a point-mass model used by the American Association of State Highway Transportation Officials (AASHTO) design policy, a steady-state "bicycle model" formulation that considers only per-axle forces, a transient formulation of the bicycle model commonly used in vehicle stability control systems, and finally, a full multi-body simulation (CarSim and TruckSim) regularly used in the automotive industry for high-fidelity vehicle behavior prediction. The presence of skidding – the friction demand exceeding supply – was calculated for each model considering a wide range of vehicles and road situations. *Results:* The results indicate that the most complicated vehicle models are generally unnecessary for predicting skidding events. However, there are specific maneuvers, namely braking events within lane changes and curves, which consistently predict the worst-case friction margins across all models. This suggests that any vehicle model used for roadway safety analysis should include the effects of combined cornering and braking. *Practical Implications:* The point-mass model typically used by highway design professionals may not be appropriate to predict vehicle behavior on high-speed curves during braking in low-friction situations. However, engineers can use the results of this study to help select the appropriate vehicle dynamic model complexity to use in the highway design process.

1. Introduction

This paper presents the results of a comprehensive three-year project to predict vehicle skidding events on roads of differing geometry. The goal of these simulations is to identify roadway design practices that maximize the margin of safety between the friction demanded by users of the roadway and the maximum friction that can be supplied on the roadway during normal operation. This study is motivated by the concern for increased accident rates in areas that have steep downgrades combined with sharp curves. Such downgrades often occur in mountainous areas, and the difficult terrain of these areas often requires the use of minimum-radius curves as per current highway design rules. Design practice for minimum-radius curves is to use "superelevation," or banked curves, to enable tighter turn geometries while presumably maintaining reasonable lateral friction demand from the vehicle's tires. Thus, steep downgrade curves contain features that interact in all three dimensions — planar curves, grade, and superelevation. This complexity makes the prediction of vehicle skidding quite difficult, particularly for simple simulation models that have historically been used for road geometry design guidance, a fact that has motivated research into road measurement for vehicle simulation purposes (Chemistruck, Detweiler, Ferris, Reid, & Gorsich, 2009; Dembski, Rizzoni, Soliman, Malmedahl, & Disaro, 2006; Detweiler & Ferris, 2010; Kern & Ferris, 2007; Stine, Hamblin, Brennan, & Donnell, 2010).

A specific challenge in this study is therefore to identify models of suitable complexity to accurately predict friction demand on a 3D roadway, but at the same time be simple enough to facilitate broad, sweeping studies of roadway design variations. These models must be based on physically measurable properties – road friction values, vehicle geometries, vehicle inertial properties, road geometries, and so forth – and must be verifiable via field measurements. The range of

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http://dx.doi.org/10.1016/j.jsr.2014.03.005
0022-4375/