Committee ANB20
Safety Data, Analysis and Evaluation

Synthesis Report

On safety-related papers presented at the 92nd TRB Annual Meeting

January 13-17, 2013, Washington, D.C.

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Contents

1 Introduction

This report is mainly aimed at facilitating access to Committee ANB20-related presentations and events at the 92nd Annual TRB meeting (see Table 1 and Table 2). With this aim, papers sponsored by the Committee have been split into subthemes and the abstracts reproduced. For each subtheme, a brief comment on the methodological and application perspectives of the presented papers is reported. Further, some papers sponsored by other Committees which are within the scope of ANB20[1] have been identified and classified in order to promote better interaction between ANB20 and these other Committees.

Information on the Committee activities can be found at sites.google.com/site/trbanb20/home.

This year, twenty events sponsored by ANB20 are planned (see Tables 1 and 2):

- Three workshops;
- Nine lectern sessions;
- Three poster sessions; and
- Five meetings.

The Committee meeting will be held on Tuesday, January 15, 7:30PM – 10:00PM.

Fifty-nine papers sponsored by ANB20 are identified. They will be presented in the following sessions:

- Four in the lectern session 433 (Monday, January 14, 7:30PM – 9:30PM);
- Four in the poster session 438 (Monday, January 14, 7:30PM – 9:30PM);
- One in the lectern session 454 (Monday, January 14, 7:30PM – 9:30PM);
- Twenty-six in the poster session 724 (Wednesday, January 16, 8:30PM – 10:15PM); and
- Twenty-four in the poster session 725 (Wednesday, January 16, 8:30PM – 10:15PM).

The papers address the following topics (some papers were classified in more categories):

a) Crash data and safety analysis tools,
b) Safety performance functions,
c) Crash severity prediction,
d) Network screening,
e) Before-and-after safety evaluations,
f) Surrogate measures of safety.

[1] This committee is concerned with the study of roadway safety. This includes the collection, maintenance and use of crash records and related roadway, road user, and vehicle data; the development of theories, analytical techniques, and evaluation methodologies for improving the understanding of roadway safety; and the application of these theories, techniques and methods to identify road user, vehicle and/or roadway-based treatments that will enhance roadway safety.

Table 1 ANB20 events, Sunday and Monday

Event type	Time	Title	Location
Workshop (115)	Sunday, January 13, 9:00AM – 12:00PM	Pivotal Role of Speed Management Across the Five Road Safety Pillars Sponsors: ANB10, ANB10(8), ANB20(5)	Marriott, Washington B6
Workshop (147F)	Sunday, January 13, 9:00AM – 5:00PM *Ticket Required*	HF-06 Safety Data: What Is It? Where Is It? How Do We Use It? Sponsors: ANB20, AR070	
Workshop (190)	Sunday, January 13, 1:30PM – 4:30PM	The Future of National Household Travel Data: Getting Feedback from the User Community Sponsors: ABJ30, ABJ40, ADA20, ANB20, ABJ45T	Hilton, Columbia Hall 6
Lectern session (202)	Monday, January 14, 8:00AM – 9:45AM	Accident Investigations by National Transportation Safety Board Sponsors: ANB00, ANB20	Marriott, Thurgood Marshall East
Lectern session (210)	Monday, January 14, 8:00AM – 9:45AM	International Benchmarking on Road Safety: Network for International Road Traffic and Accident Database Sponsors: ANB20, ANB10(8)	Marriott, Delaware A
Lectern session (277)	Monday, January 14, 10:15AM – 12:00PM	MAP-21 Demands on Safety Data Sponsors: ABJ00, ABJ20, ANB00, ANB20	Hilton, Columbia Hall 7
Meeting	Monday, January 14, 10:15AM – 12:00PM	Traffic Speed and Safety - Cross-cutting Issues Joint Subcommittee of ANB20, AHB65, ANB10	Marriott, Park Tower Suite 8222
Lectern session (302)	Monday, January 14, 1:30PM – 3:15PM	Ensuring Data Quality: What Are the Pitfalls and How Can We Overcome Them? Sponsors: ABJ80, ANB00, ANB20	Marriott, Delaware B
Lectern session (433)	Monday, January 14, 7:30PM – 9:30PM	Improving Safety Data, Analysis, and Evaluation Sponsors: ANB20	Marriott, Maryland B
Poster session (438)	Monday, January 14, 7:30PM – 9:30PM	Speed Data Needs and Methodologies Sponsors: ABJ30, ADB30, ABJ35, AHB15, AHB65, ANB10, ANB20, ANB40, ANB20(5)	Marriott, Salon 2
Lectern session (454)	Monday, January 14, 7:30PM – 9:30PM	Safety Evaluation and Cyclist Safety Sponsors: ANB20, ANF20	Hilton, Georgetown West

Table 2 ANB20 events, Tuesday and Wednesday

Event type	Time	Title	Location
Meeting	Tuesday, January 15, 10:15AM – 12:00PM	Surrogate Measures for Crash Data Subcommittee, ANB20(3) Sponsors: ANB20	Marriott, Taylor
Lectern session (584)	Tuesday, January 15, 1:30PM – 3:15PM	Collect It Once, Use It Many Times: Leveraging Existing Data Sources Sponsors: ABC30, ABC40, ABJ20, ABJ35, ANB20, ANB25, HIGHWAY SAFETY PERFORMANCE	Hilton, Lincoln West
Lectern session (593)	Tuesday, January 15, 1:30PM – 3:15PM	Use, Reuse, and Recycle: Getting the Most from National Household Travel Survey Data Sponsors: ADA20, ANB20, ABJ40(1), ADD50(1), ABJ45T	Hilton, International East
Meeting	Tuesday, January 15, 3:45PM – 5:30PM	Bicycle and Pedestrian Crash Relationships Joint Subcommittee of ANB20, ANF10, ANF20	Marriott, Park Tower Suite 8219
Meeting	Tuesday, January 15, 7:30PM – 10:00PM	Safety Data, Analysis and Evaluation Committee	Marriott, Harding
Poster session (724)	Wednesday, January 16, 8:30AM – 10:15AM	Safety: Performance, Data, and New Advances, Part 1	Marriott, Salon 2
Poster session (725)	Wednesday, January 16, 8:30AM – 10:15AM	Safety: Performance, Data, and New Advances, Part 2	Marriott, Salon 2
Meeting	Wednesday, January 16, 10:15AM – 12:00PM	Animal-Vehicle Collisions Subcommittee, ANB20(2) Sponsors: ADC30, ANB20	Hilton, Northwest
Lectern session (806)	Wednesday, January 16, 4:30PM – 6:00PM	Mythbusters: Speeding, Speed Management, and Safety Relationships Sponsors: ANB10, ANB40, ANB20(5)	Marriott, Thurgood Marshall North

2 Papers on crash data and safety analysis tools

Real-world crash data play a vital part in the development of safer transport since information on crash data is essential as a means of understanding why crashes occurred in the past, how the occurrence of similar events may be prevented in the future, and in refining design criteria currently being used.

The Subcommittee identified fourty five papers dealing with crash data and safety analysis tools. Twenty one papers were sponsored by the ANB20 Committee while twenty four papers were sponsored by other Committees.

From a methodological perspective, different methodologies were used, such as effect of "Information Priors" on Bayesian Hierachial models (*Yu and Abdel-Aty*), a spatial generalized ordered-response model (*Castro et al.*), logistic regression models (*Qin et al.*), comparison of "sichel" and NB models in EB estimation (*Zou et al.*), models with alternate discrete choice frameworks (*Yasmin and Eluru*), multivariate spatial models for excess crash frequency (*Aguero-Valverde*), estimating traffic conflicts for signalized intersections (*Zhang and He*), using geographically weighted regression technique (*Pirdavani et al.*), using terporal and spatial factors in driver behavior analysis (*Ellison et al.*), using game theory in analysis of rear-end events (*Chatterjee and Davis*), using generalized non-linear models in rear-end events (*Lao et al.*), and on-duty vehicles/personnel crashes (*Yu et al., 13-3317*).

From a conceptual point of view, there are different concepts that are studied such as explicit look at crash causation (*Washington and Haque*), effect of truck traffic on safety (*Qin et al.*), effect of public rest areas on crashes (*McArthur et al.*), effect of gender and age difference on crashes (*Russo and Biancardo*), use of remote-sensing thecnologies in collecting roadside data (Jalayer et al.), data privacy issues (*Elango et al.; Sun et al.; Wallace and Hong; Zarrillo et al.*), safety impacts of design exceptions (*Wood and Porter*), vehicle-highway automation (*Schendzielorz et al.*), space/time relations between primary and secondary crashes (*Chung*), probability of out-of-state drivers being at fault (*Harootunian et al.*), effect of sun glare on crashes (*Hagita and Mori*), studying NDS data (*Wu and Jovanis*), effects of spatial autocorrelation and sample data size (*Manepalli and Bham*), and studying freeway secondary crashes (*Yang et al., 13-4866*).

From an applications perspective, the papers addressed several issues, such as a way of extracting useful information from crash reports (*Gao and Wu*), new way of estimating AADT (*Wang et al.*), integrating crash data with lane closure system data (*Cheng et al.*), using GIS to develop intersection database (*Lefler et al.*), using GPS data of a moving vehicle to measure grade (*Boroujeni and Frey*), estimating VMT using GPS traveling time (*Zhang and Liu*), bicycle and pedestrian data collectin methods (*Charreyron et al.; Nordback et al.; Miranda-Moreno et al.; Turner and Lasley*), using time-traveled to estimate exposure to crashes (*Guler et al.*), naturalistic data reduction (*McDonald et al.*), using microscopic traffic and weather data to estimate crashes (*Yu et al., 13-0718*), automating intersection data extraction (*Yang et al., 13-4566*), developing a GIS componenet for Safety Analyst (*Ma et al.*), review of crash databases in Australia, Europe, and US (*Montella et al.*), and aggregate crash data in the US (*Borsos et al.*).

There are also four presentation-only sessions related to this topic with no paper available for the topics. These are sessions 277 "MAP-21 Demandson Safety Data", 302 "Ensuring Data Quality: What are the pitfalls and how can we overcome them", 399 "Case Studies in Performance-based Analysis of Geometric Design", and 566 "New to Naturalistic Driving Data? An Update on Naturalistic Driving Studu (NDS) Projects, Data, Analysis, and Use."

Authors	Jonathan Aguero-Valverde, Universidad de Costa Rica
Sponsoring Committee	ABJ80, Statistical Methods
Session Number	658
Session Title	Statistical Methods Research for Transportation
Paper Number	13-1061
Paper Title	Multivariate Spatial Models of Excess Crash Frequency at Area Level: Case of Costa Rica
Abstract	Recently, areal models of crash frequency have being used in the analysis of various area-wide factors affecting road crashes. On the other hand, disease mapping methods are commonly used in epidemiology to assess the relative risk of the population at different spatial units. A natural next step is to combine these two approaches to estimate the excess crash frequency at area level as a measure of absolute crash risk. Furthermore, multivariate spatial models of crash severity are explored in order to account for both frequency and severity of crashes and control for the spatial correlation frequently found in crash data. This paper aims to extent the concept of safety performance functions to be used in areal models of crash frequency. A multivariate spatial model is used for that purpose and compared to its univariate counterpart. Full Bayes hierarchical approach is used to estimate the models of crash frequency at canton level for Costa Rica. An intrinsic Multivariate Conditional Autoregressive model is used for modeling spatial random effects. The results show that the multivariate spatial model performs better than its univariate counterpart in terms of the penalized goodness-of-fit measure Deviance Information Criteria. Additionally, the effects of the spatial smoothing due to the multivariate spatial random effects are evident in the estimation of excess equivalent property damage only crashes.

Authors	Jonathan F. Antin, Virginia Polytechnic Institute and State University
Sponsoring Committee	FA000, SHRP 2 Technical Coordinating Committee for Safety
Session Number	566
Session Title	New to Naturalistic Driving Data? An Update on Naturalistic Driving Study (NDS) Projects, Data, Analysis, and Uses
Paper Number	P13-5050
Paper Title	Update on NDS Progress, Sample Descriptive Statistics, and Data Dissemination
Abstract	No abstract available

Authors	Cheryl Bornheimer, Kansas Department of Transportation Howard Lubliner, Kansas Department of Transportation
Sponsoring Committee	AHB65, Operational Effects of Geometrics
Session Number	399
Session Title	Case Studies in Performance-Based Analysis of Geometric Design
Paper Number	P13-6787
Paper Title	Highway Safety Manual Use in Kansas: Designing to a Budget
Abstract	No abstract available

Authors	Behdad Yazdani Boroujeni, North Carolina State University, Raleigh H. Christopher Frey, North Carolina State University, Raleigh
Sponsoring Committee	ABJ20, Statewide Transportation Data and Information Systems
Session Number	423
Session Title	Transportation Data Applications
Paper Number	13-1417
Paper Title	Quantifying Road Grade Based on In-Vehicle Measurements with Global Positioning System Receivers
Abstract	Variability in real-world vehicle fuel use and emissions during a trip depends primarily on vehicle speed, acceleration, and road grade. However, there is not a standard method for measuring road grade from a moving vehicle. Changes in road grade of more than a percentage point significantly affect fuel use and emission rates. Consumer grade Global Positioning System receivers with barometric altimeter (GPS/BA) are used to measure position and elevation. Data were collected from 12 vehicles, each using 3 GPS receivers, for a total of 36 repeated GPS/BA runs on eight one-way routes in the Research Triangle Park, NC region. Road grade was estimated by combining data from 9, 18, and 36 runs and applying linear regression to non-overlapping and adjacent road segments of length d. The accuracy of the estimated road grade was evaluated based on comparison to estimates from aircraft-based LIDAR measurements. The average grade is found to be accurate. The average precision is 0.39, 0.25, and 0.16 percentage points, for sample sizes of 9, 18, and 36 runs, respectively, among 1,116 individual road segments. The proportion of segments that have road grade precision within a target of +/-0.5 percentage points are 80 percent for 9 runs, 98 percent for 18 runs, and 99.8 percent for 36 runs. Thus, the use of a low cost GPS/BA is a promising approach for accurate and precise measurement of grade relative to data quality needs for quantifying variability in fuel use and emissions.

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John N. Ivan, University of Connecticut
Nalini Ravishanker, University of Connecticut
Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-3947
Paper Title Analysis of Aggregate Crash Data in the United States for 1967-2010
Abstract In a previous paper the authors completed a country-level as well as a time-dependent road safety analysis focusing on countries where data were available for a longer period of time (1965-2009). One of the conclusions was that the USA is lagging behind compared to twenty five – mostly European – countries in terms of fatalities per population. In some European countries this value is already below 5 fatalities per 100,000 population, whereas in the USA it was around 11 in 2010. A possible explanation for that was higher vehicle miles traveled and preference for car travel. This paper – as a continuation of the previous research –addresses two issues. One is a thorough international comparison of road safety indicators in the US and some selected countries. The second is to investigate the road safety situation and trends on the state level. The evolution of road safety in the USA on the national as well as the state-level is modeled for a longer period of time (1967-2010). Fatality rates (fatalities per population and VMT) are used for the comparison of countries as well as US states and the change of these values over time is analyzed. The states with rates lower than the national average are generally more urban or smaller in area, and those with rates higher than the national average are generally more rural or larger in area. The fatality rates in the former group are comparable to those for the best countries in Western Europe.

Authors Kenneth L. Campbell, Transportation Research Board
Sponsoring Committee FA000, SHRP 2 Technical Coordinating Committee for Safety
Session Number 566
Session Title New to Naturalistic Driving Data? An Update on Naturalistic Driving Study (NDS) Projects, Data, Analysis, and Uses
Paper Number P13-5052
Paper Title Update on NDS Data Analysis Projects
Abstract No abstract available

Authors Marisol Castro, University of Texas, Austin
Rajesh Paleti, University of Texas, Austin
Chandra R. Bhat, University of Texas, Austin
Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-3810
Paper Title Spatial Generalized Ordered-Response Model to Examine Highway Crash Injury Severity
Abstract This paper proposes a flexible econometric structure for injury severity analysis at the level of individual crashes that recognizes the ordinal nature of injury severity categories, allows unobserved heterogeneity in the effects of contributing factors, as well as accommodates spatial dependencies in the injury severity levels experienced in crashes that occur close to one another in space. The modeling framework is applied to analyze the injury severity sustained in crashes occurring on highway road segments in Austin, Texas. The results from our analysis underscore the value of our proposed model to accurately estimate variable effects.

Authors Ann M. Brach, Transportation Research Board
Sponsoring Committee FA000, SHRP 2 Technical Coordinating Committee for Safety
Session Number 566
Session Title New to Naturalistic Driving Data? An Update on Naturalistic Driving Study (NDS) Projects, Data, Analysis, and Uses
Paper Number P13-5053
Paper Title NDS Database Stewardship, Access, and Users
Abstract No abstract available

Authors Samuel Charreyron, McGill University, Canada
Stewart Jackson, McGill University, Canada
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Sponsoring Committee ABJ35, Highway Traffic Monitoring
Session Number 640
Session Title Bicycle and Pedestrian Counting Data and Collection Methods
Paper Number 13-3284
Paper Title Toward a Flexible System for Pedestrian Data Collection Using Microsoft Kinect Motion-Sensing Device
Abstract Information about pedestrian activity, including volumes, walking speed, and trajectories, are used by transportation agencies and researchers for planning, design and analysis purposes. There exist a number of technologies for automatic pedestrian data collection; however all have inherent limitations either in functionality or in monetary cost. Also, most technologies only provide counts. This paper proposes the use of an inexpensive motion sensing device: the Microsoft Kinect, which is able to track multiple people in low-light conditions and could be combined with existing video based daytime tracking. The tracking software and speed estimation methodologies are described, and indoor and outdoor studies show the system's effectiveness at determining pedestrian volumes and walking speeds. The accuracy of speed data is very satisfactory, with correlation of 98% or more with respect to video data validation speeds. The accuracy of pedestrian volume data varies with traffic conditions, however in low to moderate traffic conditions its performance is accept able with an under counting error of about 8%. The different applications of the sensor and its complementarity with other sensors is discussed, this being the first step towards a multi-sensor system.

Authors Indrajit Chatterjee, University of Minnesota, Twin Cities
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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-3326
Paper Title Evolutionary Game Theoretic Approach to Rear-Ending Events on a Congested Freeway
Abstract Rear-ending crashes on freeways contribute significantly to non-recurring congestion. Reducing these events would then significantly improve freeway capacity, particularly during peak hours. Although promising countermeasures, such as variable speeds limits, changeable message signs, and vehicle-based improvements, are under consideration, at present there is a shortage of demonstrably proven countermeasures targeted to freeway rear-ending crashes. Liability rules, where the direct cost associated with a crash is divided between the drivers and/or their insurance companies, are a primary mechanism for influencing the occurrence of freeway rear-ending crashes, and can be expected to continue in importance in the future. This paper describes an exploratory effort at using concepts from evolutionary game theory to predict the effects of liability rules on rear-ending crashes. In a typical two-vehicle car following scenario, driving behavior can be associated with a utility which each driver expects to achieve depending upon his/her and the opponentâ€™s action. Such interactions between leader and follower are modeled as the outcome of an evolutionary process, where drivers with different driving behaviors are randomly and repeatedly matched against each other to play a two-player game. The outcome of these games determines the fraction of drivers pursuing a particular driving strategy for the next phase of the game. The stable long-run distribution of driving strategies is then used to predict the proportion of drivers who are more likely to be involved in a rear-ending accident. It turns out that when direct crash costs are allocated evenly to the involved drivers, a population where all drivers act to avoid crashes is not evolutionarily stable.

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David A. Noyce, University of Wisconsin, Madison
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Sponsoring Committee ABJ20, Statewide Transportation Data and Information Systems
Session Number 423
Session Title Transportation Data Applications
Paper Number 13-3359
Paper Title Enhanced Analysis of Crashes in the Proximity of Work Zones through Integration of Statewide Crash Data with Lane Closure System Data
Abstract Highway work zones interrupt regular traffic flow and lead to safety concerns. Comprehensive knowledge of the crashes and work zones is essential to identify the risk factors. The Wisconsin Lane Closure System (WisLCS), a scheduling and reporting system for highway lane closures statewide, provides a new opportunity to match crashes to specific work zones on a system-wide level. This study conducts an analysis of the safety risks in the proximity of work zones. The WisLCS and the MV4000 Crash Data Retrieval Facility, both part of the WisTransProtal system at the University of Wisconsin-Madison TOPS Laboratory, provide the necessary data for this study. A matching algorithm is used to relate reported work zone crashes with the corresponding work zones, which relies on a common underlying linear referencing system used in the two data systems. Based on the results, it is clear that work zones cause safety concerns outside of the physical boundaries (upstream and downstream) and scheduled time periods (before and after the reported operation hours). In some scenarios, those crashes occurring outside of work zones even have a higher risk of overall and severer injury. Some suggestions are also made based on the findings to improve work zone safety and enhance work zone reporting monitoring in the future. Although developed based on the systems in Wisconsin, the general ideas of this study can also be applied to similar information systems.

Authors Gregory L. Chisholm, McCormick Rankin, Canada
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Sponsoring Committee AHB65, Operational Effects of Geometrics
Session Number 399
Session Title Case Studies in Performance-Based Analysis of Geometric Design
Paper Number P13-6794
Paper Title Quantitative Road Safety Analysis in Value Engineering: Case Study
Abstract No abstract available

Authors Younshik Chung, Korea Transport Institute
Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-1148
Paper Title Identifying Primary and Secondary Accidents from Spatiotemporal Accident Impact Analysis
Abstract The identification of secondary accidents is accompanied by the definition of the primary accident impact area. Although the accident impact area varies with the geometric characteristics of roads and periodic characteristics of traffic flow as well as with accident types, most previous studies used a fixed boundary to identify secondary accidents and primary accidents. Thus, the objective of this research is to develop a method to define the spatio-temporally different boundaries varying with different types of accident. Based on the developed boundaries, the secondary accident is identified in the primary accident location as well as in its opposite direction. Secondary accidents in the same and opposite directions were identified to be 8.1% and 3.7% of total primary accidents, respectively. Also, only 0.4% of total primary accidents were connected with the secondary accident both in the same and opposite directions. Although the proposed method seems to be complicated, the results from the method will be useful to understand secondary accident characteristics in more realistic analysis through the spatio-temporal accident impact area in the

accident direction as well as in its opposite direction. Specifically, they can be used by public sector transportation agencies in making operational strategies for reducing the secondary accidents on freeways.

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Sponsoring Committee AHB65, Operational Effects of Geometrics
Session Number 399
Session Title Case Studies in Performance-Based Analysis of Geometric Design
Paper Number P13-6792
Paper Title HSM Pilot Project: SR 147--Safety Performance Evaluation
Abstract No abstract available

Authors Vetri Venthan Elango, Georgia Institute of Technology
Sara Khoeini, Georgia Institute of Technology
Yanzhi Xu, Georgia Institute of Technology
Randall Guensler, Georgia Institute of Technology
Sponsoring Committee A0030T, Special Task Force on Data for Decisions and Performance Measures
Session Number 325
Session Title Data Privacy Issues in a World Where Technology Is Way Ahead of Policy
Paper Number 13-0820
Paper Title Longitudinal GPS Travel Data and Breach of Privacy via Enhanced Spatial and Demographic Analysis
Abstract Longitudinal GPS travel data provide a wealth of information related to travel behavior and on-road vehicle behavior that are very valuable to researchers. Sharing the data publicly allows researchers to explore the data and create new knowledge beyond the initial research objectives. However, if any data are to be used outside of a secure server, the data must be processed in such a manner that ensures the confidentiality of the data will not be breached. High resolution GPS data (e.g. second-by-second speed and location information), when associated with the individual households or drivers, compromises privacy and have a significant potential to harm human subjects. This paper explores how data from the Commute Atlanta Study could be processed to make it useful to researchers while protecting the privacy of the participants. The research developed and assessed methodologies designed to identify the individual participants' home location from processed data and then tested analytical datasets for breach of privacy. The research effort found that the home location can be identified to within reasonably small neighborhoods and when the household demographic information are included within the datasets (which is necessary for researchers) exact households can be identified. While there may be some new data processing approaches that could be used to eliminate privacy concerns, until such systems are developed and proven to be not breachable through rigorous analysis, the Georgia Tech team has determined that researchers should access the high-resolution data within controlled secure labs and that the datasets should not be made public without undertaking additional efforts to ensure that home locations cannot be identified when external data sources are leveraged in the analyses.

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Stephen Greaves, University of Sydney, Australia
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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4541
Paper Title Examining Heterogeneity of Driver Behavior Using Temporal and Spatial Factors
Abstract Temporal and spatial characteristics of the road environment are known to influence driver behaviour and consequently the risk of an injury or fatality crash. Nonetheless, much of our understanding of the risks of injury and fatality associated with driving relies heavily on police crash records. These capture the most serious of crashes but underreport other events. Studies which rely on these data sources typically ignore the temporal and spatial factors. Advances in technology have enabled more detailed study of driving on a day-to-day basis and therefore the opportunity to examine driver behaviour for the same driver across time and space. However, this has brought with it its own difficulties. This includes extensive intra and inter-driver heterogeneity which is not apparent when using 'traditional' data collection methods. This paper presents a framework and methodology for isolating the influence of drivers' inherent characteristics on driver behaviour. This is done by constructing temporal and spatial identifiers which control for the influence of the road environment. Results of analyses conducted using empirical driving information collected from 106 vehicles in Sydney, Australia to examine the effectiveness of this approach are included. The results indicate that in 80 percent of road environments there is less intra-driver variability in speeding behaviour than inter-driver variability when accounting for temporal and spatial characteristics. Clustering and regression analyses for the most frequently observed road environments are also presented. Further work is necessary to establish the extent to which these results apply across datasets with different characteristics.

Authors Erin M. Ferguson, Kittelson & Associates, Inc.
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Sponsoring Committee AHB65, Operational Effects of Geometrics
Session Number 399
Session Title Case Studies in Performance-Based Analysis of Geometric Design
Paper Number P13-6790
Paper Title US-12 Chehalis Safety Study
Abstract No abstract available

Authors Lu Gao, University of Houston
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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 433
Session Title Improving Safety Data, Analysis, and Evaluation
Paper Number 13-2292
Paper Title Verb-Based Text Mining of Road Crash Report
Abstract Traffic accident report is usually completed by police officers at the scene and contains important information on the cause and outcome of automobile accidents. However, a significant part of the report is stored in unstructured textual format. In the existing literature, there is only a handful of studies on extracting useful information from the crash report. In this research, we developed a verb-based text mining method. This method identifies and extracts the main verbs representing the vehicle actions in a sentence. Using those verbs, we are able to extract the sequence of events of the crash accident. The vehicle action entities are identified through using Natural Language Processing (NLP) techniques to identify both syntactic and semantic units in the text. The developed verb-based approach can effectively handle complex sentence structures such as clauses and conjunctive sentences. In the case study, we evaluated the proposed method using a total of 945 accidents records published by Missouri State Highway Patrol during the period from May 19, 2012 to June 27, 2012. The obtained results show that the extracted information is useful not only to crash classifications but also to help understand the causes of crashes.

Authors Michael S. Griffith, Federal Highway Administration
Sponsoring Committee ABJ00, Data and Information Systems
Session Number 277
Session Title MAP-21 Demands on Safety Data
Paper Number P13-5114
Paper Title Safety Data Requirements in MAP-21: FHWA Perspective
Abstract No abstract available

Authors Sukran Ilgin Guler, University of California, Berkeley
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David R. Ragland, University of California, Berkeley
Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-0522
Paper Title Using Time-Based Metrics to Compare Crash Risk Across Modes and Locations
Abstract The objective of this work is to identify better metrics of exposure when comparing traffic crash risk across modes or across locations. We propose that total time travelled should be used for road user exposure to crash risk. The idea behind this is that travel time reflects the differences in speeds across different modes and hence should be used as the basic exposure metric from which crash risk based on other metrics, such as travel distance, can easily be derived. We also propose that when comparing crash risk of different modes across different locations the time based mode share should be used as an explanatory variable. By using mode share we are generalizing the safety in numbers concept which focuses on absolute numbers. This work presents a discussion on why these two metrics were chosen and how they are different from the commonly used metrics. Quantitative evidence for the choice of time based metrics is also presented using travel survey data to compare crash risk across modes and locations.

Authors Kenji Hagita, National Research Institute of Police Science, Japan
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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-2388
Paper Title Effect of Sun Glare on Traffic Accidents in Japan
Abstract This study aims to clarify effect of sun glare on traffic accident occurrence. Traffic accidents analyses were carried out to calculate the position of the sun relative to the first vehicle concerned (i.e., the vehicle most responsible for causing the accident) at the accident time and spot by using the traffic accident database of Chiba Prefecture. Daytime traffic accidents that occurred during fine weather were extracted for analysis. The traffic accident rate was found to increase when the viewing angle decreased to less than 90 degrees. Daytime traffic accidents during fine weather were extracted, and traffic accidents in which this viewing angle was less than 90 degrees were regarded as sun-glare-related ones, and all others were regarded as sun-glare-unrelated ones. Logistic regression analyses were carried out, with the viewing angle as the dependent variable and certain traffic accident data items as the independent variables. When the sun was in front of the first vehicle concerned, the accident rate was much higher for pedestrian accidents, bicycle accidents and accidents at intersection and slightly higher for right-turning accidents and accidents in winter. However, the tendency for vehicle drivers to be affected adversely by sun glare was not observed to increase with increases in vehicle speed. The sun glare tended to cause drivers to not see pedestrians and cyclists at signalized intersections. Traffic safety measures against such kinds of accidents are needed.

Authors	Kristine Harootunian, University of Vermont Lisa Aultman-Hall, University of Vermont Brian H. Y. Lee, University of Vermont
Sponsoring Committee	ANB20, Safety Data, Analysis and Evaluation
Session Number	724
Session Title	Safety: Performance, Data, and New Advances, Part 1
Paper Number	13-1597
Paper Title	Crash Fault Analysis of Out-of-State Drivers in Vermont
Abstract	This study examined single- and two-vehicle police-reported crashes in Vermont between 2003 and 2008. It evaluated the likelihood of being at fault for Vermont drivers versus out-of-state drivers. Analysis using odds ratios estimated that out-of-state drivers are 98% more likely to be at-fault for a single-vehicle crash and 9% more likely to be at-fault for a two-vehicle crash. Age, gender, season of year, light conditions, and road type were statistically significant interactions for Vermont and out-of-state drivers for single-vehicle crashes. Male drivers and driving during the winter months had more pronounced effects of increasing single-vehicle crash fault for out-of-state drivers than for Vermont drivers. Vermont drivers, on the other hand, were more apt to cause a crash on gravel roads. The interactions were less pronounced for two-vehicle crashes. Being male or an older driver increased crash odds for both groups. Driving during the summer months increased out-of-state drivers crash odds by 21%, while it was insignificant for Vermont drivers. The other factors tested were insignificant for both groups. The crash evaluation of fault for "foreign" drivers' crashes has been understudied in the United States. Previous research, conducted mostly in other countries, has been limited but has shown that foreign drivers are more likely to be involved in a crash. This study in Vermont strongly suggests the need for further study of this factor as well as identification of associated interventions.

Authors	Patricia S. Hu, Research and Innovative Technology Administration Rolf R. Schmitt, Bureau of Transportation Statistics
Sponsoring Committee	ABJ00, Data and Information Systems
Session Number	277
Session Title	MAP-21 Demands on Safety Data
Paper Number	P13-5116
Paper Title	MAP-21 Safety Data: BTS Response and Vision
Abstract	No abstract available

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Sponsoring Committee	ANB25, Highway Safety Performance
Session Number	289
Session Title	Highway Safety Performance
Paper Number	13-4709
Paper Title	Evaluation of Remote-Sensing Technologies for Collecting Roadside Feature Data to Support Highway Safety Manual Implementation
Abstract	Roadside feature data are critical inputs to highway safety models as described in the Highway Safety Manual (HSM). Collecting safety-related roadside feature data is an important step for HSM implementation. Many state DOTs routinely collect data on roadside objects using a variety of sensing methods, and these programs often incur significant cost. At present, it is unknown which of these methods or any combination of these methods is capable of efficiently collecting safety-related roadside feature data while minimizing cost and safety concern. The objective of this research is to identify required roadside feature data for various types of highway segments and to characterize the capability of existing sensing methods in contrast to required roadside feature data through literature review and a nation-wide survey, and large-scale field trials of selected sensing methods. The results of literature review and surveys are reported in this paper. The findings of this research suggest that either mobile LiDAR or the combination of video/photo log method with aerial imagery method is capable of collecting required HSM-related roadside information. However, due to the high data reduction effort, the current mobile LiDAR method needs significant improvement in the LiDAR data processing and feature extraction stage.

Authors	Kohinoor Kar, Arizona Department of Transportation Mark Poppe, Arizona Department of Transportation Taylor Reece Ehrick, Kimley-Horn & Associates, Inc. Mike Colety, Kimley-Horn & Associates, Inc.
Sponsoring Committee	AHB65, Operational Effects of Geometrics
Session Number	399
Session Title	Case Studies in Performance-Based Analysis of Geometric Design
Paper Number	P13-6793
Paper Title	Application of HSM Predictive Method and Interactive Highway Safety Design Model to Design Decision Making: Arizona Case Study
Abstract	No abstract available

Authors Alan F. Karr, National Institute of Statistical Sciences
Sponsoring Committee ABJ80, Statistical Methods
Session Number 302
Session Title Ensuring Data Quality: What Are the Pitfalls and How Can We Overcome Them?
Paper Number P13-6728
Paper Title Data Quality: Old Problems, New Problems, Big Problems
Abstract No abstract available

Authors Yunteng Lao, University of Washington
Guohui Zhang, University of New Mexico
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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-3903
Paper Title Generalized Nonlinear Models for Rear-End Crash Risk Analysis
Abstract A Generalized Nonlinear Model (GNM)-based approach for modeling highway rear-end crash risk is formulated using Washington State traffic safety data. Previous studies majorly focused on causal factor identification and crash risk modeling using Generalized linear Models (GLMs), such as Poisson regression, Logistic regression, etc. However, their basic assumption of a generalized linear relationship between the dependent variable (for example, crash rate) and independent variables (for example, contribute factors to crashes) established via a link function can be often violated in reality. Consequently, the GLM-based modeling results could provide biased findings and conclusions. In this research, a GNM-based approach is developed to utilize a nonlinear regression function to better elaborate non-monotonic relationships between the independent and dependent variables using the rear end accident data collected from ten highway routes from 2002 through 2006. The results show for example that truck percentage and grade have a parabolic impact: they increase crash risks initially, but decrease them after the certain thresholds. Such non-monotonic relationships cannot be captured by regular GLMs which further demonstrate the flexibility of GNM-based approaches in the nonlinear relationship among data and providing more reasonable explanations. The superior GNM-based model interpretations help better understand the parabolic impacts of some specific contributing factors for selecting and evaluating rear-end crash safety improvement plans.

Authors Nancy X. Lefler, Vanasse Hangen Brustlin Inc
Sponsoring Committee ABJ20, Statewide Transportation Data and Information Systems
Session Number 423
Session Title Transportation Data Applications
Paper Number 13-4663
Paper Title Using Geographic Information Systems to Develop an Intersection Inventory for Safety
Abstract In 2010, there were 30,196 fatal crashes, 23 percent of which were intersection or intersection-related. One of the major challenges transportation agencies face when trying to address intersection safety is not having a sufficient enough intersection inventory that provides information on the location, operations, or geometrics of the intersections. The goal of this paper is to demonstrate how agencies can use readily available tools, such as geographic information systems (GIS), and existing transportation datasets to develop a base intersection inventory. This paper will also demonstrate how an agency can conduct a more robust data collection effort by expending only a little more resources. This is based on an effort conducted for the New Hampshire Department of Transportation (NHDOT) to build an intersection inventory of 10,300 intersections. The Federal Highway Administration (FHWA) funded this effort as part of a project to demonstrate the feasibility of collecting Model Inventory of Roadway Elements (MIRE) data and incorporating them into an agency's safety program.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-3969
Paper Title Development of a Geographic Information System for SafetyAnalyst for Location Selection and Output Visualization
Abstract SafetyAnalyst was developed as a cooperative effort by the Federal Highway Administration (FHWA) and participating state and local agencies. Released in 2010, the system is a set of software tools developed to aid state and local highway agencies in highway safety management. SafetyAnalyst uses the empirical Bayes method and incorporates all the steps of the roadway safety management process. However, it lacks the Geographic Information System (GIS) component; SafetyAnalyst provides only the data interface needed to exchange spatial data. Given the spatial nature of crash analysis, there is a need for a GIS component to allow users to graphically select locations and display analysis results from SafetyAnalyst. SafetyAnalyst assumes that an agency will adapt its existing GIS system to provide that capability. However, it is unlikely that an agency will have an existing GIS system that can be customized to work with the unique file structures of SafetyAnalyst. This paper discusses SafetyAnalyst, its input and output file structures, and a standalone GIS system designed to interface with SafetyAnalyst. The system provides an alternate method for selecting locations for analysis by SafetyAnalyst using a graphical display. The system also provides a graphical display of the results from SafetyAnalyst's network screening module. While the system was developed for Florida, it can be easily customized for similar applications in other states.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4846
Paper Title Identification of Crash Contributing Factors: Effects of Spatial Autocorrelation and Sample Data Size
Abstract This paper uses sample sets of crash data to examine the similarities in crash contributing factors among various counties that have similar effects on spatial autocorrelation (SA). Moran's I and Getis-Ord Gi* statistics were used to determine the correlation, and the multinomial logistic regression to identify the crash contributing factors. Seventy-five counties in the state of Arkansas were divided into five categories based on the Z-values of the Getis-Ord Gi* statistic. Depending on the sample size, crash data from a county or a group of counties from each of these categories were used, and factors contributing to crashes in each of the categories were identified based on the crash severity index. Results indicated that most of the crash contributing factors identified for each category were also identified by the crash data from a county or a group of counties in that category. Pulaski county, with the highest Z-value from the first category indicated largest cluster of crashes and identified the highest percentage (55%) of factors that contributed to crashes in that category using sample crash data. From the sample data used, the multinomial logistic regression indicated the following factors to be positively associated with crash severity: nighttime driving, driving under the influence of alcohol, roadway gradient, curved alignment, rural areas, and head-on and sideswipe-same direction collision types. The results of this research can be used for better allocation of funds by departments of transportation to identify crash contributing factors that are associated with higher levels of crash severity by analyzing smaller sets of data.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 433
Session Title Improving Safety Data, Analysis, and Evaluation
Paper Number 13-0162
Paper Title Effects of Public Rest Areas on Fatigue-Related Crashes
Abstract Fatigue-related crashes account for 2.2 to 2.6 percent of all fatal crashes in the United States on an annual basis. These types of crashes are prevalent in rural areas and often result in severe injuries to crash-involved occupants. Public roadside rest areas were developed largely to alleviate motorist fatigue and reduce the opportunity for fatigue-related crashes by providing safe parking areas for tired drivers. However, research as to the safety effects of rest areas has been limited. This paper presents the results of a spatial analysis to investigate the effects of a road segment's proximity to a rest area on the frequency of fatigue-related crashes. Poisson and negative binomial models are estimated for freeways and two-lane highways in order to isolate the effects of proximity while control for other relevant factors, such as traffic volumes. The results of these models indicate that the proximity of a road segment to the nearest rest area significantly influences crash frequencies on both types of facilities. Traffic volumes tended to have similar effects on both facility types while the effects of proximity were slightly more pronounced on two-lane highways. The study results suggest that roadside rest areas provide a safety benefit and the crash prediction models developed as a part of this research provide a simple, practical tool for use by road agencies in quantifying these impacts.

Authors Michael J. McDonald, Delaware State Police
Sponsoring Committee ABJ80, Statistical Methods
Session Number 302
Session Title Ensuring Data Quality: What Are the Pitfalls and How Can We Overcome Them?
Paper Number P13-6729
Paper Title Data Quality: Establishing a Data Quality Improvement Process
Abstract No abstract available

Authors Anthony D. McDonald, University of Wisconsin, Madison
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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-2947
Paper Title The Language of Driving: Advantages and Applications of Symbolic Data Reduction for Naturalistic Driving Data Analysis
Abstract Recent advances in onboard vehicle data recording devices have created an abundance of naturalistic driving data. The amount of data exceeds the resources available to analyze it, forcing researchers to focus on analyses of "critical events," which are identified using simple heuristics. This critical event analysis eliminates the context that can be critical in understanding driver behavior, reducing the generalizability of the analysis. This work introduces a method of naturalistic driving data analysis that will allow researchers to examine entire datasets by reducing them by over 90%. The method utilizes a symbolic data reduction algorithm, Symbolic Aggregate approXimation (SAX), which reduces time-series data to a string of letters. SAX can be applied to any continuous measurement and SAX output can be reintegrated into a dataset to preserve categorical information. This work explores the application of SAX to speed and acceleration data from a naturalistic driving dataset and demonstrates SAX's integration with other methods that can begin to tame the complexity of naturalistic data.

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Sponsoring Committee ABJ35, Highway Traffic Monitoring
Session Number 640
Session Title Bicycle and Pedestrian Counting Data and Collection Methods
Paper Number 13-3007
Paper Title Classification of Bicycle Traffic Patterns in Five North American Cities
Abstract This paper analyses bicycle ridership patterns using a unique database of automated bicycle counts from approximately 40 locations in five North American cities and along the Route Verte in Quebec. The cities involved in this study are Montreal, Ottawa, Portland, San Francisco, and Vancouver. Count data show that the bicycle volume patterns at each location can be classified as utilitarian, mixed utilitarian, recreational and mixed recreational. Study locations classified into each of these categories are found to have consistent hourly and weekly traffic patterns, despite important differences between these cities in terms of factors such as weather, size, and urban form. Expansion factors for each location type are presented by hour and day of the week. There were differences in seasonal patterns of bicycle activity between the study locations, so different monthly expansion factors are presented for each city. Finally, some traffic volume characteristics are presented for comparison purposes.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4219
Paper Title Crash Databases in Australasia, European Union, and United States: Review and Prospects for Improvemen
Abstract Since the quality of decision making in road safety is dependent on the quality of the data on which decisions are based, efforts to improve the quality, timeliness and accuracy of crash databases are crucial. To contribute to the scientific debate for the identification of directions for improvement of the existing databases, a critical review of Australasian, EU, and US crash databases has been performed and future directions have been identified. Major issues are related to access procedures to crash data, crash report form, severity of crashes reported in the databases, crash location, crash classification, and crash severity. Access to crash databases might be provided to approved road safety professionals through a web-based portal, providing also the detailed police crash reports. The use of electronic crash report forms is strongly recommended since it might solve most of the problems associated with paper. Severity of crashes reported in the databases vary across the countries and not all the countries report property damage only crashes. However, both PDO and injury crashes might give information on crashes to be prevented and we recommend consistency between the countries in collecting also property damage only crashes and using these crashes to develop safety strategies. Combined use of GPS devices and GIS improves crash location and overcomes the traditional problems in crash location, such as inaccuracies and collection mistakes. To develop effective countermeasures, we recommend to classify crashes by the maneuvers and sequence of events of each traffic unit. The adoption of the same system for crash severity classification in different countries would allow comparisons in the safety performances between countries and jurisdictions.

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Sponsoring Committee ABJ35, Highway Traffic Monitoring
Session Number 640
Session Title Bicycle and Pedestrian Counting Data and Collection Methods
Paper Number 13-3281
Paper Title Estimating Annual Average Daily Bicyclists: Error and Accuracy
Abstract Cities around the country are investing in bicycle infrastructure for which they seek to report bicycle use and safety improvements in order to secure additional transportation funding. A fundamental data need for performing safety studies and reporting facility use is bicyclist traffic volume. To address this need, manual bicycle counting programs have been established that count cyclists for a few hours per year at each designated location. A key issue that arises in designing counting programs (apart from the count locations) is the timing and frequency of the counts required to obtain a reliable estimate of annual average daily bicyclists (AADB). In particular, in which days of the week, hours of the day, and months of the year should counts be collected? And most important to the program cost, how many hours should be counted? This study uses continuous bicycle counts from Boulder, Colorado to estimate AADB and analyze the estimation errors that would be expected from various bicycle-counting scenarios. AADB average estimation errors were found to range from 15% with four weeks of continuous count data to 54% when only one hour is counted per year. This study recommends that counts be conducted for at least twenty-four hours, but perferrably for an entire week, using automated counting devices specificially calibrated for bicycle counting. Seasons with higher bicycle volumes have less variation in bicycle counts and thus more accurate estimates.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-1049
Paper Title Spatial Analysis of Fatal and Injury Crashes in Flanders, Belgium: Application of Geographically Weighted Regression Technique
Abstract Generalized Linear Models (GLMs) are the most widely used models utilized in crash prediction studies. These models illustrate the relationships between the dependent and explanatory variables by estimating fixed global estimates. Since the crash occurrences are often spatially heterogeneous and are affected by many spatial variables, the existence of spatial correlation in the data is examined by means of calculating Moran's I measures for dependent and explanatory variables. The results indicate the necessity of considering the spatial correlation when developing crash prediction models. The main objective of this research is to develop different Zonal Crash Prediction Models (ZCPMs) within the Geographically Weighted Generalized Linear Models (GWGLM) framework in order to explore the spatial variations in association between Number of Injury Crashes (NOICs) (including fatal, severely and slightly injury crashes) and other explanatory variables. Different exposure, network and socio-demographic variables of 2200 Traffic Analysis Zones (TAZs) are considered as predictors of crashes in the study area, Flanders, Belgium. To this end, an activity-based transportation model framework is applied to produce exposure measurements while the network and socio-demographic variables are collected from other sources. Crash data used in this study consist of recorded crashes between 2004 and 2007. GWGLMs are developed using a Poisson error distribution and are often referred to as Geographically Weighted Poisson Regression (GWPR) models. Moreover, the performances of developed GWPR models are compared with their corresponding GLMs. The results show that GWPR models outperform the GLM models; this is due to the capability of GWPR models in capturing the spatial heterogeneity of crashes.

Authors Robert Pollack, Federal Highway Administration
Sponsoring Committee ABJ00, Data and Information Systems
Session Number 277
Session Title MAP-21 Demands on Safety Data
Paper Number P13-5115
Paper Title Safety Data Quality Implications of MAP-21
Abstract No abstract available

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 433
Session Title Improving Safety Data, Analysis, and Evaluation
Paper Number 13-3047
Paper Title Developing a Truck Corridor Crash Severity Index
Abstract According to the United States Department of Transportation (USDOT) estimates, over 500,000 truck accidents occur every year. Of that number, approximately 5,000 trucking accidents result in fatalities. Compared to extensive studies conducted on freeway truck safety, the research on arterial streets is considerably disproportionate. Making the connections between truck traffic generators, arterial streets are key links in door-to-door deliveries. There is an urgent need to study truck safety on arterial streets because of the strong growth of truck traffic. Truck related crashes are expected to be reduced through the careful planning of the location, design, and operation of driveways, median openings, street connections and street sections. By collecting extensive data on selected arterial corridors that are heavily used by trucks, truck crash frequency and severity contributing factors have been identified using negative binomial model and multinomial logit (MNL) model, respectively. Subsequently, a crash severity index (CSI) for the truck arterial corridors was developed. The findings from the study will not only benefit state and local agencies in planning, design, and manage a safer truck arterial corridor, but also help carriers to optimize their routes from the safety perspective.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-2067
Paper Title Modeling Large-Truck Safety Using Logistic Regression Models
Abstract Statistics shows that crashes involving large trucks are generally more severe than those involving other vehicles due to the size, weight, and speed differential between trucks and other vehicles. Given the critical position of trucking in the process of economic recovery and growth, it is urgent to improve truck safety and mitigate any negative impacts to non-truck vehicles. Statistical models have been used universally to identify the contributing factors to crash severities and estimate injury probabilities. These different methodologies, albeit addressing different issues, may provide mixed results and the estimate accuracy may vary. The primary objective of this research is to investigate the effects of key determents to crash severities involving large trucks and to explore the relationship between them. The secondary objective is to provide insight on statistical applications by evaluating three logistic regression models: multinomial

logistic (MNL), partial proportional odds (PPO), and mixed logistic (ML) models. The model results show that the majority of the coefficient estimates are consistent across the models studied. A few exceptions include young drivers and the use of safety constraints, which are not statistically significant in the ML model. The goodness-of-fit and model predictive power indicates that the PPO model produced the results that more closely resembled observations.

Authors April Renard, Louisiana Department of Transportation and Development
Sponsoring Committee AHB65, Operational Effects of Geometrics
Session Number 399
Session Title Case Studies in Performance-Based Analysis of Geometric Design
Paper Number P13-6786
Paper Title Quantifying Safety Benefits Associated with Various Design Alternatives for Interstate 12
Abstract No abstract available

Authors Francesca Russo, University of Naples Federico II, Italy
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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-1313
Paper Title Gender Gaps in Crash Data: Statistical Look at Gender and Age Differences as Related to Crash Frequencies
Abstract This study was performed to calibrate safety performance functions (SPFs) to predict the number of injurious crashes per year per km per 10^8 vehicles on the horizontal homogeneous segment of two-lane rural roads. The crashes were analyzed from the perspective of driver gender for three main injurious crash types (head-on/side and rear collisions, tail crashes, and single-vehicle run-off-road crashes) as observed on the network. We analyzed more than 3,700 km of road network with 2,242 accidents recorded from 2003 to 2010, of which 1,597 were injurious, and 645 resulted in only damage to property. Generalized estimating equations with a negative binomial distribution and additional log linkage equations were implemented. A very exciting statistical variable was introduced in the models constructed according to plotted crash risk maps by varying the crash type, the number and gender of the drivers involved in the crash and the scenario represented by a particular combination of infrastructural and environmental conditions surveyed on the site at the time of the crash. We have also introduced lane width, horizontal curvature indicators and mean speed as consistent explanatory factors in the model. Countermeasures are suggested for reducing crash frequency such as awareness campaigns and road structural operations.

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Sponsoring Committee AHB30, Vehicle-Highway Automation
Session Number 647
Session Title Vehicle-Highway Automation
Paper Number 13-3887
Paper Title Intelligent Cooperative Intersection for Improving Traffic Safety
Abstract New communication technologies offer the possibility to exchange data amongst vehicles and between infrastructural entities and vehicles. These opportunities have led to the new field of the Cooperative Systems in the area of Intelligent Transport Systems. A lot of research to adapt Cooperative Systems to different areas in ITS has already taken place, but Cooperative Systems are still under development as the presented review in the paper shows. One field of application is urban intersections. These are still accident prone areas despite improved safety features in vehicles and infrastructural improvements. Through the use of data exchange among the vehicles and the infrastructure the authors developed the Intelligent Cooperative Intersection Safety System – IRIS – to improve traffic safety at urban intersections. The paper presents the concept of the IRIS application and focuses on the fusion of data directly from the vehicles, road-based detectors and the traffic light controller to create an enhanced overview of the situation at the intersection by modeling the road users' movements. This overview is assessed afterwards and if a threat for a road user is detected, a warning message is sent to the vehicles involved in the critical situation. The paper includes a report on the tests conducted at a real intersection in the City of Dortmund, Germany. These tests proved that the IRIS concept makes a valuable contribution to make urban intersections safer.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 302
Session Title Ensuring Data Quality: What Are the Pitfalls and How Can We Overcome Them?
Paper Number P13-6730
Paper Title Data Quality Management from User's Perspective
Abstract No abstract available

Authors Terry T. Shelton, National Highway Traffic Safety Administration
Sponsoring Committee ABJ00, Data and Information Systems
Session Number 277
Session Title MAP-21 Demands on Safety Data
Paper Number P13-5111
Paper Title Safety Data Needs: The Big Picture
Abstract No abstract available

Authors	Hyeonshic Shin, Morgan State University
Sponsoring Committee	AHB65, Operational Effects of Geometrics
Session Number	399
Session Title	Case Studies in Performance-Based Analysis of Geometric Design
Paper Number	P13-6791
Paper Title	Impacts of Segment Length and Different Sampling Strategies on Local Calibration Factors for the Highway Safety Manual
Abstract	No abstract available

Authors	Omar G. Smadi, Iowa State University
Sponsoring Committee	FA000, SHRP 2 Technical Coordinating Committee for Safety
Session Number	566
Session Title	New to Naturalistic Driving Data? An Update on Naturalistic Driving Study (NDS) Projects, Data, Analysis, and Uses
Paper Number	P13-5051
Paper Title	Update on Roadway Data Being Acquired for NDS Linkage and Analysis
Abstract	No abstract available

Authors	Steven K. Smith, Federal Motor Carrier Safety Administration
Sponsoring Committee	ABJ00, Data and Information Systems
Session Number	277
Session Title	MAP-21 Demands on Safety Data
Paper Number	P13-5113
Paper Title	MAP-21 and Motor Carrier Safety Data
Abstract	No abstract available

Authors	Clifford H. Spiegelman, Texas A&M University System
Sponsoring Committee	ABJ80, Statistical Methods
Session Number	302
Session Title	Ensuring Data Quality: What Are the Pitfalls and How Can We Overcome Them?
Paper Number	P13-6727
Paper Title	What Are Quality Data?
Abstract	No abstract available

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Sponsoring Committee	A0030T, Special Task Force on Data for Decisions and Performance Measures
Session Number	325
Session Title	Data Privacy Issues in a World Where Technology Is Way Ahead of Polic
Paper Number	13-3144
Paper Title	Privacy Protection Method for Fine-Grained Urban Traffic Modeling Using Mobile Sensors
Abstract	Privacy in transportation is controversial and under-studied. With the ubiquitous applications of Intelligent Transportation System (ITS) technologies, privacy issues in transportation are becoming increasingly important and need to be addressed carefully. As a well-known trade-off, data needs and privacy protection should be deliberately balanced for different applications. This paper focuses on developing privacy mechanisms to simultaneously satisfy privacy protection and modeling needs for fine-grained urban traffic modeling using mobile sensors. To accomplish this, a virtual trip lines (VTL) zone-based system and related filtering approaches are developed. Traffic-knowledge-based adversary models are proposed to evaluate the effectiveness of such system by making privacy attacks. The results show that besides ensuring an acceptable level of privacy, the released datasets from such privacy-enhancing system can also be applied to traffic applications with satisfactory performance. Albeit application specific, such "Privacy-by-Design" approach would hopefully shed some light on other applications.

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Sponsoring Committee	AHB65, Operational Effects of Geometrics
Session Number	399
Session Title	Case Studies in Performance-Based Analysis of Geometric Design
Paper Number	P13-6788
Paper Title	Converting Divided Urban Four-Lane Roadway to Five-Lane Roadway: Successful Case Study in Louisiana
Abstract	No abstract available

Authors	Shawn M. Turner, Texas A&M Transportation Institute Philip H. Lasley, Texas A&M Transportation Institute
Sponsoring Committee	ABJ35, Highway Traffic Monitoring
Session Number	640
Session Title	Bicycle and Pedestrian Counting Data and Collection Methods
Paper Number	13-2552
Paper Title	Quality Counts for Pedestrians and Bicyclists: Quality Assurance Procedures for Nonmotorized Traffic Count Data
Abstract	As pedestrian and bicyclist monitoring increases among public agencies, it is critically important that data quality principles be included in the data collection practices. The main objective of this paper was to outline key quality assurance principles and their application to pedestrian and bicyclist traffic count data. Three key principles of quality

assurance were described: 1) Quality assurance starts before data are collected; 2) "Acceptable" data quality is determined by its use; and 3)Measures can quantify different quality dimensions. The authors provide specific recommendations for 2 data quality measures: accuracy and validity.

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Sponsoring Committee A0030T, Special Task Force on Data for Decisions and Performance Measures
Session Number 325
Session Title Data Privacy Issues in a World Where Technology Is Way Ahead of Polic
Paper Number 13-4295
Paper Title Ethical and Legal Issues Relating to Government Agencies and Intelligent Transportation Systems Data
Abstract The convergence of sensing, wireless telecommunications, and multi-media platforms have provided new opportunities for the development of intelligent transportation systems (ITS). These systems can provide real-time information to travelers and transportation agencies. As well as increase the overall efficiency and improve the management of the transportation network. While ITS applications, including those derived from connected vehicle technology, can enhance mobility, increase safety, and improve the environmental performance of the transportation system, they also raise legal and ethical questions about privacy, anonymity, and other concerns related to use of ITS data. As a prerequisite to deployment of ITS technologies, issues regarding the collection, management, and use of data must be addressed to the satisfaction of all parties, including government agencies, businesses, and private citizens. This paper summarizes the legal environment surrounding ITS, as well as controls used by agencies and industry to ensure ethical practices relating to ITS. Next, it describes specific ITS applications and discusses several issues relating to government involvement with ITS applications and data. Finally, the paper outlines specific recommendations for ITS planners and developers. These recommendations address determining system attributes and requirements while considering ethical implications and tradeoffs; resolving acceptance, adoption, and equity issues; and designing a system for the ethical governance and management of ITS and the information they create.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-3490
Paper Title Estimating Annual Average Daily Traffic for Local Roads for Highway Safety Analysis
Abstract Annual average daily traffic (AADT) is a required input to the newly released SafetyAnalyst software application. Further, AADT is also required to calculate crash rates. Traditionally, AADTs are estimated using a mix of permanent and temporary traffic counts collected in the field. Because field collection of traffic counts is expensive, it is usually performed for only the major roads. The mandate by the Federal Highway Administration (FHWA) to report the top 5% of high crash locations on all public roads underscores, for the first time, the need for state Departments of Transportation to acquire AADTs for also the non-state local roads. However, many local jurisdictions either do not have any AADT data, or they do not have them in sufficient quality. This paper presents a method to estimate AADTs for local roads using the travel demand modeling method. A major component of the method involves a parcel-level trip generation model that estimates the trips generated by each parcel. The generated trips are then distributed to existing traffic count sites using a parcel-level trip distribution gravity model. The all-or-nothing trip assignment method is then applied to assign the trips between the parcels and the traffic count sites onto local roadway network to yield estimates of AADTs. The estimated AADTs were compared with those from an existing regression-based method using actual traffic counts from Broward County, Florida. The results show that the proposed method produces significantly lower mean absolute percentage errors.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 433
Session Title Improving Safety Data, Analysis, and Evaluation
Paper Number 13-1841
Paper Title On the commonly accepted assumptions regarding observed motor vehicle crash counts at transport system locations
Abstract Readily accepted knowledge regarding crash causation is consistently omitted from efforts to model and subsequently understand motor vehicle crash occurrence and their contributing factors. For instance, distracted and impaired driving accounts for a significant proportion of crash occurrence, yet is rarely modeled explicitly. In addition, spatially allocated influences such as local law enforcement efforts, proximity to bars and schools, and roadside chronic distractions (advertising, pedestrians, etc.) play a role in contributing to crash occurrence and yet are routinely absent from crash models. By and large, these well-established omitted effects are simply assumed to contribute to model error, with predominant focus on modeling the engineering and operational effects of transportation facilities (e.g. AADT, number of lanes, speed limits, width of lanes, etc.) The typical analytical approach—with a variety of statistical enhancements—has been to model crashes that occur at system locations as negative binomial (NB) distributed events that arise from a singular, underlying crash generating process. These models and their statistical kin dominate the literature; however, it is argued in this paper that these models fail to capture the underlying complexity of motor vehicle crash causes, and thus thwart deeper insights regarding crash causation and prevention. This paper first describes hypothetical scenarios that collectively illustrate why current models mislead highway safety researchers and engineers. It is argued that current model shortcomings are significant, and will lead to poor decision-making. Exploiting our current state of knowledge of crash causation, crash counts are postulated to arise from three processes: observed network features, unobserved spatial effects, and 'apparent' random influences that reflect largely behavioral influences of drivers. It is argued; furthermore, that these three processes in theory can be modeled separately to gain deeper insight into crash causes, and that the model represents a more realistic depiction of reality

than the state of practice NB regression. An admittedly imperfect empirical model that mixes three independent crash occurrence processes is shown to outperform the classical NB model. The questioning of current modeling assumptions and implications of the latent mixture model to current practice are the most important contributions of this paper, with an initial but rather vulnerable attempt to model the latent mixtures as a secondary contribution.

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Sponsoring Committee AHB65, Operational Effects of Geometrics
Session Number 399
Session Title Case Studies in Performance-Based Analysis of Geometric Design
Paper Number P13-6789
Paper Title Performance-Based Design of Interchanges
Abstract No abstract available

Authors Jonathan S. Wood, University of Utah
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Sponsoring Committee AFB10, Geometric Design
Session Number 679
Session Title Performance-Based Tools to Assess Geometric Design Decisions
Paper Number 13-4078
Paper Title Safety Impacts of Design Exceptions on Nonfreeway Segments
Abstract The objective of this research was to compare safety, measured by expected crash frequency and severity, on road segments where design exceptions were approved and constructed to similar road segments where no design exceptions were approved or constructed. Data were collected for design exceptions in Utah in the years 2001 through 2006. Multiple data sources were used to identify and define road segments with and without design exceptions. Propensity scores were applied in this study to assess similarities between treatment and comparison sites. Ultimately, a total of 34 non-freeway segments with design exceptions and 80 non-freeway segments without design exceptions were used for modeling. The relationship between design exception presence and crash frequency was explored using a negative binomial regression modeling approach. The relationship between design exception presence and crash severity was explored in three ways: 1) computing severity distributions at locations with and without design exceptions; 2) estimating separate negative binomial regression models by severity level; and 3) estimating multinomial logit models to predict the severity outcome of a crash. Design exception presence was represented in the regression models by an indicator variable (1 = one or more design exceptions; 0 = no design exceptions). Crash data from the years 2007 through 2010 were used for model estimation. There were no significant differences in expected crash frequencies and crash severities between non-freeway road segments with and without design exceptions. This overall finding is consistent with two previous, related efforts in Kentucky and Indiana.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4293
Paper Title Screening Naturalistic Driving Study Data
Abstract This study responds to the need to screen events observed during naturalistic driving studies to derive a set of crashes and near crashes with common etiologies; referred to as well-defined surrogate events. Two factors are critical to the identification of these well- defined surrogate events: selection of screening criteria and the designation of a time window to be used for event search. This paper describes testing conducted using an algorithm developed in a previous paper (Wu and Jovanis, 2011b). The algorithm allows for the use of a range of search criteria to identify events with common etiology from raw naturalistic driving data. A range of kinematic search criteria are used to screen events including lateral and longitudinal accelerations averaged over different time windows and characterized by average as well as maximum values during a time window. The testing is conducted using data from road departure events collected during a concluded 100-car naturalistic driving study. A total of 51 non-intersection and 12 intersection-related run-off-road events are included in the testing. Different sets of events were identified using different search criteria with different time windows. Diagnostic tools borrowed from medicine identify the best screening criteria and time windows. The methods allow for enhanced identification of well-defined surrogates using covariates such as driver attributes context and driver fatigue. The research illustrates a flexible procedure using a variety of statistical methods that are shown to effectively screen crashes and near crashes.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4566
Paper Title Automated Intersection Safety Evaluation Using Linear Referencing System Methods
Abstract Effective evaluation of intersection safety requires the ability to develop meaningful benchmarks to help assess the relative safety risk for a given intersection. One approach is to develop a database of average crash rates over intersections with similar features such as functional class, intersection geometry, and, signalization in order to provide

a basis for comparison when evaluating specific intersections for potential safety issues. However development and maintenance of such a database requires significant manual effort. This paper introduces an automated intersection safety data collection method, including an algorithm to update intersection crash rates and geometric features from existing sources. The automation algorithm involves the integration of four separate Wisconsin Department of Transportation (WisDOT) databases through association with a common Linear Referencing System (LRS). The result of the application of the automation algorithms suggest the methodology is feasible and can improve the quality of intersection safety data collection. Although the methodology introduced is specific to Wisconsin data, the results can also be applied to other state DOTs that manage traffic data with respect to an LRS.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4866
Paper Title Investigating the Characteristics of Secondary Crashes on Freeways
Abstract Prevention of secondary crashes is one of the priorities in traffic incident management. However, limited information on secondary crashes has largely impeded the selection of appropriate countermeasures. The primary goal of this paper is to improve the understanding of secondary crashes, which is achieved by two major steps. First, an analysis framework is developed to accurately identify secondary crashes by integrating rich traffic sensor data with the statewide crash data sets. Second, the characteristics of the identified secondary crashes are investigated in detail. Secondary crashes that occurred on a 27-mile section of a major highway in New Jersey were mined using the proposed analysis framework. A thorough examination of their characteristics was then performed. Empirical findings on the frequency of secondary crashes, their spatio-temporal distributions, clearance time, crash type, severity, and major contributing factors were highlighted. These preliminary results can help transportation agencies make more informed decisions on mitigating secondary crashes and improve their incident management operations. To complement the results, further in-depth investigations based on more high-resolution sensor data and high-quality incident records are suggested.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-4081
Paper Title Evaluating Alternate Discrete Choice Frameworks for Modeling Crash Injury Severity
Abstract This paper focuses on the relevance of alternate discrete choice frameworks for modeling driver injury severity. The study empirically compares the ordered response and unordered response models in the context of driver injury severity in traffic crashes. The alternative modeling approaches considered for the comparison exercise include: for the ordered response framework- ordered logit (OL), generalized ordered logit (GOL) and for the unordered response framework - multinomial logit (MNL), nested logit (NL) and ordered generalized extreme value logit (OGEV) model. A host of comparison metrics are computed to evaluate the performance of these alternative models. To our knowledge, the study provides a first of its kind comparison exercise of the performance of ordered and unordered response models for examining the impact of exogenous factors on the driver injury severity. The research also captures the effect of potential underreporting on alternative choice frameworks by artificially creating an underreported data sample from the driver injury severity sample. The empirical analysis is based on the 2010 General Estimates System (GES) data base. The comparison exercise clearly highlights the superiority of the GOL model on the estimation and the validation sample in terms of data fit compared to the OL and MNL models. The estimation with the artificial underreported sample consistently obtains the wrong elasticities and these errors are substantially reduced for both GOL and MNL models with the correction measures for the thresholds/constants of these models based on the true aggregate shares. The most striking finding is the fact that the MNL model does not perform any better in the underreporting context. In fact, the GOL elasticity effects of underreported estimates with corrections are closer to the true elasticity effects than that of the MNL model. Overall, the results of the empirical comparison provide credence to the belief that an ordered systems that allow for exogenous variable effects to vary across alternatives offer superior fit compared to unordered systems in modeling driver injury severity.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-3317
Paper Title Characteristics and Contributing Factors of On-Duty Struck-by Crashes
Abstract Emergency responders and roadway workers are on-duty to assist incidents and perform roadway maintenance and construction, which benefits all road users. However, the location of their work implies that they are exposed to being struck by surrounding traffic. On-duty struck-by crashes are defined as a traffic incident that involves police officers, roadway workers, firefighters and EMT/First Responders, who are hit by a motorist while on duty assisting an incident or at a work zone. The objective of this research is to summarize and analyze struck-by crashes. Initial crash data are extracted from the WisTransPortal on Wisconsin's State Trunk Network (STN). Data are selected from 2000-2010 and included several filtering steps and manual identification for data reduction. Two hundred sixty-five crashes are identified as struck-by crashes and the characteristics and contributing factors are analyzed. Responder and worker

struck-by crashes are separately analyzed with different characteristics shown, all STN crashes from 2000-2010 are used as a comparison group. Characteristics are classified into crash, highway, environment, and on-duty person characteristics. Driver contributing factors are also presented. Results show that for responders crashes, police officers are the predominant type of on-duty person. A large proportion of responder crashes occurred on rural interstate highways. Speeding or "too fast for conditions" is the key driver factor that leads to struck-by crashes at incidents and adverse roadway/weather conditions are the most significant environmental factor. Most emergency responder struck-by crashes occur when responders are assisting traffic incidents. On the other hand, for roadway workers, flagmen hit by surrounding traffic account for around half of all worker struck-by crashes, worker crashes are likely uncorrelated with adverse weather, roadway or lighting conditions. Inattentive driving of civilian drivers is the most significant contributing factor. These results could provide a basis for countermeasures to protect emergency responders and roadway workers.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-0222
Paper Title Formulating Informative Priors and Effects on Bayesian Hierarchical Crash Models
Abstract The Bayesian inference method has been frequently adopted to develop safety performance functions. One advantage of the Bayesian inference is that prior information about the independent variables can be included in the models, which could benefit the inference conclusions from avoiding implausible results due to data fluctuations. However, there are few past studies discussing how to formulate the informative priors and what are the effects of having informative priors in developing Safety Performance Functions. This paper fills the void by introducing four approaches of developing informative priors for the independent variables based on historical data or general information. Merits of these informative priors have been tested along with two types of Bayesian Hierarchical models (Poisson-gamma model and Random effect Poisson model). Deviance Information Criterion (DIC), R-square values and standard errors were utilized as evaluation measures to select the best model(s). Comparisons across the models indicate that the Poisson-gamma model is superior with better model fitting and it is much more robust with the informative priors. Moreover, model fitting and coefficient estimation accuracies have been enhanced by the informative priors. Finally, based on the results, recommendations are made for the different informative prior development techniques.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-0718
Paper Title Crash-Type Propensity Analysis with Bayesian Models Using Microscopic Traffic and Weather Data
Abstract This study investigates a range of effects of microscopic traffic and weather factors and roadway geometry information on the specific crash type for a mountainous freeway. Crashes have been categorized as rear-end, sideswipe and single-vehicle crashes. Six-minute Automatic Vehicle Identification (AVI) segment average speed, real-time weather data and roadway geometry data are utilized as explanatory variables in this study. First, two binary logistic regression models were estimated by comparing single-vehicle to multi-vehicle crashes and sideswipe crashes to rear-end crashes. Then a full model which simultaneously fits two conditional logistic regression models (mixed logit model) for the three crash types has also been estimated. Results from the models indicate that single-vehicle crashes are more probable in the snow season, at moderate slopes, three-lane segments, under the free-flow conditions; while the sideswipe crash occurrence differs from rear-end crashes with the visibility situation, number of lanes, grades and their directions (up or down). Moreover, the results of the Bayesian random effects logistic regression models have been compared with the results from the classic logistic regression with the Frequentist and Bayesian inference techniques. It was demonstrated that the Bayesian random effects logistic regression outperforms the other two approaches with higher accuracy and lower Brier scores. The innovative way of estimating two conditional logistic regression models simultaneously in the Bayesian framework fits the data structure well. Conclusions from this study imply that different active traffic management strategies should be designed for three- and two-lane roadway sections and also considering the seasonal effects.

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Sponsoring Committee A0030T, Special Task Force on Data for Decisions and Performance Measures
Session Number 325
Session Title Data Privacy Issues in a World Where Technology Is Way Ahead of Polic
Paper Number 13-0650
Paper Title Integrated Transportation Payment System Security and Privacy Breaches: Extent of the Problem and Simulated Case Study
Abstract This research investigates the security and privacy breaches of electronic Integrated Transportation Payment Systems, ITPS, via Radio-Frequency Identification, RFID, tags and smart cards, their frequency of occurrence and type. This National Science Foundation, NSF, funded study has created a website that collects news events reporting breaches worldwide and automatically categorizes them by various characteristics, including five defined categories for security types of breaches and five categories of privacy breaches. A preliminary statistical analysis reports the existing extent of the problem in electronic ITPS. A second objective requires investigation of the impact on traffic operations due to

the adoption of security protection measures or software algorithms. One case study, a toll collection facility on the Massachusetts Turnpike is simulated in PTV Vision VISSIM traffic software for various transaction times. This ITPS is a ticketing tolling payment system located on the I-90 east-west Turnpike in Massachusetts, USA. Simulations were performed with and without added times at the point of the payment transaction. Initial results indicate that the impact on operations is negligible for security measures that add milliseconds of transaction time. However, for added transaction times in a range of seconds, the impact is more significant.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-2427
Paper Title Modeling Frequency of Traffic Conflicts at Signalized Intersections Using Generalized Linear Regression Models
Abstract The primary objective of this study was to identify the potential of using conflict prediction models to predict the frequency of traffic conflicts at signalized intersections. The opposing left-turn conflicts were selected for the development of conflict prediction models. Using data collected at thirty approaches at twenty signalized intersections where the permitted left-turn phases were used, the underlying distributions of the conflict frequency for different volume regimes in different time intervals were examined. It was found that the conflict frequency generally followed a negative binominal distribution. Different conflict prediction models were developed, including a linear regression model, an overall negative binomial model, and separate models developed for four traffic scenarios which were defined based on the volume to capacity ratio of the conflicting traffic flows. The prediction performance of different models was compared. It was found that the linear regression model was not appropriate for modeling the conflict frequency data. In addition, drivers behaved differently under different traffic conditions. Thus, the effects of conflicting traffic volumes on conflict frequency were different in different traffic conditions. The generalized linear regression models developed for different traffic scenarios provided the best estimates for the field measured conflicts.

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Sponsoring Committee ABJ20, Statewide Transportation Data and Information Systems
Session Number 423
Session Title Transportation Data Applications
Paper Number 13-2402
Paper Title Feasibility and Advantages of Estimating Local Road VMT Based on GPS Travel Data
Abstract A critical part of the US national transportation data program is the Highway Performance Monitoring System (HPMS) and the reporting of vehicle miles traveled (VMT) on different levels of roadways. While the amount of travel on higher-level roads can often be reliably estimated from traffic counts and other data sources, existing heuristic methods for estimating lower-level and local road VMT suffer from the lack of ground truth data. At the same time, information on local roads across the nation is becoming increasingly important due to several emerging transport-related issues such as revenue allocation, emissions, and safety exposure. This paper develops a novel method for estimating local road VMT from GPS and other supplemental data sources, and investigates the associated statistical issues. The proposed method is applicable at the national, state, and any local levels, and is demonstrated in a case study in Maryland. By matching GPS data with GIS road networks, GPS-based travel surveys provide very reliable ground truth data for local road VMT estimation. GPS survey sample size and duration required for reliable VMT estimation are also analyzed within the case study. Results show that by lengthening survey duration, the required sample size could be reduced significantly. However, the sample size reduction effect of longer survey duration diminishes as the survey duration exceeds a certain threshold. Our case study and statistical analysis show that a 30-day GPS survey would reduce the required sample size by 50~60% compared to a single-day survey, and a 15-day GPS survey with 670 participating drivers could provide VMT estimates with a 5% margin of error at the 95% confidence level. Survey designer could employ longer survey duration to further reduce sample size or recruit more participants for a shorter survey. These findings suggest GPS-based surveys are feasible and cost-effective options for VMT estimation on different levels of roadways including local roads. Federal, state and local agencies may just use GPS-surveys already planned for other purposes (e.g., travel demand modeling and planning applications) for VMT estimation.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-2938
Paper Title Comparison of Sichel and Negative Binomial Models in Estimating Empirical Bayes Estimates
Abstract Traditionally, transportation safety analysts have used the empirical Bayes (EB) method to improve the estimate of the long-term mean of individual sites and to identify hotspots locations. The EB method combines two different sources of information: (1) the expected number of crashes estimated via crash prediction models, and (2) the observed number of crashes at individual sites. Crash prediction models have extensively been estimated using a negative binomial (NB) modeling framework due to the over-dispersion commonly found in crash data. Recent studies have shown that the Sichel (SI) distribution provides a promising avenue for developing crash prediction models. The objective of this study is to examine the application of the SI model in calculating EB estimates. To accomplish the objective of the study, the SI models with a fixed/varying dispersion term are developed using the crash data collected

at 4-lane undivided rural highways in Texas. The important conclusions can be summarized as follows: (1) the selection of the crash prediction model (i.e., the SI or NB model) will affect the value of weight factor used for estimating the EB output; (2) the identification of hazardous sites, using the EB method, can be different when the SI model is used. Finally, a simulation study designed to examine which crash prediction model can better identify the hotspot is recommended as our future research.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-2138
Paper Title Evaluating Double Poisson Generalized Linear Model
Abstract The objectives of this study are to: 1) examine the applicability of the double Poisson (DP) generalized linear model (GLM) for analyzing motor vehicle crash data characterized by over- and under-dispersion and 2) compare the performance of the DP GLM with the COM-Poisson GLM in terms of goodness-of-fit and theoretical soundness. The DP distribution has seldom been investigated and applied since its first introduction two decades ago. The hurdle of applying the DP is related to its normalizing constant (or multiplicative constant) which is not available in closed form. This study proposed a new method to approximate the normalizing constant of the DP with high accuracy and reliability. The DP GLM and COM-Poisson GLM were developed using two observed over-dispersed datasets and one simulated under-dispersed dataset. The performances of the NB GLM (for over-dispersion) and Poisson GLM (for under-dispersion) were also provided as reference. The modeling results indicate that the DP GLM with its normalizing constant approximated by the new method can handle crash data characterized by over- and under-dispersion. Its performance is comparable to the COM-Poisson GLM in terms of GOF, although COM-Poisson GLM provides a slightly better fit. For the over-dispersed data, the DP GLM performs similar to the NB GLM. This study also shows that the traditional Poisson GLM overestimates the standard errors of the coefficients when the data are characterized by under-dispersion. Considering the fact that the DP GLM can be easily estimated and computationally inexpensive, it offers a flexible and efficient alternative for researchers to model the count data.

3 Papers on safety performance functions

Safety performance functions (SPFs) are developed for estimating the expected crash frequency (including by crash severity and collision types) of a network, facility, or individual site. The predictive methods provide a quantitative measure of the expected average crash frequency under both existing conditions and conditions which have not yet occurred.

Thirty papers were identified by the subcommittee to address safety performance functions (SPFs). Among these papers, twenty five involve the development or calibration of SPFs for both microscopic (road segments and intersections) and macroscopic crash (area) prediction. Three papers applied previously developed SPFs in the Highway Safety Manual (HSM) for case studies. The other two contributed to the review and discussion of current SPF modeling methods. When developing SPFs, a variety of traditional methods were employed, such as the Negative Binomial (NB) model, random parameter models, count models considering random effects and spatial correlations, tobit model, time-series models, Generalized Nonlinear Models (GNM) and Bayesian computation techniques. The research interests extended to the prediction of crash frequency under different severity levels and collision types on the macroscopic level, freeway segments, ramps, interchange influence areas, highway segments, intersections and roundabouts.

From an application perspective, several papers addressed freeway sections' safety (*Cafiso et al.; Chngye and Ranjitkar; Geedipally et al.; Hong et al.; Kim et al.; Venkataraman et al.*), intersections' safety (*Lim and Kweon*; *Potts et al.; Wang et al.; Zhang and Liu*), highway sections' safety (*Avelar et al.; Hout et al.; Lao et al.; Mehta and Lou; Russo and Biancardo; Xu et al.; Zeng and Schrock*), as well as spatial areas' safety (*Aguero-Valverde; Antoniou and Yannis; Chi et al.; Huang et al.; Karim et al.; Lee et al.; Pirdavani et al.*). Among macroscopic crash analysis papers, different spatial scales were studied, such as the Traffic Analysis Zone (TAZ) (*Pirdavani et al.; Huang et al.*), Traffic Safety Analysis Zone (TSAZ, regionalization of TAZs) (*Huang et al.*), ZIP code area (*Lee et al.).* and other scales (*Aguero-Valverde; Antoniou and Yannis; Chi et al.; Karim et al.*). Among others are papers that were specifically focusing on roundabouts (*Qin et al.*), freeway interchange influence areas (*Lu et al.*) and horizontal curves on rural undivided roadways (*Khan et al.*).

Several papers considered the influence of spatial heterogeneity and correlations on crash patterns (*Aguero-Valverde; Chi et al.; Hong et al.; Karim et al.; Pirdavani et al.; Wan et al.*). A few papers dedicated to explore specific SPFs for clustered roadways, intersections, spatial zones, and crashes based on various features (*Avelar et al.; Chngye and Ranjitkar; Hout et al.; Huang et al.; Khan et al.; Kim et al.; Potts et al.; Venkataraman et al.*). Three papers have investigated the temporal variability of SPFs (*Antoniou and Yannis; Hong et al.; Zeng and Schrock*). One paper introduced approaches to develop informative priors for Bayesian models (*Yu et al.*). One has discussed the efficiency of traditional count models in predicting crash frequency (*Washington and Haque*). Other topics include the prediction of the proportion of crash frequency on each severity level (*Geedipally et al.*), the calibration of HSM SPFs in the State of Alabama (*Mehta and Lou*), network screening (*Laumet; Lim and Kweon*), segmentation of freeways (*Cafiso et al.*).

Methodologically, traditional count models, such as the Poisson-gamma and Poisson-lognormal model are still the mainstream (*Avelar et al.; Chngye and Ranjitkar; Hout et al*.; *Huang et al.; Karim et al.; Kim et al.; Lee et al.; Russo and Biancardo*). On the basis of these traditional count models, several papers further considered spatial heterogeneity and correlations by using random effect models (*Chi et al.; Wang et al.*), random parameter models (*Hong et al.; Venkataraman et al.*), and autoregressive models (*Aguero-Valverde*). In addition, both the full Bayesian and Empirical Bayesian computation techniques were widely employed (*Aguero-Valverde; Karim et al.;*

Laumet; Lim and Kweon; Lu et al.; Qin et al.; Wang et al.; Yu et al.). The other methodologies include Geographically Weighted Generalized Linear Models for macroscopic safety (*Pirdavani et al.*), nonparametric models for crash data classification (*Khan et al.*), time-series models to predict macroscopic crash frequency (*Antoniou and Yannis*), Generalized Nonlinear Models to estimate rear-end crash frequency (*Lao et al*.), and tobit model to handle endogeneity issues (*Xu et al.*).

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-1061
Paper Title Multivariate Spatial Models of Excess Crash Frequency at Area Level: Case of Costa Rica
Abstract Recently, areal models of crash frequency have being used in the analysis of various area-wide factors affecting road crashes. On the other hand, disease mapping methods are commonly used in epidemiology to assess the relative risk of the population at different spatial units. A natural next step is to combine these two approaches to estimate the excess crash frequency at area level as a measure of absolute crash risk. Furthermore, multivariate spatial models of crash severity are explored in order to account for both frequency and severity of crashes and control for the spatial correlation frequently found in crash data. This paper aims to extent the concept of safety performance functions to be used in areal models of crash frequency. A multivariate spatial model is used for that purpose and compared to its univariate counterpart. Full Bayes hierarchical approach is used to estimate the models of crash frequency at canton level for Costa Rica. An intrinsic Multivariate Conditional Autoregressive model is used for modeling spatial random effects. The results show that the multivariate spatial model performs better than its univariate counterpart in terms of the penalized goodness-of-fit measure Deviance Information Criteria. Additionally, the effects of the spatial smoothing due to the multivariate spatial random effects are evident in the estimation of excess equivalent property damage only crashes.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-1788
Paper Title Assessment of Exposure Proxies for Macroscopic Road Safety Prediction
Abstract Road safety is a major global health problem and no effort should be spared in trying to limit its impacts. Modeling road safety is a complex task, which needs to consider both the quantifiable impact of specific parameters, as well as the underlying trends that cannot always be measured or observed. Macroscopic data are often not available, or not in the form that they are desired. Therefore, it is often required to attempt to consider alternative sources of data, which may be correlated with the modeled phenomenon. The objective of this research is to investigate the suitability of alternative proxy variables for macroscopic road safety modeling, using three suitable exposure proxies: (i) number of vehicles in circulation, (ii) GDP and (iii) fuel consumption. Several structural time-series models have been developed for each proxy for two Mediterranean countries with many similar socio-economic characteristics: Greece and Cyprus. Based on the findings of this analysis, a number of observations can be drawn. Proxy variables can provide reasonable results, when exposure data are not available. Furthermore, even in two countries with many similarities the selected proxy measure differs. This suggests that the underlying conditions that make a variable a suitable proxy for exposure is complex and needs further investigation.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-5331
Paper Title Influence of Land Use and Driveway Placement on Safety Performance of Arterial Highways
Abstract Characterizing driveway safety is a relevant and relatively complex topic in transportation safety research. Current literature proposes many factors to consider for design and evaluation of safety performance of roadside elements. This research studied the safety link of driveways in Oregon highways. This work is based on two probability samples from arterial state highways at both urban and rural designations. The primary goal of this research is to provide alternative safety performance functions (SPFs) to evaluate the safety impacts of various driveway-related configurations in more detail than average driveway density. The statistical models and methodologies in this paper are comparable to those in the Highway Safety Manual (HSM). The proposed models exhibited different ranges effects for urban and rural conditions, but type of land use proved a prominent factor for both models. In addition, the rural model uncovered a safety relationship of clusters of driveways that are within 1.5 seconds or less of each other.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-2887
Paper Title Network Safety Screening in the Context of Agency-Specific Screening Criteria
Abstract Network screening for identifying locations with specific safety needs is an important aspect of the safety management for any highway agency. Network screening is usually governed by specific criteria set by a particular agency. This study shows how an integrated safety management system can help achieve agency's goal in identifying locations under various screening criteria. The safety framework can be interfaced with the agency's crash database(s) and different support systems for implementing user-defined screening and project planning. The case study shows implementation of facility-level and segment-based network screening on a single route. The analysis route and associated crash information were fixed whereas the screening method and performance measures were varied. Results showed that both sliding window and peak search techniques showed comparable results and better performance than simple ranking technique in identifying hotspots with respect to different performance measures. In general, the sliding window technique shows more mileage of hotspots identified, whereas the peak search technique has better accuracy in terms of crash density. The coefficient of variation (CV) based sliding window on facility screening showed better performance in terms of mileage and crash density of identified hotspots. This study can help agency understand the underlying factors that affect their network screening process.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-4372
Paper Title Investigating Influence of Segmentation in Estimating Safety Performance Functions for Roadway Sections
Abstract Safety performance functions (SPFs) are crucial to science-based road safety management. Success in developing and applying SPFs depends fundamentally on two key factors: the validity of the statistical inferences for the available data and on how well the data can be organized into distinct homogenous entities. The latter aspect plays a key role in the identification and treatment of road sections or corridors with problems related to safety. Indeed, the segmentation of a road network could be especially critical in the development of SPFs that could be used in safety management for roadway types, such as motorways (freeways in North America), that have a large number of variables that could result in very short segments if these are desired to be homogeneous. This consequence, from an analytical point of view, can be a problem when the location of crashes is not precise and when there is an over abundance of segments with zero crashes. Lengthening the segments for developing and applying SPFs can mitigate this problem, but at a sacrifice of homogeneity. This paper seeks to address this dilemma by investigating five approaches for segmentation for motorways, using sample data from Italy. The best results were obtained for the segmentation based on two curves and two tangents within a segment and the segmentation with fixed length. The segmentation characterized by a constant value of all original variables inside each segment was the poorest approach by all measures.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-1688
Paper Title Urban-Rural Difference of Gasoline Price Effects on Traffic Safety
Abstract A large literature base has found that economic factors have important effects on traffic crashes. A small but growing branch of literature also examines the role of gasoline prices in the occurrence of traffic crashes. However, no studies have investigated the possible difference of these effects between urban and rural areas. In this study, we used the monthly traffic crash data from 1998–2007 at the county level in Minnesota to investigate the possibly different effects gasoline prices may have on traffic crashes per million vehicle miles traveled in urban versus rural areas. The results indicate that gasoline price effects on total crashes, property-damage-only crashes, and injury crashes are stronger in rural areas than in urban areas. Gasoline prices also significantly affect fatal crashes in both urban and rural areas; however, the difference is not significant. The results concerning the differences between urban and rural areas have important policy implications for traffic safety planners and decision makers.

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Sponsoring Committee	ANB20, Safety Data, Analysis and Evaluation
Session Number	724
Session Title	Safety: Performance, Data, and New Advances, Part1
Paper Number	13-1976
Paper Title	Modeling Traffic Accidents on Auckland Motorway, New Zealand
Abstract	This paper investigates motorway safety by developing accident prediction models that link accident frequencies to their non-behavioural contributing factors, including traffic conditions, geometric and operational characteristics of road, and weather conditions. The study used a sample of accidents occurred from 2004 through 2010 on a 74 km long section of Auckland motorway. A number of accident prediction models were developed and assessed for their predictive ability using negative binomial regression models under three categories: first for the whole of the motorway, second for rural and urban motorway segments separately and third for motorway segments without ramp, with on-ramp and with off-ramp separately. The results uncovered the safety impacts of different non-behavioural contributing factors, in which segment length, AADT per lane and the number of lanes always have the most profound effects on accident frequency. The findings make the recommendation of effective countermeasures on motorway safety to be possible.

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Sponsoring Committee	ANB25, Highway Safety Performance
Session Number	289
Session Title	Highway Safety Performance
Paper Number	13-2873
Paper Title	Severity Distribution Function For Freeway Segments
Abstract	To date, the focus of modeling efforts for freeway safety has been on developing safety prediction functions (SPFs) and crash modification factors (CMFs), with only limited consideration for crash severity distributions. As a result, relatively little is known about the safety effects of design elements, such as lane width, rumble strips, and longitudinal barriers on crash severity. In some cases, countermeasures are implemented with the intent to reduce fatal crashes, but the effect of these treatments on less severe crashes is not well understood. Research was conducted to develop severity distribution functions (SDFs) to predict the proportion of crashes in each severity category as a function of roadway geometric design elements and traffic control features. The SDFs were calibrated using freeway segment data from California, Maine and Washington. The findings from this research show that barrier presence, increased traffic volume, increased lane width, and urban area type reduce the proportion of high-severity crashes. At the same time, rumble strip and horizontal curvature presence increase the proportion of high-severity crashes. These SDFs can be applied along with SPFs and CMFs to obtain more precise estimates of the safety effects of design decisions.

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Sponsoring Committee	ANB20, Safety Data, Analysis and Evaluation
Session Number	724
Session Title	Safety: Performance, Data, and New Advances, Part1
Paper Number	13-2397
Paper Title	Analysis of Factors Affecting Freeway Traffic Crash Frequency Under Different Light Conditions with Random Parameter Count Models
Abstract	This research develops a random parameter count model of crash frequency on freeways with a speed limit of 110 km/h in Korea and performs a comparison between time periods (daytime, nighttime, twilight, and the whole 24 hour period). Data for crashes in 2007-2010, excluding vehicle factors such as engine overheating and malfunction in damping device and human factors such as drunk driving and dosing off at the wheel, was drawn from Korea freeway crash data. The results show several factors having random effects on crashes: traffic share of light vehicles, number of lanes, urban area, and foggy area. While some factors are statistically significant regardless of the time period (e.g., traffic share of light vehicles, number of lanes, urban area, frequent fog in area, and number of days with snowfall), some factors have statistical effects only during certain time periods (e.g., number of interchanges/junctions and number of bridges during daytime, traffic share of heavy vehicles during nighttime and the whole 24 hour period, and short tangent (<1,421 m) and number of crest vertical curves during twilight). The results indicate that the effect of roadway geometrics on crash frequency differs by time of day which can be used in driver information systems to supply different information to drivers about the road ahead based on time of day. For example, during daytime drivers need more information about upcoming interchanges/junctions. The results indicate that roadway design should try to avoid combining horizontal and sag vertical curves.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-5302
Paper Title Predicting road casualties in Flanders in relation to an ageing population: combining decomposition and disaggregation
Abstract This paper describes an approach to predict casualty rates in the Flanders region of Belgium. The objective of the paper is to demonstrate the strength of the proposed approach that combines the decomposition method with a disaggregate analysis as a prediction approach to study road safety problems. The prediction for the Flanders region will hereby serve as an illustration for this approach.The evolution of the number of casualties is explained by its components exposure and risk, where exposure is further decomposed into population numbers and the travel patterns of itsindividuals. Upon the decomposition a disaggregate approach is followed to take into account thevarious differences in exposure and risk that exist between distinct subgroups.A reduction of the number of casualties with 57% is found in 2020 compared to 2001. Our approach however also allows to determine the relative contribution of each component to thecasualty rate. Because of the different trends in population, exposure and risk, casualty numbers evolve differently for different groups. Therefore their share in the total traffic casualties will change and new target groups for road safety policy emerge. In Flanders older women will be such new target group since it will become one of the most sizeable casualty groups.

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Sponsoring Committee ANB10, Transportation Safety Management
Session Number 439
Session Title Transportation Safety Management and Alcohol Research
Paper Number 13-1855
Paper Title Transportation Safety Planning: Spatial Analysis Approach
Abstract In the past decade, considerable efforts have been made to explore various safety conscious planning approaches to form the next-generation planning method, i.e. Transportation Safety Planning (TSP). This study proposes a spatial analysis approach for TSP, with four phases, i.e. Data preparation, Examination of Modifiable Areal Unit Problem (MAUP), Regionalization for Traffic Safety Analysis Zone (TSAZ), and Development of TSP-Prediction Model (TSP-PM). To illustrate the approach, we present a preliminary analysis using Hillsborough County data of Florida (2005-2007). Based on the existing TAZ delineations, we re-regionalized the whole county with zone numbers at an incremental step-size of 50, resulting in 14 zoning schemes. In the regionalization, a multivariate combination of key factors was used as the regionalization criteria, i.e. severe crashes, total road length and total trip production with weights 0.5, 0.25 and 0.25, which respectively reflect the level of safety, transportation facilities, and trips as a major concern at the planning level. Accompanied with a univariate MAUP examination, a total of 64 exploratory TSP-PMs were developed based on the 14 new zoning schemes and three major categories of factors, i.e. intersection density, road length with different speed limit, and trip generation factors. Results showed that as the number of zones increases, the safety interpretation power by transportation system factors decreases while the spatial autocorrelation increases. To the contrary, better model-fitting performance is associated with larger number of zones. Therefore, rational selection of zoning schemes would have to depend on detailed requirements for specific usage of zoning partitions. This research effort is expected to achieve a substantial step toward a new generation of spatial decision support system for TSP practice.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4435
Paper Title Safety Evaluation of Horizontal Curves on Rural Undivided Roads
Abstract The objective of this research was to develop total crash and fatal/injury crash prediction models for rural horizontal curves on undivided roads, with focus on three distinct aspects. The first was an emphasis on assembling a high quality large dataset. Crash prediction models were developed using a dataset of 11,427 rural horizontal curves on Wisconsin State Trunk Network roads with over 13 different parameters and four distinct types of crash dataset. The second focus area was to use regression tree analysis in creating a simple model of horizontal curve safety aimed at practitioners of systemic road safety management and creating subsets of data which warranted further analysis. Regression tree results identified curve radius of approximately 2,500 feet as a significant point below which there is a marked increase in crashes on horizontal curves. The third focus area of this research was to compare horizontal curve crash prediction models using different crash datasets. Models based on crash dataset with and without crashes in the proximity of intersections were compared. The results show that when crashes on horizontal curves are selected where crash report forms indicate the presence of a horizontal curve, crashes in proximity of intersections do not impact model results significantly; therefore, the inclusion of such crashes would increase the size of dataset benefiting model development.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-3758
Paper Title Safety Performance Functions Reflecting Categorical Impact of Exposure Variables for Freeways
Abstract The aim of this study is to develop safety performance functions (SPFs) reflecting the categorical impact of exposure variables that may vary with freeway segments. A four-step procedure is constructed including clustering analysis, distribution selection, model specification, and model integration. First, clustering analysis is employed to classify freeway segments into three similar groups. A goodness-of-fit test is performed to select suitable distributions for the SPFs of each of the three groups. We compare three forms of relationships between crash frequency and exposure variables and select the best one by using statistical indices. Two final models are proposed, one for fatal-injury (FI) crashes and one for total crashes, based on the evaluations performed by a test for taste variations and a paired asymptotic t-test. All of the coefficients and constants in the proposed models are statistically significant. In addition, both models show higher statistical significance than the models reflecting constant relationships between crash frequency and exposure variables. The proposed four-step procedure for SPF makes it possible to predict crash frequency more accurately, and it can be easily applicable to predict the number of crashes without any additional data or complex simulation procedures. If additional explanatory variables are available for criteria on the difference and similarity, the ability to explain the data may be enhanced. It would be necessary to select an appropriate tool for characteristics of targeted roads, which is a subject for further research.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-3145
Paper Title Spatial Effect on Zone-Level Collision Prediction Model
Abstract A recent study developed a set of zone-level negative binomial collision prediction models (CPMs) to investigate the relationship between various transportation and socio-demographic characteristics, and the overall roadway safety (1). The developed models used data from Metro Vancouver, British Columbia, and considered the Poisson variations and the heterogeneity (extra-variation) on collision occurrence of collisions. This study aims to evaluate the spatial effects on the occurrence of collisions and to check whether the inclusion of spatial variables can improve the goodness of fit and inference the capability of the previously developed CPMs presented in (1). The transit reliant and application based collision prediction models with spatial correlations were developed using the WinBUGS software. The convergences of the developed models were tested by the trace plots of the parameter estimated, the BGR statistics, and ratios of Monte Carlo errors relative to the standard deviations of the estimates. The results showed that the incorporation of the spatial correlation affected the parameter estimates, the values of dispersion parameters and intercepts, and also the t-statistics. The effect of the main exposure variable on all of the models for total, severe and property damage only collisions were found to be smaller under spatial models. The smaller values of the exponents of the main exposure variable asserted our assumption that spatial effects need to be considered in CPMs to mitigate any potential bias associated with model misspecification.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-3903
Paper Title Generalized Nonlinear Models for Rear-End Crash Risk Analysis
Abstract A Generalized Nonlinear Model (GNM)-based approach for modeling highway rear-end crash risk is formulated using Washington State traffic safety data. Previous studies majorly focused on causal factor identification and crash risk modeling using Generalized linear Models (GLMs), such as Poisson regression, Logistic regression, etc. However, their basic assumption of a generalized linear relationship between the dependent variable (for example, crash rate) and independent variables (for example, contribute factors to crashes) established via a link function can be often violated in reality. Consequently, the GLM-based modeling results could provide biased findings and conclusions. In this research, a GNM-based approach is developed to utilize a nonlinear regression function to better elaborate non-monotonic relationships between the independent and dependent variables using the rear end accident data collected from ten highway routes from 2002 through 2006. The results show for example that truck percentage and grade have a parabolic impact: they increase crash risks initially, but decrease them after the certain thresholds. Such non-monotonic relationships cannot be captured by regular GLMs which further demonstrate the flexibility of GNM-based approaches in the nonlinear relationship among data and providing more reasonable explanations. The superior GNM-based model interpretations help better understand the parabolic impacts of some specific contributing factors for selecting and evaluating rear-end crash safety improvement plans.

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Sponsoring Committee ANB10, Transportation Safety Management
Session Number 439
Session Title Transportation Safety Management and Alcohol Research
Paper Number 13-2228
Paper Title Analysis of Residence Characteristics of Drivers, Pedestrians, and Bicyclists Involved in Traffic Crashes
Abstract In this study, we investigate the demographic, socioeconomic and travel characteristics of residential areas of the drivers involved in crashes. The main objective of this study is to find out the relationship between crashes and the characteristics of the origin rather than the location of traffic crashes. Various zonal factors based on the postal code (ZIP code) area of drivers' residence were used in the study. ZIP codes were obtained from police crash reports of the year of 2002 and corresponding demographic, socioeconomic and travel characteristics were collected from Census 2000. Five negative binomial (NB) models were estimated for the number of crashes by ZIP area of at-fault drivers (total and severe crashes) DUI drivers, and pedestrians and bicyclists) who were involved in traffic crashes. GIS analyses were also conducted to find out the residence area with many drivers involved in crashes. We found that the demographic and socioeconomic factors such as age, ethnicity, major commuting mode, average travel time to work, household income, occupation, number of households in urban area, and median year of structure built in the area of the residence are associated with the number of traffic crashes. The findings from the study implied that several demographic and socioeconomic as well as travel characteristics of residence zones also contribute to the crash occurrence. Even in the planning phase, we can forecast not only the number of future trips but also the number of crashes with the models in this study. From operational perspective, the results from the study can be used to identify zones with higher potential of at-fault drivers or victims of traffic crashes, thus we can concentrate on these zones for safety treatments including education or stricter enforcement.

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Sponsoring Committee ANB10, Transportation Safety Management
Session Number 439
Session Title Transportation Safety Management and Alcohol Research
Paper Number 13-4035
Paper Title Comparison Between Traditional Methods and Empirical Bayes with Safety Performance Function Method for Identifying High Crash-Risk Intersections
Abstract Identifying high crash-risk locations, called hot-spots, is a most important step to improve roadway safety and the Empirical Bayes (EB) coupled with the safety performance function (SPF) is regarded as the state of practice in identifying such locations. To apply the EB-SPF method, however, requires considerable resources in preparing data and statistical expertise. Consequently, many highway agencies still rely on traditional methods such as crash frequency and crash rate in identifying locations for potential safety improvement without knowing the extent of accuracy of such methods. This study examined four traditional identification methods widely used to understand the extent of accuracy of the four methods in identifying potential locations for safety improvement as compared to the EB-SPF method and to suggest the best method among the four: crash frequency, crash rate, rate-quality control, and equivalent property damage only (EPDO). This study was limited to 4-leg intersections with either signal or 2-way stop and 2004-2008 data were collected at 1,670 such intersections. The study found that the crash frequency method performed the best among the four in correct identification of top 1 percent unsafe intersections yet tends to flag intersections falsely being at top hot-spots and the rate-quality control method performed the best for the top 5 and 10 percent unsafe intersections. The findings are expected to help highway agencies continuing use of the traditional methods choose the best so that scarce resources available for safety improvement would be invested effectively.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-4828
Paper Title Full versus Simple Safety Performance Functions: A Comparison Based on Urban Four-Lane Freeway Interchange Influence Areas in Florida
Abstract The empirical Bayes (EB) approach adopted in the Highway Safety Manual (HSM) and the SafetyAnalyst application requires the use of Safety Performance Functions (SPFs). SafetyAnalyst adopts a form of SPF, known as simple SPF, which relates crash experience to only traffic volume. It is a flow-only model that is calibrated using all sites irrespective of their base geometric conditions. Full SPFs, on the other hand, relate crash occurrence to roadway geometric characteristics in addition to traffic characteristics. This study compares the simple SPFs provided in SafetyAnalyst with full SPFs in two safety applications: crash prediction performance and high crash locationsâ€™ (HCLs) identification. To compare the prediction performance, the simple and full SPFs were estimated using data collected on urban four-lane freeway interchange influence areas in Florida. Models were estimated for both total crashes and F+I (fatal and injury) crashes. The mean absolute deviance (MAD) and the mean square prediction error (MSPE) were used to assess and compare the prediction performance of the two models, and the variation in ranking the HCLs using each model was also examined. The results showed that the two models yielded very similar performance of crash prediction and network screening. This empirical result supports the use of the flow-only SPF model adopted in SafetyAnalyst, which requires much less effort to develop compared to full SPFs.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-4221
Paper Title Safety Performance Function Calibration and Development for the State of Alabama: Two-Lane Two-Way Rural Roads and Four-Lane Divided Highways
Abstract The Highway Safety Manual (HSM) published by the American Association of State Highway Transportation Officials provides procedures and statistical tools for estimating the expected number of crashes for different roadway facilities. One critical component of the HSM method is the Safety Performance Function (SPF). SPFs are essentially regression models that correlate quantitatively the expected number of crashes with traffic exposure and geometric characteristics of the road. Since these models are developed using data from other states, its transferability is not guaranteed. As part of a project performed by researchers from the University of Alabama to facilitate the implementation of the new HSM procedures in the State of Alabama, this study aims to evaluate the applicability of HSM predictive methods to Alabama data, and to develop state-specific statistical models for two facility types, namely two-lane two-way rural roads and four-lane divided highways. This study first calibrates the HSM base SPFs using two approaches. Besides the method recommended by HSM, this study also proposes a new approach that treats the estimation of calibration factors as a special case of a negative binomail regression. In addition, new forms for state-specific SPFs are further investigated to identify the best model using Poisson-gamma regression techniques. Four new functional forms are studied in this project. The prediction capabilities of the two calibrated models and the four newly developed state-specific SPFs are evaluated using a validation data set. Five performance measures are considered for model evaluation. They are the mean absolute deviance, the mean squared prediction error, the mean prediction bias, the log likelihood value, and the Akailke's Information Criterion. The study is able to identify a particular state-specific SPF that fits the Alabama data well and outperforms other models, including the calibrated SPFs. The best model describes the mean crash frequency as a function of annual average daily traffic, segment length, lane width, year, and speed limt. The study finds that the HSM-recommended method for calibration factor estimation also performs well. Although it is not as good as the best state-specific SPF, it is still a good alternative considering the approach is very straightforward and can be easily applied.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part1
Paper Number 13-1049
Paper Title Spatial Analysis of Fatal and Injury Crashes in Flanders, Belgium: Application of Geographically Weighted Regression Technique
Abstract Generalized Linear Models (GLMs) are the most widely used models utilized in crash prediction studies. These models illustrate the relationships between the dependent and explanatory variables by estimating fixed global estimates. Since the crash occurrences are often spatially heterogeneous and are affected by many spatial variables, the existence of spatial correlation in the data is examined by means of calculating Moran's I measures for dependent and explanatory variables. The results indicate the necessity of considering the spatial correlation when developing crash prediction models. The main objective of this research is to develop different Zonal Crash Prediction Models (ZCPMs) within the Geographically Weighted Generalized Linear Models (GWGLM) framework in order to explore the spatial variations in association between Number of Injury Crashes (NOICs) (including fatal, severely and slightly injury crashes) and other explanatory variables. Different exposure, network and socio-demographic variables of 2200 Traffic Analysis Zones (TAZs) are considered as predictors of crashes in the study area, Flanders, Belgium. To this end, an activity-based transportation model framework is applied to produce exposure measurements while the network and socio-demographic variables are collected from other sources. Crash data used in this study consist of recorded crashes between 2004 and 2007. GWGLMs are developed using a Poisson error distribution and are often referred to as Geographically Weighted Poisson Regression (GWPR) models. Moreover, the performances of developed GWPR models are compared with their corresponding GLMs. The results show that GWPR models outperform the GLM models; this is due to the capability of GWPR models in capturing the spatial heterogeneity of crashes.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-4854
Paper Title Safety of Channelized Right-Turn Lanes for Motor Vehicles and Pedestrians
Abstract This paper presents the results of research undertaken to evaluate how the safety performance of intersection approaches with channelized right-turn lanes compares to that of intersection approaches with conventional right-turn lanes or shared through/right-turn lanes. Crash data for nearly 400 intersection approaches in Toronto, Ontario, Canada, including intersection approaches with channelized right-turn lanes, conventional right-turn lanes, and shared through/right-turn lanes, were analyzed to compare the safety performance of the three right-turn treatment types. The research results indicate that intersection approaches with channelized right-turn lanes appear to have similar motor-vehicle safety performance as approaches with conventional right-turn lanes or shared through/right-turn lanes. This was found to be the case both at the downstream end of the channelized right-turn lane (where the right-

turning vehicle merges with the cross street) as well as at the upstream end of the channelized right-turn lane (where the right-turning vehicle begins the right-turn maneuver). Intersection approaches with channelized right-turn lanes also appear to have similar pedestrian safety performance as approaches with shared through/right-turn lanes. Intersection approaches with conventional right-turn lanes have substantially more pedestrian crashes (approximately 70 to 80 percent more) than approaches with channelized right-turn lanes or shared/through right-turn lanes.

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Sponsoring Committee ANB75, Roundabouts
Session Number 542
Session Title All You Wanted to Know About Roundabouts: Capacity, Safety, Trucks, and Modeling
Paper Number 13-2060
Paper Title Evaluation of Roundabout Safety
Abstract While roundabouts are still fairly new in the U.S. and Wisconsin, their safety benefits have been studied with varied results. In this study, 24 roundabouts built in 2007 or before were analyzed for their safety performance. Three years of before and after crash data were gathered as well as geometric and traffic volume data. An empirical Bayes (EB) analysis was used to examine the safety benefits for total crashes and injury (K, A, B, C) crashes. The EB analysis was performed using the Safety Performance Functions (SPFs) from the Highway Safety Manual (HSM). Mixed results were found for total crash frequency but a significant decrease in crash severity was identified. Wisconsin roundabouts had an unbiased estimate of a 9.2 percent decrease in total crashes. National numbers similarly show decreases in total crashes. Wisconsin roundabouts showed a significant 52 percent decrease in injury crashes. Roundabouts nationwide are also experiencing a significant decrease in severe crashes. When evaluating predictors, the speed limit of the approaches did not show a significant impact on the safety of the roundabout. While multi-lane roundabouts seemed to be safer than single lane roundabouts when considering combined injury crashes, single lane roundabouts saw the largest decrease in total crashes. Two-way stop controlled (TWSC) intersection conversion to a roundabout had the highest safety benefit as compared to all-way stop controlled (AWSC) and signalized intersections.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-1313
Paper Title Gender Gaps in Crash Data: Statistical Look at Gender and Age Differences as Related to Crash Frequencies
Abstract This study was performed to calibrate safety performance functions (SPFs) to predict the number of injurious crashes per year per km per 10^8 vehicles on the horizontal homogeneous segment of two-lane rural roads. The crashes were analyzed from the perspective of driver gender for three main injurious crash types (head-on/side and rear collisions, tail crashes, and single-vehicle run-off-road crashes) as observed on the network. We analyzed more than 3,700 km of road network with 2,242 accidents recorded from 2003 to 2010, of which 1,597 were injurious, and 645 resulted in only damage to property. Generalized estimating equations with a negative binomial distribution and additional log linkage equations were implemented. A very exciting statistical variable was introduced in the models constructed according to plotted crash risk maps by varying the crash type, the number and gender of the drivers involved in the crash and the scenario represented by a particular combination of infrastructural and environmental conditions surveyed on the site at the time of the crash. We have also introduced lane width, horizontal curvature indicators and mean speed as consistent explanatory factors in the model. Countermeasures are suggested for reducing crash frequency such as awareness campaigns and road structural operations.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4344
Paper Title Some Insights into Roadway Geometric Effects on Interstate Crash Occurrence from a Crash Typology Perspective
Abstract This paper proposes a crash frequency modeling typology for interstate freeways. Using a nine-year continuous panel of crash histories of total crash frequencies on interstates in Washington State for the period (1999-2007), random parameter negative binomial (RPNB) models are estimated for a variety of crash related outcomes. A total of 21 different outcomes were assessed in terms of four typologies: a) severity, b) number of vehicles involved, c) crash type, and d) crashes by interchange type. The sub-models within these major categories included: RPNB specifications for all severities (property damage only, possible injury only, evident injury, disabling injury and fatality), number of vehicles involved (one-vehicle to five-or-more-vehicle), crash type (sideswipe, same direction, overturn, head-on, fixed object, rear-end and other), and location types (urban interchange, rural interchange, urban non-interchange, rural non-interchange). A total of 1,153 directional segments comprising of the seven Washington State interstates were analyzed, yielding a statistical model of crash frequency based on 10,377 observations. It was found that several geometric effects were random in their interaction with the logarithm of average daily traffic, meaning the interaction varied from segment to segment. These results suggest that segment specific insights into crash frequency occurrence can be improved for appropriate design policy and prioritization insights via more accurate characterization with interactions. This suggests that flow interactions are critical even after flow is accounted for as a main effect. The conventional approach has been to include flow as a main effect either in logarithmic form or in linear form.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part1
Paper Number 13-2698
Paper Title Systematic Approach for Hazardous Intersection Identification and Countermeasure Development
Abstract Safety performance functions (SPFs) are typically used to correlate geometric, traffic and environmental characteristics with total crashes and to identify hotspots which have high overall crash frequencies. However, with a distinct conflict pattern in vehicle maneuvers, each crash type is likely to associate with different risk factors. This study developed approach-level SPFs using a full Bayesian method to assess the safe effects of specific risk factors for rear-end, left-turn, right-angle, sideswipe and total crashes. To account for the spatial correlations among approaches at the same intersection, a random intersection-specific effect term was incorporated into each model. It was affirmed that these models were helpful in identifying high risk intersections with specific safety problems, and could serve as useful complements to general hotspot analyses using expected crash totals. In addition, it was found that certain variables (e.g. number of through lanes, median, and left-turn protection all on the entering approach) could have even contrary effects on crash occurrence of different types. Approach-level crash type models provide valuable insights in developing countermeasures aimed at reducing certain crash types and an improved ability in identifying deficiencies related to geometric and traffic characteristics for each intersection approach.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 433
Session Title Improving Safety Data, Analysis, and Evaluation
Paper Number 13-1841
Paper Title On the commonly accepted assumptions regarding observed motor vehicle crash counts at transport system locations
Abstract Readily accepted knowledge regarding crash causation is consistently omitted from efforts to model and subsequently understand motor vehicle crash occurrence and their contributing factors. For instance, distracted and impaired driving accounts for a significant proportion of crash occurrence, yet is rarely modeled explicitly. In addition, spatially allocated influences such as local law enforcement efforts, proximity to bars and schools, and roadside chronic distractions (advertising, pedestrians, etc.) play a role in contributing to crash occurrence and yet are routinely absent from crash models. By and large, these well-established omitted effects are simply assumed to contribute to model error, with predominant focus on modeling the engineering and operational effects of transportation facilities (e.g. AADT, number of lanes, speed limits, width of lanes, etc.) The typical analytical approach—with a variety of statistical enhancements—has been to model crashes that occur at system locations as negative binomial (NB) distributed events that arise from a singular, underlying crash generating process. These models and their statistical kin dominate the literature; however, it is argued in this paper that these models fail to capture the underlying complexity of motor vehicle crash causes, and thus thwart deeper insights regarding crash causation and prevention. This paper first describes hypothetical scenarios that collectively illustrate why current models mislead highway safety researchers and engineers. It is argued that current model shortcomings are significant, and will lead to poor decision-making. Exploiting our current state of knowledge of crash causation, crash counts are postulated to arise from three processes: observed network features, unobserved spatial effects, and 'apparent' random influences that reflect largely behavioral influences of drivers. It is argued; furthermore, that these three processes in theory can be modeled separately to gain deeper insight into crash causes, and that the model represents a more realistic depiction of reality than the state of practice NB regression. An admittedly imperfect empirical model that mixes three independent crash occurrence processes is shown to outperform the classical NB model. The questioning of current modeling assumptions and implications of the latent mixture model to current practice are the most important contributions of this paper, with an initial but rather vulnerable attempt to model the latent mixtures as a secondary contribution.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-1266
Paper Title A Note on Influencing Factors of Crash Rates Using Tobit Model with Endogenous Variable
Abstract The objective of this study is to identify the influencing factors of crash rates from the perspective of access management techniques in urban areas. The target areas are located in the Las Vegas Metropolitan area, and 19 arterials are selected. In order to address the interdependency between crash rates and travel speeds, and left-censored issue, a tobit model with endogenous variable is presented. The structure of the tobit model addresses the left-censored issue for the segments meanwhile the endogeneity issue between crash rates and travel speeds is explained. The results indicate that there is a strong interdependency between crash rates and travel speeds. The segment length, driveway density, median opening density, posted speed limit and AADT per lane are statistically significant factors that influence both crash rates and travel speeds on segments, moreover, crash rates are significantly influenced by two-directional median opening density.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-0222
Paper Title Formulating Informative Priors and Effects on Bayesian Hierarchical Crash Models
Abstract The Bayesian inference method has been frequently adopted to develop safety performance functions. One advantage of the Bayesian inference is that prior information about the independent variables can be included in the models, which could benefit the inference conclusions from avoiding implausible results due to data fluctuations. However, there are few past studies discussing how to formulate the informative priors and what are the effects of having informative priors in developing Safety Performance Functions. This paper fills the void by introducing four approaches of developing informative priors for the independent variables based on historical data or general information. Merits of these informative priors have been tested along with two types of Bayesian Hierarchical models (Poisson-gamma model and Random effect Poisson model). Deviance Information Criterion (DIC), R-square values and standard errors were utilized as evaluation measures to select the best model(s). Comparisons across the models indicate that the Poisson-gamma model is superior with better model fitting and it is much more robust with the informative priors. Moreover, model fitting and coefficient estimation accuracies have been enhanced by the informative priors. Finally, based on the results, recommendations are made for the different informative prior development techniques.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-4943
Paper Title Safety-Effectiveness of Various Types of Shoulders on Rural Two-Lane Roads in Winter and Nonwinter Periods
Abstract There has been growing recognition of the quantitative effects of various roadway designs and traffic control strategies on safety. Meanwhile, there is increasing interest in measuring the variances of safety effectiveness in different periods of the year for similar roadway designs or similar traffic control strategies. This study tried to address the variances of safety effectiveness between the winter and non-winter periods for the ten most common shoulder designs in Kansas. Traffic and geometric data were collected on 6,510 miles (10,477 km) of rural two-lane highways in Kansas. A cross-sectional approach was applied to develop winter period safety performance functions (SPFs), non-winter period SPFs and SPFs aggregated at an annual level in which shoulder designs were treated as independent variables. A variance test was conducted based on these SPFs to investigate the variances of safety effectiveness between the two different periods. It was found that wider and upgraded shoulders offer significant less safety benefit in reducing total crash number during winter periods than during non-winter periods. The indexes of safety effectiveness for the winter period are larger than those for the non-winter period by between 13 to 25 percent. However, winter weather appears not to significantly diminish wider and/or upgraded shouldersâ€™ safety benefit in reducing crash severity and the number of shoulder related crashes. The results demonstrate that treating the winter and non-winter data equally is likely to bias a shoulder's estimated safety effectiveness in total crashes.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part1
Paper Number 13-2427
Paper Title Modeling Frequency of Traffic Conflicts at Signalized Intersections Using Generalized Linear Regression Models
Abstract The primary objective of this study was to identify the potential of using conflict prediction models to predict the frequency of traffic conflicts at signalized intersections. The opposing left-turn conflicts were selected for the development of conflict prediction models. Using data collected at thirty approaches at twenty signalized intersections where the permitted left-turn phases were used, the underlying distributions of the conflict frequency for different volume regimes in different time intervals were examined. It was found that the conflict frequency generally followed a negative binominal distribution. Different conflict prediction models were developed, including a linear regression model, an overall negative binomial model, and separate models developed for four traffic scenarios which were defined based on the volume to capacity ratio of the conflicting traffic flows. The prediction performance of different models was compared. It was found that the linear regression model was not appropriate for modeling the conflict frequency data. In addition, drivers behaved differently under different traffic conditions. Thus, the effects of conflicting traffic volumes on conflict frequency were different in different traffic conditions. The generalized linear regression models developed for different traffic scenarios provided the best estimates for the field measured conflicts.

4 Papers on crash severity prediction

Identifying factors that affect crash injury severity and understanding how these factors affect injury severity is critical in planning and implementing highway safety improvement programs.

From a methodological perspective, several methodologies were used.

Numerous papers used ordered regressions:

- Bayesian hierarchical ordered logistic (*Huang et al.*);
- Ordered logit models (*Yasmin et al., 13-658; Yasmin et al., 13-669*);
- Generalized ordered logit model (*Yasmin and Eluru, 13-4081; Yasmin et al., 13-3987*);
- Ordered probit models (*Jang et al.; LaMondia and Morgan);* and
- Random parameter ordered probit models (*LaMondia and Morgan; Jang et al*.).

Unordered regressions were commonly used:

- Logistic regressions (*Amarasingha et al., 13-1411; Lee et al., 13-0655; Qin et al., 13-2067; Qin et al., 13-3047; Wang et al., 13-0386; Yasmin and Eluru, 13-4081; Yasmin et al., 13-3987; Yu et al., 13-0718*);
- Nested logit (*Lee et al., 13-0655; Yasmin and Eluru, 13-4081; Yasmin et al., 13-3987*); and
- Multinomial logit models (*Aluengeh and Zhang; Amarasingha and Dissanayake, 13-3023; Jung et al.; Qin et al., 13-658; Qin et al., 13-3047; Yasmin and , 13-4081; Yasmin et al., 13-3987;*).

Other papers used multivariate poisson lognormal models (*Karoim et al.*), full Bayes estimates (*Aguero-Valverde; Miranda-Moreno et al.; Wang and Kockelman, 13-1252; Yang et al., Yu et al.; 13-724; Zou et al.;),* and multivariate spatial models (*Aguero-Valverde*).

From an applications perspective, the papers addressed environmental factors (*Aguero-Valverde; Aluengeh and Zhang; Banihashemi; Castro et al.; Jang et al.; Karim et al.; Yasmin et al., 13-3987; Yang et al.*), vehicle characteristics (*Huang et al.; Jung et al*.; *Lee et al., 13-4465; Lee et al., 13-0655; Qin et al., 13-2067; Qin et al., 13-3047;*), driver characteristics (*Aluengeh and Zhang; Amarasingha and Dissanayake, 13-3023; Amarasingha and Dissanayake, 13-1411; Jung et al.; Lee et al., 13-0655.; Lee et al., 13-4465;*), traffic characteristics (*LaMondia and Morgan; Yu et al., 13-0718*), highway characteristics (*Banihashemi et al.; Castro et al.; LaMondia and Morgan; Marisol et al.; Miranda-Moreno et al.; Zou et al.;*), roadside features (*Aguero-Valverde; Aluengeh and Zhang; Amarasingha et al., 13-3023; Amarasingha et al., 13-1411; Banihashemi; Qin et al., 13-3047; Wang et al., 13-2395; Wang et al., 13-0386*).

The papers investigated also specific road users and vehicle types, such as:

- Pedestrians (*Jang et al.; Wang et al., 13-2395; Yasmin et al., 13-3987*);
- Young drivers (*Amarasingha and Dissanayake, 13-3023; Amarasingha and Dissanayake, 13-1411; Jung et al.; Lee et al., 13-4465*);
- Older drivers (*Jung et al.; Lee et al., 13-4465*);
- Commercial vehicle drivers (*Huang et al.*),
- Bicycles (*Wang et al., 13-0386; Winters et al.*);
- Motorcycles (*Lee et al., 13-4465; Jung et al*.); and
- Trucks (*Qin et al., 13-2067; Qin et al., 13-3047*).

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Sponsoring Committee ANB10, Transportation Safety Management
Session Number 439
Session Title Transportation Safety Management and Alcohol Research
Paper Number 13-2901
Paper Title Modeling and Examining Alcohol-Impaired Driver Behavior and Characteristics for Intersection-Related Crash Severities in New Mexico
Abstract Nationally, approximately one third of all motor vehicle crash fatalities involve alcohol-impaired driving. According to the National Highway Traffic Safety Administration (NHTSA), alcohol-impaired motor vehicle crashes cost more than an estimated $37 billion annually. Alcohol impaired driver behavioral activities and demographic characteristics are needed for composing effective countermeasures and developing proper policies against traffic crashes and reducing related costs. This study focuses on the impacts of alcohol impaired driver behavior and characteristics on traffic crash severities at intersections in New Mexico. Statistical analyses were conducted to identify the most significant alcohol impaired driver behavioral activities and demographic characteristics and time periods of driving. The transportation econometric models, multinomial Logit regression models, were developed to analyze crash severities for regular drivers and alcohol impaired drivers using the data collected from the State of New Mexico from 2010 to 2011. The research findings provide a better understanding of traffic alcohol-related accident causes in New Mexico that will help transportation agencies and decision makers find cost-effective solutions for reducing the severity of crashes to improve safety and enhance policy development.

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Sponsoring Committee ANB30, Operator Education and Regulation
Session Number 436
Session Title Research on Young Drivers
Paper Number 13-3023
Paper Title Characteristics, contributory causes, and factors affecting the severity of crashes involving young drivers
Abstract Young drivers are over-represented in both fatal and non-fatal crashes compared to other drivers and understanding the reasons would help improving safety. This study explored the detailed characteristics of young-driver-involved crashes and contributory causes, and compared those with experienced drivers. Multinomial Logit models were developed to identify severity affecting factors. It was found that teen drivers were more likely to be involved in crashes due to failure to give time and attention and falling asleep. Among other factors, alcohol involvement, not wearing seat belts, driving without a valid license, having restrictions on driver's license, and involvement in off-roadway crashes were factors which increased young-driver injury severity. Understanding these contributory causes could lead to better crash-mitigation strategies. It is important for teen drivers to gain better education about these critical factors that are helpful to increase training, prevent crashes, and minimize driving risk.

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Sponsoring Committee ANB30, Operator Education and Regulation
Session Number 436
Session Title Research on Young Drivers
Paper Number 13-1411
Paper Title Contributory causes and risk factors associated with crashes involving unlicensed young drivers
Abstract Unlicensed young drivers' involvement in crashes in the United States (U.S.) and the risk factors associated with crashes involving these drivers have not been fully explored. Few studies provide evidence of fatal crash involvement of young unlicensed drivers. This study investigates characteristics and contributory causes of unlicensed young driver crashes that occurred in Kansas, using crash data obtained from the Kansas Department of Transportation (KDOT). In this study, the age range of drivers from 15 years to 24 years was investigated. A binary logistic regression model was developed to investigate unlicensed young driver injury severity. There were 5,781 young unlicensed driver crashes, representing 3.61% of all young drivers' crashes, during the five-year period considered in this study. A total of 19 young unlicensed driver-involved fatal crashes occurred during the period. According to the coefficients of the logistic model, seat-belt restrained, unlicensed young drivers were less likely to suffer severe injuries when involved in crashes. Failure to yield right way was a contributory cause, which increased unlicensed young driver injury severity. Based on the identified factors, crash mitigation strategies were presented.

Authors Jonathan Aguero-Valverde, Universidad de Costa Rica
Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-1061
Paper Title Multivariate Spatial Models of Excess Crash Frequency at Area Level: Case of Costa Rica
Abstract Recently, areal models of crash frequency have being used in the analysis of various area-wide factors affecting road crashes. On the other hand, disease mapping methods are commonly used in epidemiology to assess the relative risk of the population at different spatial units. A natural next step is to combine these two approaches to estimate the excess crash frequency at area level as a measure of absolute crash risk. Furthermore, multivariate spatial models of crash severity are explored in order to account for both frequency and severity of crashes and control for the spatial correlation frequently found in crash data. This paper aims to extent the concept of safety performance functions to be used in areal models of crash frequency. A multivariate spatial model is used for that purpose and compared to its univariate counterpart. Full Bayes hierarchical approach is used to estimate the models of crash frequency at canton level for Costa Rica. An intrinsic Multivariate Conditional Autoregressive model is used for modeling spatial random effects. The results show that the multivariate spatial model performs better than its univariate counterpart in terms of the penalized goodness-of-fit measure Deviance Information Criteria. Additionally, the effects of the spatial

smoothing due to the multivariate spatial random effects are evident in the estimation of excess equivalent property damage only crashes.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-2634
Paper Title Calibration Factor with the Consideration of Short-term Trend in Crash Occurrence
Abstract Crash prediction models are used to estimate the expected number of crashes for different highway facilities. These models re calibrated periodically, using short-term near-past crash data, regardless of the State data being used in the model development. For each facility type the calibration factor is estimated by dividing the observed number of crashes by the number of crashes predicted by the model over the same period. This factor is then used in the prediction of the expected number of crashes for near-future periods. One major short-coming of the current method in estimating the calibration factors is the lack of consideration of short-term trends in crash occurrences that are caused by factors that have no contribution in the models. Crashes observed in most States since 2006 show an example of such trend. Many of the safety improvements in vehicles and highways that are the major causes for this declining trend are not considered in the crash prediction models. This research proposes a methodology for estimating calibration factors that will consider the effect of such trends. Crash prediction models introduced in the Highway Safety Manual are used to examine this methodology. Data used in this study are from Washington State for rural two-lane, rural multilane and urban/suburban arterial highway segments. Crash data from 2006-2008 are used for estimating the calibration factors and 2009-2010 data are used to validate the hypothesis that calibration factors that are estimated by consideration of short-term trends are of better quality compared to the conventional calibration factors.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-3810
Paper Title Spatial Generalized Ordered-Response Model to Examine Highway Crash Injury Severity
Abstract This paper proposes a flexible econometric structure for injury severity analysis at the level of individual crashes that recognizes the ordinal nature of injury severity categories, allows unobserved heterogeneity in the effects of contributing factors, as well as accommodates spatial dependencies in the injury severity levels experienced in crashes that occur close to one another in space. The modeling framework is applied to analyze the injury severity sustained in crashes occurring on highway road segments in Austin, Texas. The results from our analysis underscore the value of our proposed model to accurately estimate variable effects.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-1754
Paper Title Indexing Crashworthiness and Crash Aggressiveness by Major Car Brands
Abstract This study aims at indexing crash worthiness and crash aggressivity of 23 major car brands in Florida with consideration of the brand origin. It contributes to the literature by proposing a method for redefining the safety performance of cars by taking into account the cars¡¯ hazardousness imposed to counterpart cars that are involved in the same crashes. A Bayesian hierarchical ordered logistic model was applied to relate the injury severity level of drivers to crash compatibility of car brands. In the models, we assume that the driver injury depends on the difference of the striking cars¡¯ aggressivity and the struck cars¡¯ self-protectiveness in two-vehicle crashes with external factors controlled. A total of 17,178 two-vehicle-crash records with 34,356 car involvements in Florida were used in the investigation. The results show that most of the premium cars such as Volvo, Cadillac, Infiniti and Lexus possess excellent crash worthiness and relatively low crash aggressivity. Self-protection abilities of popular car brands such as Ford, Toyota, Honda and Chevrolet vary considerably, but their hazardousness perform similarly and are lower than the average level. European cars perform relatively good self-protection but are also more hazardous to the counterpart cars when crashes occur. Japanese cars show lower worthiness and aggressivity than American cars, while South Korean cars are associated with the lowest crash worthiness and mean crash aggressivity.

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-3433
Paper Title Evaluation of Pedestrian Safety: Geographical Identification of Pedestrian Crash Hotspots and Evaluating Risk Factors for Injury Severity
Abstract Pedestrian-involved crashes that occurred in the city of San Francisco over six years from 2002-2007 were analyzed to evaluate two key aspects of pedestrian safety: occurrence and severity. This was done to identify locations with frequent occurrences of pedestrian-involved crashes and to examine various risk factors on the injury severity of pedestrian-involved crashes. A Geographical Information System (GIS) analysis used for the former shows that the frequency of pedestrian crashes is higher in the vicinity of the central business district, while the rate is higher in the periphery of the city. The latter specifies an ordered probit model to evaluate risk factors that increase the probability of severe injury and fatality. Those factors were: i) age (<15 and 65+), alcohol consumption and cell-phone use among pedestrian characteristics; ii) nighttime, weekends and rainy weather among environmental characteristics; and iii) influence of alcohol, larger vehicles (pickup, bus and truck) and vehicle proceeding straight in striking a pedestrian among crash characteristics. The methods discussed in this paper are readily applicable to evaluation of safety performance in other regions where pedestrian crash data are available.

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Sponsoring Committee ANF30, Motorcycles and Mopeds
Session Number 545
Session Title Making Motorcycles a Safe Transportation Mode
Paper Number 13-1631
Paper Title Estimation of Motorcyclist Injury Severity and Evaluation of Motorcycle-Related Safety Strategies: A California Study
Abstract Fast growing demographics of motorcyclist fatalities aged less than 25 and 45 to 54 are conspicuous in California. The intent of this study was to quantitatively examine factors associated with motorcyclist fatalities and assess the relevant improvement strategies for motorcyclist safety with an emphasis on the young and older aged motorcyclist victims. To accomplish this goal, injury severities for young and older motorcyclist victims were separately estimated using multinomial logit models and pseudo-elasticity with data from five-year motorcycle involved collisions. The results were compared with motorcyclists aged 35 to 44, a middle aged group that shows a consistent trend of fatalities. As a result, key findings include: types of driver and passenger, violations related to speeding, turning and wrong side of road, and roadway conditions did not significantly affect motorcyclist fatalities throughout all three age groups; motorcyclists under alcohol/drug influence and collided with truck were more likely to be fatally injured regardless of age groups; collision types were found to increase either young or older motorcyclist fatalities; no helmet use, intersection and dark street without light were significantly and strongly associated with increased older motorcyclist fatalities; the middle aged motorcyclists were more likely to be fatally injured when drifting off the lane, on opposed lane, or during twilight condition. Based on the statistically significant factors identified, the following safety strategies are convinced as effective methods to reduce motorcyclist fatalities: public education of sobriety, enforcement of heavy vehicle violation, helmet use promotion, clear roadway design and street lighting system, and motorcyclist training.

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Sponsoring Committee ANB25 Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-3145
Paper Title Formulating Informative Priors and Effects on Bayesian Hierarchical Crash Models
Abstract A recent study developed a set of zone-level negative binomial collision prediction models (CPMs) to investigate the relationship between various transportation and socio-demographic characteristics, and the overall roadway safety (1). The developed models used data from Metro Vancouver, British Columbia, and considered the Poisson variations and the heterogeneity (extra-variation) on collision occurrence of collisions. This study aims to evaluate the spatial effects on the occurrence of collisions and to check whether the inclusion of spatial variables can improve the goodness of fit and inference the capability of the previously developed CPMs presented in (1). The transit reliant and application based collision prediction models with spatial correlations were developed using the WinBUGS software. The convergences of the developed models were tested by the trace plots of the parameter estimated, the BGR statistics, and ratios of Monte Carlo errors relative to the standard deviations of the estimates. The results showed that the incorporation of the spatial correlation affected the parameter estimates, the values of dispersion parameters and intercepts, and also the t-statistics. The effect of the main exposure variable on all of the models for total, severe and property damage only collisions were found to be smaller under spatial models. The smaller values of the exponents of the main exposure variable asserted our assumption that spatial effects need to be considered in CPMs to mitigate any potential bias associated with model misspecification.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performancen
Paper Number 13-3584
Paper Title Comprehensive Predictive Model of Interstate Highway Crash Severity
Abstract Highway safety is a topic that is at the forefront of most, if not all, state agendas, and roadway safety will become increasingly more important as the volume of traffic on roadways increases over time. However, currently not enough work exists in regard to modeling the combined effect of a wide variety of variables have on crash severity. This research uses crash data and supporting spatial data from Alabama to define the relationship between crash severity, broken down into nine distinct severity outcomes, and a comprehensive set of independent variables of: roadway infrastructure data, highway traffic and demand data, and spatially related socieconomic and demographic data, via an ordered probit regression model. This study identifies the most important links between crash-occurrence spatial specific variables (infrastructure, roadway demand, connected urban areas land use/demographics) driver/passenger specific, meteorological data and crash severity. Among the results, roadway infrastructure and spatial environments are some of the most important factors influencing crash severity. The comprehensive predictive model presented in this paper can be applied to a number of statewide settings and assist in identifying critical areas for improvements both today and in the future.

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Sponsoring Committee ANF30, Motorcycles and Mopeds
Session Number 545
Session Title Research on Young Drivers
Paper Number 13-4465
Paper Title Motorcycle Type Matters: Helmet Use, Speeding, and Drinking in Motorcycle Crashes
Abstract Motorcyclist traffic crashes and fatalities continue to remain a primary concern for traffic safety in the United States. In 2010, Florida had 7.3 percent of the registered motorcycles in the U.S., yet 8.7 percent of motorcycle related fatalities occurred in Florida. Many studies have been conducted to examine motorcycle crashes, causes, and outcomes to shed light on potential countermeasures to efficiently and effectively reduce motorcycle related injuries and fatalities. While previous research has controlled for several important factors in analyses, many studies have often examined data without recognizing motorcycle types. Different motorcycle types can represent certain characteristics unique to the people that ride them. This study analyzed Florida crash data and annual observational surveys of motorcyclists in Florida to understand the unique characteristics and crash outcomes according to motorcycle type. Statistical analysis and regression models are used to examine the factors that affect the level of injury severity by motorcycle type. The main findings of the study include the following: 1. Helmet use is highly associated with motorcycle type; 2. The composition of motorcycle type in the motorcycle crash data is different by age; 3. Young motorcyclists, as well as sport bikes, are overrepresented in motorcycle crashes; 4. Fatally injured sport bike riders were more likely to speed whereas cruiser and touring riders were more likely to be under the influence of alcohol; and 5. The same contributing factors increase the level of injury severity in motorcycle crashes regardless of motorcycle type.

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Sponsoring Committee ANB30, Operator Education and Regulation
Session Number 436
Session Title Research on Young Drivers
Paper Number 13-0655
Paper Title Investigation into Young Drivers' Attitudes, Perceptions, and Behavior in Korea
Abstract The main objective of this study is to investigate and provide in-depth understanding of the attitudes, perceptions and behavior of Korean young drivers aged between 18 and 24 years old. Overall 188 survey questionnaire responses were collected to find out the significant factors affecting the involvement of young drivers in crashes and receiving citations in Korea. Two-way analysis was conducted to find out factors associated with age, gender, involvement in at-fault crashes and traffic violations. Based on these factors, binary logistic regression and nested logit models were constructed to explain young drivers¡¯ involvement in at-fault crashes and violations, respectively. The models¡¯ results showed that the involvement in at-fault crashes is positively associated with the average mileage per year and dangerous behavior such as running the red light, using mobile phones and exceeding speed limits, but is negatively associated with the desirable behavior of yielding for pedestrians/bicycles. Meanwhile a citation model showed that the average car use frequency and distraction represented by actions such as adjusting the car audio, smoking, eating or drinking, and using the mobile phone while driving are significant factors that increase the probability of receiving a citation. It is concluded from this study that there are several hazardous actions and attitudes that increase the possibility of involvement in at-fault crashes and also violations for young drivers in Korea. These results can be used by municipal government officials, police and driving school instructors to focus on specific items to ameliorate the driving behavior and attitudes which have effects on crashes as well as traffic violations.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-3042
Paper Title Full Bayes Methods for Road Safety Studies: Does Prior Specification Matter?
Abstract This paper investigates the effect of prior assumptions when applying Full Bayes (FB) methods in road safety analysis. The effect of prior choice is evaluated in the accuracy of model parameters, hotspot identification, goodness-of-fit, and treatment effectiveness index in before-after studies. Particular attention is devoted to conditions with lack of data referenced as the low-mean and small-sample problem. In this research, informative, semi-informative, and no-informative priors were determined based on past published studies. Using a simulation framework, various scenarios of sample size and crash occurrence mean are evaluated. Simulated data is generated based on two real databases of divided/undivided rural highway segments in New York and Texas. Diverse sample mean values were obtained considering different time periods (number of years) and classifying accidents in injury-fatal and total accidents. Among other results, it was found that under low-mean and small sample conditions, the outcomes can be significantly biased. However, the introduction of informative priors can still make feasible observational before-after studies when working with small number of observations from treatment and/or comparison sites. Informative priors can help provide more accurate estimates of the treatment effectiveness. Finally, in accordance with previous works, it was shown that the inverse dispersion parameter is significantly affected by prior specifications; nevertheless, regression parameters, goodness-of-fit, and hotspot identification are only slightly sensitive to prior choices.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-2067
Paper Title Modeling Large-Truck Safety Using Logistic Regression Models
Abstract Statistics shows that crashes involving large trucks are generally more severe than those involving other vehicles due to the size, weight, and speed differential between trucks and other vehicles. Given the critical position of trucking in the process of economic recovery and growth, it is urgent to improve truck safety and mitigate any negative impacts to non-truck vehicles. Statistical models have been used universally to identify the contributing factors to crash severities and estimate injury probabilities. These different methodologies, albeit addressing different issues, may provide mixed results and the estimate accuracy may vary. The primary objective of this research is to investigate the effects of key determents to crash severities involving large trucks and to explore the relationship between them. The secondary objective is to provide insight on statistical applications by evaluating three logistic regression models: multinomial logistic (MNL), partial proportional odds (PPO), and mixed logistic (ML) models. The model results show that the majority of the coefficient estimates are consistent across the models studied. A few exceptions include young drivers and the use of safety constraints, which are not statistically significant in the ML model. The goodness-of-fit and model predictive power indicates that the PPO model produced the results that more closely resembled observations.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 433
Session Title Improving Safety Data, Analysis, and Evaluation
Paper Number 13-3047
Paper Title Developing a Truck Corridor Crash Severity Index
Abstract According to the United States Department of Transportation (USDOT) estimates, over 500,000 truck accidents occur every year. Of that number, approximately 5,000 trucking accidents result in fatalities. Compared to extensive studies conducted on freeway truck safety, the research on arterial streets is considerably disproportionate. Making the connections between truck traffic generators, arterial streets are key links in door-to-door deliveries. There is an urgent need to study truck safety on arterial streets because of the strong growth of truck traffic. Truck related crashes are expected to be reduced through the careful planning of the location, design, and operation of driveways, median openings, street connections and street sections. By collecting extensive data on selected arterial corridors that are heavily used by trucks, truck crash frequency and severity contributing factors have been identified using negative binomial model and multinomial logit (MNL) model, respectively. Subsequently, a crash severity index (CSI) for the truck arterial corridors was developed. The findings from the study will not only benefit state and local agencies in planning, design, and manage a safer truck arterial corridor, but also help carriers to optimize their routes from the safety perspective.

Authors	Yiyi Wang, University of Texas, Austin Kara Kockelman, University of Texas, Austin
Sponsoring Committee	ANF10, Pedestrian Design, Safety, and Behavior
Session Number	669
Session Title	Pedestrian Design, Safety, and Behavior
Paper Number	13-1252
Paper Title	A conditional autoregressive model for spatial analysis of pedestrian crash counts across neighborhoods
Abstract	This work examines the relationship between 3-year pedestrian crash counts across Census tracts in Austin, Texas, while controlling for land use, network, and demographic attributes, such as land use balance, residents' access to transit, sidewalk density, lane-mile densities by roadway classes, and population and employment densities (by type). The model specification allows for both region-specific heterogeneity and spatial autocorrelation via a Poisson-based conditional auto-regressive (CAR) framework and is estimated using Bayesian Markov chain Monte Carlo method. Least-squares regression estimates of walk-miles traveled per zone serve as the exposure measure. Model results suggest that higher shares of residences near transit stops are associated with greater pedestrian crash risks, ceteris paribus, presumably since such access encourages more walking activity and more potential conflict between pedestrian and vehicles movements. Sidewalk provision is associated with lower pedestrian crash rates, presumably due to lower speeds and narrower roadways in network-dense and sidewalk-prominent settings, though exposure is likely higher.

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Sponsoring Committee	ANF20, Bicycle Transportation
Session Number	494
Session Title	Cycling Infrastructure and Safety
Paper Number	13-0386
Paper Title	Modeling Impacts of Access Design and Spatial Pattern on Crash Risks of Pedestrians and Bicyclists on Urban Multilane Highways in Florida
Abstract	This paper presents a study on the impacts of access design and spatial pattern on the risk of pedestrian and/or cycling crashes at access points on urban multilane highways. Two prediction models, using negative regression and logistic regression, were developed to evaluate the impacts in terms of crash frequency and injury severity respectively. For developing the models, crash records were collected at 153 access points with different access designs for a period of 4 years (2007-2010) on the state roads in Florida. Results of this study show that, four-leg access point with directional median opening is most likely to increase the frequency of pedestrian/bicycle crashes at access points than other access designs at all spatial locations. Inner lanes experience the most pedestrian/bicycle crashes, followed by side roads (SR) and outside lanes (TO) for all access types. Three-leg access point with closed median opening and three-leg access point with full median opening experience a higher injury risk if a pedestrian/bicyclist crash occurs at an access point. Medians and inner lanes experience the highest injury risk if a pedestrian/bicyclist crash occurs at an access point. Middle lanes, outside lanes, left turn bays, crossing walks are more likely to increase injury severity of pedestrian/bicycle crashes than road side, side roads, and auxiliary lanes. In terms of crash occurrence, the top "dangerous" points are inner lanes, side roads, and outside through lanes with the access design of four-leg access point with directional median opening. In terms of injury severity, the top "dangerous" points are medians with any access design and inner lanes with the access designs of three-leg access point with closed or full median opening. Based on the results, suggested countermeasures for improving pedestrian/bicyclist safety at access points were provided.

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Sponsoring Committee	ANB20, Safety Data, Analysis and Evaluation – ANF20, Bicycle Transportation
Session Number	454
Session Title	Safety Evaluation and Cyclist Safety
Paper Number	13-2995
Paper Title	Bicyclists' Injuries and the Cycling Environment: Impact of Route Infrastructure
Abstract	Introduction. Safety concerns have contributed to low bicycling rates in North America. Injury rates are lower and cycling is more common in northern European countries where route infrastructure is designed for cyclists, yet few studies have examined the relationship between the cycling environment and injuries. Methods. 690 people injured while cycling were recruited via emergency departments in Toronto and Vancouver, Canada. Conditional logistic regression compared route infrastructure at each injury site to that of a randomly selected control site from the same trip. The case-crossover design controlled for exposure to risk and for personal characteristics and other factors that are stable within a trip. Results. Of 15 route types, cycle tracks (physically separated paths alongside city streets) had

the lowest risk, about 9 times lower than the reference (arterials and collectors with parked cars and no bike infrastructure). Bike lanes on arterials and collectors with no parked cars, local streets, and off street bike paths had 2-fold risk reductions. Risks on arterials and collectors were lower when parked cars were not present. Other infrastructure characteristics were associated with increased risks: downhill grades; streetcar or train tracks; and construction. Conclusions. The results of this study indicate that the design approach used in northern Europe is effective in North America. The following route types are the best choices for common urban transportation locations and would lower injury risks to cyclists: alongside arterials and collectors – cycle tracks; on local streets – designated bikeways with traffic diversion; and off-street – bike paths.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-5001
Paper Title Effect of Removing Freeway Mainline Barrier Toll Plazas on Safety
Abstract Toll plaza safety is a critical issue. Toll plazas induce motor vehicle crashes and also put workers such as toll collectors at risk. Therefore, enhancing safety at a toll plaza is crucial to improving safety on tolled roadways. This study aims to evaluate the safety effect of removing mainline barrier toll plazas on highways using Empirical Bayesian (EB) methodology. Recent removals of barrier toll plaza on the Garden State Parkway in New Jersey were used as a case study. Multiple-year traffic and crash data before and after the removals of the barrier toll plazas were used for analysis. Toll plaza crash frequency models as a function of traffic flow and other factors were developed, with the modeling results suggesting that there is a nonlinear relationship between toll plaza crash occurrences and both traffic flow as well as toll booth configurations. The EB approach is also used to predict crash frequency assuming that the barrier toll booths were not removed. These EB-based estimates were compared with the observed number of crashes after the removals of the toll plazas. Individual comparisons show reductions in crash frequency at almost all of the toll plazas and an estimated reduction of 47.2 percent overall at all toll plazas due to the removal of the barrier toll booths. The estimated crash cost was reduced by 43.2 percent. These estimated reductions demonstrate that the removal of barrier toll plazas is a very beneficial step towards improving safety of toll roads.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-4081
Paper Title Evaluating Alternate Discrete Choice Frameworks for Modeling Crash Injury Severity
Abstract This paper focuses on the relevance of alternate discrete choice frameworks for modeling driver injury severity. The study empirically compares the ordered response and unordered response models in the context of driver injury severity in traffic crashes. The alternative modeling approaches considered for the comparison exercise include: for the ordered response framework- ordered logit (OL), generalized ordered logit (GOL) and for the unordered response framework - multinomial logit (MNL), nested logit (NL) and ordered generalized extreme value logit (OGEV) model. A host of comparison metrics are computed to evaluate the performance of these alternative models. To our knowledge, the study provides a first of its kind comparison exercise of the performance of ordered and unordered response models for examining the impact of exogenous factors on the driver injury severity. The research also captures the effect of potential underreporting on alternative choice frameworks by artificially creating an underreported data sample from the driver injury severity sample. The empirical analysis is based on the 2010 General Estimates System (GES) data base. The comparison exercise clearly highlights the superiority of the GOL model on the estimation and the validation sample in terms of data fit compared to the OL and MNL models. The estimation with the artificial underreported sample consistently obtains the wrong elasticities and these errors are substantially reduced for both GOL and MNL models with the correction measures for the thresholds/constants of these models based on the true aggregate shares. The most striking finding is the fact that the MNL model does not perform any better in the underreporting context. In fact, the GOL elasticity effects of underreported estimates with corrections are closer to the true elasticity effects than that of the MNL model. Overall, the results of the empirical comparison provide credence to the belief that an ordered systems that allow for exogenous variable effects to vary across alternatives offer superior fit compared to unordered systems in modeling driver injury severity.

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-3987
Paper Title Alternative Ordered Response Frameworks for Examining Pedestrian Injury Severity in New York City
Abstract This paper focuses on identifying the appropriate ordered response structure that is better suited to modeling pedestrian injury severity. The alternative ordered response approaches considered for the empirical analysis include: ordered logit model (OL), generalized ordered logit model (GOL) and latent segmentation based ordered logit model (LSOL). The GOL model relaxes the restrictive assumption by allowing for exogenous variable impacts on the threshold parameters in the standard ordered logit structure. Again, the LSOL model allows for differential impact on the alternatives by segmenting the pedestrian crash population into various segments with segment specific ordered logit parameters. The performance and strength of the formulated injury severity models are tested based on the "New York City (NYC) Pedestrian Research Data Base" for the year of 2002 through 2006. To our knowledge, the study provides a first of its kind exercise to identify the preferred ordered model for examining pedestrian injury severity. The model estimation results clearly highlights the presence of segmentation based on the location of pedestrian accidents; locational attributes that affect the allocation of pedestrians into these segments include: regional county, functional classification of roadway, pedestrian location on roadway, number of travel lanes and number of parking lanes in the roadway system. The key factors influencing pedestrian injury severity are weather condition, lighting condition, vehicle types, pedestrian age and season. Overall, the results of the empirical analysis provide credence to the belief that LSOL model is a preferred ordered framework choice to accommodate population heterogeneity in the context of pedestrian injury severity.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-0718
Paper Title Crash-Type Propensity Analysis with Bayesian Models Using Microscopic Traffic and Weather Data
Abstract This study investigates a range of effects of microscopic traffic and weather factors and roadway geometry information on the specific crash type for a mountainous freeway. Crashes have been categorized as rear-end, sideswipe and single-vehicle crashes. Six-minute Automatic Vehicle Identification (AVI) segment average speed, real-time weather data and roadway geometry data are utilized as explanatory variables in this study. First, two binary logistic regression models were estimated by comparing single-vehicle to multi-vehicle crashes and sideswipe crashes to rear-end crashes. Then a full model which simultaneously fits two conditional logistic regression models (mixed logit model) for the three crash types has also been estimated. Results from the models indicate that single-vehicle crashes are more probable in the snow season, at moderate slopes, three-lane segments, under the free-flow conditions; while the sideswipe crash occurrence differs from rear-end crashes with the visibility situation, number of lanes, grades and their directions (up or down). Moreover, the results of the Bayesian random effects logistic regression models have been compared with the results from the classic logistic regression with the Frequentist and Bayesian inference techniques. It was demonstrated that the Bayesian random effects logistic regression outperforms the other two approaches with higher accuracy and lower Brier scores. The innovative way of estimating two conditional logistic regression models simultaneously in the Bayesian framework fits the data structure well. Conclusions from this study imply that different active traffic management strategies should be designed for three- and two-lane roadway sections and also considering the seasonal effects.

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Sponsoring Committee ANB25 Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-0222
Paper Title Formulating Informative Priors and Effects on Bayesian Hierarchical Crash Models
Abstract The Bayesian inference method has been frequently adopted to develop safety performance functions. One advantage of the Bayesian inference is that prior information about the independent variables can be included in the models, which could benefit the inference conclusions from avoiding implausible results due to data fluctuations. However, there are few past studies discussing how to formulate the informative priors and what are the effects of having informative priors in developing Safety Performance Functions. This paper fills the void by introducing four approaches of developing informative priors for the independent variables based on historical data or general information. Merits of these informative priors have been tested along with two types of Bayesian Hierarchical models (Poisson-gamma model and Random effect Poisson model). Deviance Information Criterion (DIC), R-square values and standard errors were utilized as evaluation measures to select the best model(s). Comparisons across the models indicate that the Poisson-gamma model is superior with better model fitting and it is much more robust with the informative priors. Moreover, model fitting and coefficient estimation accuracies have been enhanced by the informative priors. Finally, based on the results, recommendations are made for the different informative prior development techniques.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-2938

Paper Title Comparison of Sichel and Negative Binomial Models in Estimating Empirical Bayes Estimates

Abstract Traditionally, transportation safety analysts have used the empirical Bayes (EB) method to improve the estimate of the long-term mean of individual sites and to identify hotspots locations. The EB method combines two different sources of information: (1) the expected number of crashes estimated via crash prediction models, and (2) the observed number of crashes at individual sites. Crash prediction models have extensively been estimated using a negative binomial (NB) modeling framework due to the over-dispersion commonly found in crash data. Recent studies have shown that the Sichel (SI) distribution provides a promising avenue for developing crash prediction models. The objective of this study is to examine the application of the SI model in calculating EB estimates. To accomplish the objective of the study, the SI models with a fixed/varying dispersion term are developed using the crash data collected at 4-lane undivided rural highways in Texas. The important conclusions can be summarized as follows: (1) the selection of the crash prediction model (i.e., the SI or NB model) will affect the value of weight factor used for estimating the EB output; (2) the identification of hazardous sites, using the EB method, can be different when the SI model is used. Finally, a simulation study designed to examine which crash prediction model can better identify the hotspot is recommended as our future research.

5 Papers on network screening

Network screening is the identification of crash hotspots, also referred to as hazardous road locations, high-risk locations, accident-prone locations, black spots, sites with promise, or priority investigation locations, is the first step of the highway safety management process. It is vital that a sound procedure be used in network screening; otherwise, resources will be wasted on locations that are incorrectly identified as unsafe while those that are unsafe will remain untreated.

The Subcommittee identified ten papers dealing with network screening. Five papers were sponsored by the ANB20 Committee, two papers were sponsored by the ANB10 Committee, and three papers were sponsored by other Committees.

From a methodological perspective, different methods to obtain performance measures were used:

- Empirical Bayes method (*Ma et al.; Lim and Kweon*);
- Full Bayes method (*Wang et al.*);
- Reliability analysis (*Yu et al.*);
- Categorical binary model approach (*Ferreira and Couto*);
- Continous Risk Profile (*Chung et al.*); and
- Combined approaches (*Aguiar-Moya et al.; Bandyopadhyaya and Mitra; Schorr et al.*).

One paper compared the different screening methods recommended by the Highway Safety Manual (*Azam et al.*).

From an applications perspective, the papers addressed several issues, such as:

- Intersections (*Ferreira and Couto; Lim and Kweon; Schorr et al.; Wang et al.*);
- Highways (*Aguiar-Moya et al.; Azam et al.; Ma et al*.);
- Mountainous freeways (*Yu et al.*);
- A GIS componenent for Safety Analyst (*Ma et al.*); and
- A new safety management tool (*Chung et al*.).

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-2286
Paper Title Methodology for Determining Traffic Accident Risk Zones
Abstract In Costa Rica, the traffic accident database is still under development. Due to the limited quantity of information it is very difficult for the DOT to the accurately locate the road sections with significant concentration of accidents, also known as "blackspots". The National Laboratory of Materials and Structural Models of the University of Costa Rica (LanammeUCR) has developed a methodology that initially assesses the potential risk of accidents associated with a combination of four different parameters related to road infrastructure and the environment. The study was performed in four of the Country's main highways, for a study length of over 1,000 km of roads. The parameters considered in the methodology were: pavement friction, retro-reflectivity of the road marking, geometrical and topographical alignment of the roadway and climatic factors. The experimental parameters associated with each category were measured directly based on NDT testing. The climatic factors were based on current and historical weather station information. The proposed methodology consists of a combination of values for each individual parameter, which finally result in a susceptibility profile for the road, which is related to the risk that an accident will occur. All of the data was plotted in geo-referenced maps to be available for road users and the government. Finally, the results were correlated with accident data to verify for the sensitivity of the method.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-2887
Paper Title Network Safety Screening in the Context of Agency-Specific Screening Criteria
Abstract Network screening for identifying locations with specific safety needs is an important aspect of the safety management for any highway agency. Network screening is usually governed by specific criteria set by a particular agency. This study shows how an integrated safety management system can help achieve agency's goal in identifying locations under various screening criteria. The safety framework can be interfaced with the agency's crash database(s) and different support systems for implementing user-defined screening and project planning. The case study shows implementation of facility-level and segment-based network screening on a single route. The analysis route and associated crash information were fixed whereas the screening method and performance measures were varied. Results showed that both sliding window and peak search techniques showed comparable results and better performance than simple ranking technique in identifying hotspots with respect to different performance measures. In general, the sliding window technique shows more mileage of hotspots identified, whereas the peak search technique has better accuracy in terms of crash density. The coefficient of variation (CV) based sliding window on facility screening showed better performance in terms of mileage and crash density of identified hotspots. This study can help agency understand the underlying factors that affect their network screening process.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-2379
Paper Title Hotspot Identification Under Limited Information: Combined Probabilistic and Fuzzy Cluster-Based Approach
Abstract Hot-Spot Identification (HSID) requires crash history information such as annual crash counts, their severities etc and details such as annual traffic exposure and geometric design details. The most recommended HSID method— Empirical Bayes utilizes at least crash history and traffic volume information to develop Safety Performance Function (SPF), which is used to compute expected number of crashes at a given site. However, in the absence of systematic data collection and maintenance, information about geometric design and traffic volume is not only difficult to obtain, but also demands significant resources. In such circumstances, only crash-count based (CCB) HSID techniques, such as Crash Frequency (CF) method, Fatal Crash Frequency (FCF) method and Equivalent Property Damage Only (EPDO) methods may only be adopted even with their known limitations. In this article, the authors suggested a new method of HSID, using disaggregate crash history information in crash severity model. Based on the probabilities of crash severities by the major contributing factors, expected numbers of severe and fatal crashes are calculated. These expected crash counts are used to classify locations into two fuzzy clusters— a) black-spots and b) white-spots using Fuzzy C-Means (FCM) algorithm. The identified hotspots are ranked based on their mean departure from core of the hotspot cluster. Site consistency, Method consistency and Total rank differences tests are used to compare the performance of the method with other CCB-HSID techniques. Results show the robustness of the proposed FCM method as it performs well in all consistency tests.

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Sponsoring Committee ANB10, Transportation Safety Management
Session Number 439
Session Title Transportation Safety Management and Alcohol Research
Paper Number 13-3936
Paper Title Developing Safety Management Tools for State Departments of Transportation
Abstract Two different safety management tools had been recently developed for the California Department of Transportation (Caltrans): one is the Continuous Risk Profile (CRP) approach which is a network screening procedure, and the other is the California Safety Analyst (CASA) which is a web-based application designed to assist state safety engineers in conducting safety investigations and documenting their findings. This paper provides a qualitative description of these two tools and also summarizes feedback from over 100 Caltrans safety engineers who attended the demonstration of the web-based application. Findings from empirical analysis and the survey revealed that CRP can significantly reduce the false positive rate and that CASA can greatly improve the efficiency of traffic safety investigations. However, there still remain misunderstandings about the relationship among CRP, other methods explained in Highway Safety Manual, and different safety management tools. These misunderstandings impose challenges for the deployment of CRP and CASA in California and these challenges are also discussed in the paper.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-0095
Paper Title Hot-Spot Identification: Categorical Binary Model Approach
Abstract This paper presents an alternative methodology for hot-spot identification based on a probabilistic model. In this methodology, the ranking criterion for hot-spot identification conveys the probability of a site being a hot-spot or a non-hot spot. A binary choice model was used to link the outcome to a set of factors that characterize the risk of the sites under analysis based on our use of two categories (0/1) for the dependent variable. The proposed methodology consists of two main steps. First, a threshold value for the number of accidents is set to distinguish hot spots from safe sites (category 1 or 0, respectively). Based on this classification, a binary model is applied that allows the construction of an ordered site list using the probability of a site being a hot-spot. The second step involves the choice of a selection strategy. The selection strategy can target a fixed number of sites with the greatest probability or, alternatively, all sites exceeding a specific probability, such as 0.5. A demonstration of the proposed methodology is provided using simulated data. For the simulation design, urban intersection data from Porto, Portugal, covering a five-year period were used. The results of the binary model showed a good fit. To evaluate and compare the probabilistic method with other commonly used methods, measures were used to test the performance of each method in terms of its power to detect the “true” hot spots. The test results indicate that the proposed method is superior to two commonly used methods. The gains of using this method are related to the simplicity of its application, while critical issues such as prior distribution effect assumptions and the regression-to-the-mean phenomenon are overcome. Further, the proposed model provides a realistic and intuitive perspective and supports easy practical application.

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Sponsoring Committee ANB10, Transportation Safety Management
Session Number 439
Session Title Transportation Safety Management and Alcohol Research
Paper Number 13-4035
Paper Title Comparison Between Traditional Methods and Empirical Bayes with Safety Performance Function Method for Identifying High Crash-Risk Intersections
Abstract Identifying high crash-risk locations, called hot-spots, is a most important step to improve roadway safety and the Empirical Bayes (EB) coupled with the safety performance function (SPF) is regarded as the state of practice in identifying such locations. To apply the EB-SPF method, however, requires considerable resources in preparing data and statistical expertise. Consequently, many highway agencies still rely on traditional methods such as crash frequency and crash rate in identifying locations for potential safety improvement without knowing the extent of accuracy of such methods. This study examined four traditional identification methods widely used to understand the extent of accuracy of the four methods in identifying potential locations for safety improvement as compared to the EB-SPF method and to suggest the best method among the four: crash frequency, crash rate, rate-quality control, and equivalent property damage only (EPDO). This study was limited to 4-leg intersections with either signal or 2-way stop and 2004-2008 data were collected at 1,670 such intersections. The study found that the crash frequency method performed the best among the four in correct identification of top 1 percent unsafe intersections yet tends to flag intersections falsely being at top hot-spots and the rate-quality control method performed the best for the top 5 and 10 percent unsafe intersections. The findings are expected to help highway agencies continuing use of the traditional methods choose the best so that scarce resources available for safety improvement would be invested effectively.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-3969
Paper Title Development of a Geographic Information System for SafetyAnalyst for Location Selection and Output Visualization
Abstract SafetyAnalyst was developed as a cooperative effort by the Federal Highway Administration (FHWA) and participating state and local agencies. Released in 2010, the system is a set of software tools developed to aid state and local highway agencies in highway safety management. SafetyAnalyst uses the empirical Bayes method and incorporates all the steps of the roadway safety management process. However, it lacks the Geographic Information System (GIS) component; SafetyAnalyst provides only the data interface needed to exchange spatial data. Given the spatial nature of crash analysis, there is a need for a GIS component to allow users to graphically select locations and display analysis results from SafetyAnalyst. SafetyAnalyst assumes that an agency will adapt its existing GIS system to provide that capability. However, it is unlikely that an agency will have an existing GIS system that can be customized to work with the unique file structures of SafetyAnalyst. This paper discusses SafetyAnalyst, its input and output file structures, and a standalone GIS system designed to interface with SafetyAnalyst. The system provides an alternate method for selecting locations for analysis by SafetyAnalyst using a graphical display. The system also provides a graphical display of the results from SafetyAnalyst's network screening module. While the system was developed for Florida, it can be easily customized for similar applications in other states.

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Sponsoring Committee ABJ80, Statistical Methods
Session Number 658
Session Title Statistical Methods Research for Transportation
Paper Number 13-3915
Paper Title Collision Propensity Index for Unsignalized Intersections: Structural Equation Modeling Approach
Abstract The objective of this paper is to develop a quantitative collision propensity index (CPI) that captures the overall propensity of a given surrounding environment to cause accidents at un-signalized intersections. Using structural equation modeling, the index can be estimated from observed geometric, vehicular, driver-related, and traffic-related characteristics. Utilizing the California Department of Transportation's data repository, information on 4388 collisions occurring at 2709 different intersections was collected and processed. A statistically significant converging structural equation model was found reflecting the safety impact of different surrounding elements/dimensions on driving behavior: The CPI provides (a) a basis for quantifying the effects of the aforementioned characteristics on traffic safety and/or incident properties, (b) a basis for comparing the differences between the dimensions affecting collision propensity based on different exogenous measures' classification schemes and (c) ranking the corresponding un-signalized intersections for improved safety performance. The framework and methodology used to develop this index has the potential to support safety policy analysis and decision making.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-2698
Paper Title Systematic Approach for Hazardous Intersection Identification and Countermeasure Development
Abstract Safety performance functions (SPFs) are typically used to correlate geometric, traffic and environmental characteristics with total crashes and to identify hotspots which have high overall crash frequencies. However, with a distinct conflict pattern in vehicle maneuvers, each crash type is likely to associate with different risk factors. This study developed approach-level SPFs using a full Bayesian method to assess the safe effects of specific risk factors for rear-end, left-turn, right-angle, sideswipe and total crashes. To account for the spatial correlations among approaches at the same intersection, a random intersection-specific effect term was incorporated into each model. It was affirmed that these models were helpful in identifying high risk intersections with specific safety problems, and could serve as useful complements to general hotspot analyses using expected crash totals. In addition, it was found that certain variables (e.g. number of through lanes, median, and left-turn protection all on the entering approach) could have even contrary effects on crash occurrence of different types. Approach-level crash type models provide valuable insights in developing countermeasures aimed at reducing certain crash types and an improved ability in identifying deficiencies related to geometric and traffic characteristics for each intersection approach.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-0477
Paper Title Feasibility of Incorporating Reliability Analysis in Traffic Safety Investigation

Abstract In this paper, the method of reliability analysis has been employed to investigate the feasibility of using it in traffic safety analysis. The reliability analysis approach, frequently used to evaluate the probabilities of failures for a specific structural system, has two main outcomes which are the reliability index and design points. Two different approaches to use these two outcomes in traffic safety analysis have been presented in this paper. Data from a mountainous freeway in Colorado was used. The reliability index was utilized to evaluate the hazardous freeway segments by incorporating the traffic flow parameters provided by radar detectors. The design points were employed to predict the crash occurrence at the disaggregate level with weather parameters. Finally the results from both approaches have been compared to the results from a traditional method, and the reliability analysis method showed promising applications in traffic safety. By using the reliability indexes, the three most hazardous segments are consistent with the results from the crash rates segment ranking approach; for the design points, by utilizing these thresholds the accuracy rate of predicting crash occurrence could be improved by 10% compared to the logistic regression method.

6 Papers on before-and-after safety evaluations

The Subcommittee identified twenty one papers dealing with before-and-after safety evaluations.

The majority of these papers employed the Empirical Bayes approach (*Bartin et al.; Chimba et al., Lan and Srinivasan; Li et al.; De Pauw et al., 13-1465, 13-1970; Persaud et al.; Qin et al.*) while the Full Bayes approach was employed in two studies (*Lan and Srinivasan; Li et al.*). Cross-sectional regression methods were employed in four studies (*Dou et al.; Ewing et al.; Sando et al.; Zeng and Schrock*) and one study used the comparison group method (*Srinivasan et al.*). Several studies included multiple evaluation approaches (*Das et al.; Lan and Srinivasan; Li et al.; Persaud et al.*). Other evaluation techniques were also proposed (*Chimba et al.; Li et al.*). Multivariate collision severity analysis was used in two studies (*Lan and Srinivasan; Li et al.*). One study (*Li et al.*) included a "jump" parameter to represent a possible sudden drop (or increase) in collision counts immediately following the safety countermeasure. The safety impact of countermeasures was generally represented by changes in collisions and collision severity. However, several studies evaluated collision surrogates (*Dou et al.; Greaves et al.; Kay et al.; Kaparias et al.; Richfield and Hourdos; Sando et al.; Zangenehpour et al.*).

The evaluated countermeasures included:

- Geometric elements (*Bartin et al.; Chimba et al.; Das et al.; Kaparias et al.; Li et al.; Persaud et al.; Sando et al..; Zangenehpour et al.; Zeng and Schrock*);
- Signage and control elements (*Chimba et al.; Dou et al.; Kay et al.; Lan and Srinivasan; Srinivasan et al.*);
- Roundabouts (*Qin et al; Richfield and Hourdos*);
- Speed reduction and enforcement (*Li et al.; Pauw et al.*);
- Traffic calming (*Ewing et al.*);
- System-wide road safety improvements (*Ewing et al.*); and
- Pedestrian and cyclist countermeasures (*Kay et al.; Kaparias et al.; Sando et al.; Zangenehpour et a*l.).

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Sponsoring Committee AFB20, Roadside Safety Design
Session Number 730
Session Title Roadside Barrier Simulation, Testing, and Performance
Paper Number 13-0528
Paper Title Safety-Effectiveness Evaluation of Cable Rail Systems in Tennessee
Abstract Performances and safety effectiveness evaluation results of median cable barrier systems in Tennessee are presented in this paper. Twenty seven segments with at least three years of complete crash data before and after cable installations were analyzed. The segments were evaluated in terms of descriptive statistics of factors associated with median crashes whose occurrences were influenced by the presence or absence of the median cable barriers. The cable systems were also evaluated in terms of percentage safety effectiveness and confidence levels comparing before and after cable conditions. The study involved review of crash hard copies where only 24% were found to be relevant for median cable barriers evaluation, 76% were not related. Descriptive statistics compared percentage of certain type of crashes, crash attributes and other elements to the total crashes before and after the barriers were installed. To evaluate the safety effectiveness, the research applied crash modeling in the form of safety performance models, and observational Empirical Bayes (EB) before and after analysis. Safety effectiveness of the installed median cable barrier systems was found to be 93% for fatal crashes, 85% for fatal and incapacitating injury crashes combined and 51% for the combination of fatal and all injury crashes all above 95% confidence level. Study also found that combined fatal and injury crashes were reduced by 21% after median cable installations while fatal crashes only were reduced by 80%. Total number of people killed or injured was reduced by 29% after installation.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-4630
Paper Title Investigating Safety Impact of Raised Pavement Markers on Freeways in Louisiana
Abstract Raised pavement markers (RPM) are intended as safety devices on roadways. Intuitively convinced by its safety benefits Louisiana Department of Transportation and Development (LADOTD) has been using RPM for many years on all freeways in the state. This paper evaluates the safety benefit of RPM along with pavement striping on freeways with nine years of data. The analysis results from three methods indicate that RPM has significant benefit in reducing nighttime crashes on rural freeways and there are no safety benefits on urban freeways.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-1465
Paper Title Redesigning Black Spots in Traffic: Effect Evaluation
Abstract This study evaluates the safety effects of an extensive black spot program that has been implemented in Flanders-Belgium. Based on their crash history, 800 locations were selected as black spots. The study evaluates 134 locations that were redesigned between 2004 and 2007. The adopted approach is an Empirical Bayes before-and-after study that accounts for effects of general trends and for the stochastic nature of crashes, including regression to the mean. Two different comparison groups were established. Dependent on the applied comparison group, the analyses showed a decrease in the number of injury crashes of 24 to 27%, significant at the 1%-level. A separate analysis for crashes with serious or fatal injuries showed a decrease of 40 to 52%, also significant at the 1% level. ANOVA-analyses were made to check whether differences in effects occur depending on the characteristics of the location or the implemented intersection design. The results suggest a more favourable evolution for intersections that were priority controlled in the before situation compared with signal-controlled intersections. Crash reductions were also higher at locations with a lower traffic volume compared to locations with a higher volume.

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Sponsoring Committee ANB40, Traffic Law Enforcement
Session Number 652
Session Title Automated Enforcement Evaluation, Application, and Effects on Highway Safety and Driver Behavior
Paper Number 13-1970
Paper Title The effect of combined speed and red light cameras on safety
Abstract This study evaluates the traffic safety effect of combined speed and red light cameras on 253 intersections in Flanders-Belgium that were installed between 2002 and 2007. The adopted approach was an Empirical Bayes before- and after study. The evolution in the number of crashes at the investigated locations was compared with the evolution in a comparison group of locations. These analyses show a non-significant increase of 5% in the number of injury crashes. For the severe crashes, with serious and fatal injuries, a decrease of 14% was found, significant at the 10% level. A distinction between side and rear-end crashes showed a significant increase of 44% in the number of rear-end crashes, but a non-significant decrease of 6% in the number of side collisions. The decrease for the severe crashes was mainly attributable to the effect on side-collisions, for which a decrease of 24% was found, also significant at the 10% level. Furthermore ANOVA-analyses showed RLC-equipped intersections outside the urban area yield more favorable results, compared to intersections inside the urban area

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Sponsoring Committee AHB50, Traffic Control Devices
Session Number 336
Session Title Current Topics in Traffic Control Devices
Paper Number 13-3694
Paper Title Evaluating Impacts of Flashing Green before Amber on Drivers' Stop and Cross Decisions at Signalized Intersections in China: an empirical approach and comparative study
Abstract To better understand the safety effects of flashing green before amber on signalized intersections in China, this study compares drivers stop/cross decisions at the onset of the amber phase at signalized intersections with and without flashing green, based on data collected from six approaches with sixteen exclusive through-lanes at five signalized intersections during on-peak and off-peak hours. It is found that flashing green installation serves only to encourage stopping but does not curb red light violations. In effect, flashing green adversely increases red light violations during off-peak hours due to a lengthier option zone. Meanwhile, flashing green induces aggressive drivers to pass the stop-line during amber with significantly higher speeds during off-peak hours. This effect is due to the reality of unreasonable legal regulations and acquiescence with respect to crossings by acceleration during amber in China. More specifically, the introduction of flashing green further expands the difference between driversi¯ acceleration/deceleration decisions, which is clearly expressed in the higher standard deviations of vehicular speeds while passing the stop-line at sites with flashing green. Moreover, flashing green alleviates driversi¯ underestimation of the time to the end of the amber phase, which may reduce early stops but does not sacrifice safety overall. However, flashing green apparently fails to work normally during on-peak hours. It has limited impacts on vehicular speeds, the proportions of amber-light running and red light violations, evidently due to car-following characteristics at intersections during on-peak hours

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Sponsoring Committee ANB10, Transportation Safety Management - ANB50, Alcohol, Other Drugs, and Transportation
Session Number 439
Session Title Transportation Safety Management and Alcohol Research
Paper Number 13-2242
Paper Title Quasi-Experimental Study of Traffic Calming Measures in New York City
Abstract This paper provides a large-scale, rigorous evaluation of traffic calming projects in the U.S. The study area is New York City, which treated 391 streets with speed tables between 1996 and 2003. Based on crash frequencies for 5 years before treatment and 5 years after, for both treated streets and well-matched comparison streets, there is no evidence that New York City's ambitious traffic calming program has led to a reduction in total crashes, pedestrian crashes, or injury crashes. This is in contrast to earlier, less carefully controlled evaluations that have reported significant reductions in crashes with traffic calming.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-0988
Paper Title Safety Evaluation of Discontinuing Late Night Flash Operations at Signalized Intersections
Abstract Performances and safety effectiveness evaluation results of median cable barrier systems in Tennessee are presented in this paper. Twenty seven segments with at least three years of complete crash data before and after cable installations were analyzed. The segments were evaluated in terms of descriptive statistics of factors associated with

median crashes whose occurrences were influenced by the presence or absence of the median cable barriers. The cable systems were also evaluated in terms of percentage safety effectiveness and confidence levels comparing before and after cable conditions. The study involved review of crash hard copies where only 24% were found to be relevant for median cable barriers evaluation, 76% were not related. Descriptive statistics compared percentage of certain type of crashes, crash attributes and other elements to the total crashes before and after the barriers were installed. To evaluate the safety effectiveness, the research applied crash modeling in the form of safety performance models, and observational Empirical Bayes (EB) before and after analysis. Safety effectiveness of the installed median cable barrier systems was found to be 93% for fatal crashes, 85% for fatal and incapacitating injury crashes combined and 51% for the combination of fatal and all injury crashes all above 95% confidence level. Study also found that combined fatal and injury crashes were reduced by 21% after median cable installations while fatal crashes only were reduced by 80%. Total number of people killed or injured was reduced by 29% after installation.

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Sponsoring Committee ANF10, Pedestrian
Session Number 700
Session Title Practical Research on Pedestrian and Driver Interactions
Paper Number 13-0309
Paper Title Analysis of pedestrian-vehicle traffic conflicts in street designs with elements of shared space
Abstract This paper investigates changes in pedestrian-vehicle traffic conflicts in urban streets redesigned according to the principles of shared space, using a recently developed Pedestrian-Vehicle Conflicts Analysis (PVCA) method. In a first step, the PVCA method is revised to more accurately reflect the features of shared space: this includes the definition of a systematic process for identifying conflict occurrences on one hand, and the full quantification of the conflict severity grading process on the other. Then, the refined PVCA method is applied to a case study in London, using video data from periods before and after the redevelopment of the Exhibition Road site from a conventional dual carriageway to a modern design with some elements of shared space. The results of the comparative analysis carried out indicate a general decrease in traffic conflict rates as a result of the redesign, but also highlight specific issues that may require additional analysis.

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Sponsoring Committee ANF20, Bicycle Transportation
Session Number 494
Session Title Cycling Infrastructure and Safety
Paper Number 13-0164
Paper Title Evaluation of Impacts of Share the Road Sign on Driver Behavior Near Bicyclists
Abstract The interaction of motorists and bicyclists, particularly during passing maneuvers, is an area of concern to the bicycle safety community as there is a general perception that motor vehicle drivers often do not share the road effectively with bicyclists. One potential countermeasure to address this concern is the use of a bicycle warning sign with a “Share the Road” plaque. This paper presents the results of a controlled field evaluation of this treatment, which involved an examination of driver behavior while passing bicyclists. A series of field studies were conducted concurrently on two segments of a high-speed, rural two-lane highway. These segments were similar in terms of roadway geometry, traffic volumes, and other relevant factors, except that one segment included centerline rumble strips while the other did not. A before-and-after study design was utilized to examine changes in motor vehicle lateral placement as they relate to the presence of the sign treatment. The signs were found to reduce the proportion of motor vehicles that passed bicyclists in the central lane position, providing evidence that the sign is effective in shifting motor vehicles away from the right edge of the travel lane. However, the sign treatment did not significantly affect the physical buffer distance between the bicyclists and passing motorists or the proportion of motor vehicles that crowded bicyclists as they passed. Vehicle type, bicyclist position, and the presence of centerline rumble strips or opposing traffic were also found to affect lateral placement during passing maneuvers.

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Sponsoring Committee ANB40, Traffic Law Enforcement
Session Number 652
Session Title Automated Enforcement Evaluation, Application, and Effects on Highway Safety and Driver Behavior
Paper Number 13-2554
Paper Title Impacts of Speed Cameras on Road Accidents: Application of Propensity Score-Matching Methods
Abstract This paper aims to evaluate the impacts of speed limit enforcement cameras on reducing road accidents in the UK. The propensity score matching (PSM) method is employed to control for selection bias and selecting proper reference groups. A naive before and after approach and the empirical Bayes (EB) method are compared with the PSM method. We observe 771 sites and 4787 sites for the treatment and the potential reference groups respectively for a period of 9 years. Both the PSM and the EB methods show similar results that there are significant reductions in accidents number at all severities at speed camera sites. It is suggested that the propensity score can be used as the criteria for selecting the reference group in before-after control studies.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4869
Paper Title Fully Bayesian Before-After Evaluation of Traffic Safety Improvements in the City of Edmonton, Canada
Abstract The objective of this study is to evaluate the safety performance of a sample of intersections that have been improved with the implementation of certain safety countermeasures targeting right-turn (RT) collisions in the City of Edmonton. A full Bayes approach is utilized to determine the effectiveness of the improvements using a before-after design with matched (yoked) comparison groups. Three linear intervention models were considered: a multivariate model which modeled treatment effects as a gradual change, a similar model but with the addition of a jump treatment effect, and a univariate model analyzing specifically right-turn collisions. The results indicate that the safety improvement program was effective, reducing up to 40% of right-turn collisions. Despite the small sample size, these reductions were statistically significant. The results show the usefulness of the FB technique in performing before and after evaluations of traffic treatment programs, absolving the need of a reference population and also allowing for far more different types of analysis, including multivariate analysis (modelling collisions of different types and severities at the same time), temporal effects (for both treatment and long term trends), and greater freedom in selection of error structure.

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Sponsoring Committee AHB65, Operational Effects of Geometrics
Session Number 253
Session Title Design Features That Affect Speed and Safety
Paper Number 13-4106
Paper Title Evaluation of Safety Performance of Passing-Relief Lanes
Abstract This paper documents the evaluation of the safety performance of passing relief lanes using data from the State of Michigan. The study was based on volume and crash history data for 7 sites where passing lanes were implemented within the study period and for 100 reference sites (without passing lanes) and 231 passing lanes sites that existed throughout the study period. The analysis involved an empirical Bayes before-after evaluation and a comparative, cross-sectional evaluation of safety performance of locations with and without passing lanes. The methodologies were also applied to adjacent non-treated sites one mile upstream and downstream of the passing relief lane segment to examine possible migration or spillover effects. Based on the results, Crash Modification Factors (CMFs) were established for passing lanes in Michigan. These CMFs, which indicated significant safety benefits of passing relief lanes, may be considered for use in locations in other jurisdictions, given that there is precious little information in this regard. The results from the cross-sectional and before-and-after evaluations were generally consistent.

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Sponsoring Committee ANB75, Roundabouts
Session Number 542
Session Title All You Wanted to Know About Roundabouts: Capacity, Safety, Trucks, and Modeling
Paper Number 13-2060
Paper Title Evaluation of Roundabout Safety
Abstract While roundabouts are still fairly new in the U.S. and Wisconsin, their safety benefits have been studied with varied results. In this study, 24 roundabouts built in 2007 or before were analyzed for their safety performance. Three years of before and after crash data were gathered as well as geometric and traffic volume data. An empirical Bayes (EB) analysis was used to examine the safety benefits for total crashes and injury (K, A, B, C) crashes. The EB analysis was performed using the Safety Performance Functions (SPFs) from the Highway Safety Manual (HSM). Mixed results were found for total crash frequency but a significant decrease in crash severity was identified. Wisconsin roundabouts had an unbiased estimate of a 9.2 percent decrease in total crashes. National numbers similarly show decreases in total crashes. Wisconsin roundabouts showed a significant 52 percent decrease in injury crashes. Roundabouts nationwide are also experiencing a significant decrease in severe crashes. When evaluating predictors, the speed limit of the approaches did not show a significant impact on the safety of the roundabout. While multi-lane roundabouts seemed to be safer than single lane roundabouts when considering combined injury crashes, single lane roundabouts saw the largest decrease in total crashes. Two-way stop controlled (TWSC) intersection conversion to a roundabout had the highest safety benefit as compared to all-way stop controlled (AWSC) and signalized intersections.

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Sponsoring Committee ANB75, Roundabouts
Session Number 626
Session Title Roundabouts: Smarter Intersections
Paper Number 13-4568
Paper Title Effect of Signs and Striping on Roundabout Safety: Observational Before-and-After Study
Abstract This paper presents the study of the impact on driving behavior changes made to striping and signing at a two-lane roundabout located Richfield, Minnesota. After its completion, this roundabout exhibited an abnormal amount of crashes. In response to this, local engineers experimented with changes in the roundabout's signs and striping, as roundabout design regulations are relatively lax and non-specific in contrast to ones for standard signalized intersections. An observational study was conducted that reduced 156 hours of before and after video records of the roundabout into a database of all the violations committed by drivers. Along with the observational data, crash report records were analyzed and demonstrated that improper turns and failing to properly yield account for the majority of collisions. The changes implemented in the approaches to the roundabout and specifically the extension of the solid line reinforced the message to the drivers that they must select the correct lane before approaching the roundabout entrance. Although choosing the correct lane does not directly address yielding violations, it does reduce the occurrence of drivers conducting an improper turn, and to some extent reduces the need for a driver to change lanes within the roundabout. The implemented changes produced a reduction of 55% in per capita occurrences of improper turns, and a 59% per capita reduction of drivers choosing the incorrect lane.

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Sponsoring Committee ANF20, Bicycle Transportation
Session Number 494
Session Title Cycling Infrastructure and Safety
Paper Number 13-2507
Paper Title Operational Analysis of "Sharrows" on Roadways with Narrow Lane Widths
Abstract Sharrows are intended to encourage shared use of a facility for both bicycles and motor vehicles, as well as identify the appropriate placement for bicyclists within the roadway. This paper analyzes the influence of several site characteristics on the operational and safety effects on bicyclists and motorists at two curbed roadway segments in Florida. Three main site variables were studied: lateral separation between vehicles and bicyclists, vehicle encroachments to the adjacent inside lane, and distance from face of curb that bicyclists track. Results suggest that installation of sharrows can increase the lateral vehicle clearance significantly. It was also observed that less restrictive lane changing conditions greatly increase the lateral separation between vehicles and bicyclists. Also, the percentage of vehicles that passed along side bicyclists with little to no encroachment was notably reduced after sharrows were placed, suggesting positive safety effects for bicyclists. Overall, operational effects for bicyclists and motor vehicles were positive with the implementation of sharrows.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-1373
Paper Title Safety Evaluation of Converting Traffic Signals from Incandescent to LED Bulbs
Abstract Data from 282 signalized intersections in Charlotte were used to examine the safety effect of converting the signals to composite light emitting diode (LED) bulbs. An empirical Bayes before-after method was used for the evaluation. Since this was a "blanket" installation by the city of Charlotte, a comparison group of stop controlled intersections were used to account for possible trends during the study period. Crash modification factors were estimated for 3 and 4 leg intersections for 8 different crash types including crashes during dawn, dusk, and dark conditions. For 3 leg intersections, all the CMFs were higher than 1.0 indicating a possible increase in crashes due to LEDs. However, none of these CMFs were statistically different from 1.0 at the 0.05 significance level. For 4 leg intersections, the CMFs associated with rear-end crashes were lower than 1.0 and statistically significant at the 0.05 level, indicating a reduction in these crash types due to the LEDs. There was substantial difference among the sites in terms of the effect of the LEDs. The reasons for these differences are not known at this time. Future research could investigate whether LEDs are more or less beneficial depending on the characteristics of the intersection including type of area, sight distance, traffic volume, and phasing scheme.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-5001
Paper Title Effect of Removing Freeway Mainline Barrier Toll Plazas on Safety
Abstract Toll plaza safety is a critical issue. Toll plazas induce motor vehicle crashes and also put workers such as toll collectors at risk. Therefore, enhancing safety at a toll plaza is crucial to improving safety on tolled roadways. This study aims to evaluate the safety effect of removing mainline barrier toll plazas on highways using Empirical Bayesian (EB) methodology. Recent removals of barrier toll plaza on the Garden State Parkway in New Jersey were used as a case study. Multiple-year traffic and crash data before and after the removals of the barrier toll plazas were used for analysis. Toll plaza crash frequency models as a function of traffic flow and other factors were developed, with the modeling results suggesting that there is a nonlinear relationship between toll plaza crash occurrences and both traffic flow as well as toll booth configurations. The EB approach is also used to predict crash frequency assuming that the barrier toll booths were not removed. These EB-based estimates were compared with the observed number of crashes after the removals of the toll plazas. Individual comparisons show reductions in crash frequency at almost all of the toll plazas and an estimated reduction of 47.2 percent overall at all toll plazas due to the removal of the barrier toll booths. The estimated crash cost was reduced by 43.2 percent. These estimated reductions demonstrate that the removal of barrier toll plazas is a very beneficial step towards improving safety of toll roads.

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Sponsoring Committee ANF20, Bicycle Transportation
Session Number 494
Session Title Cycling Infrastructure and Safety
Paper Number 13-2909
Paper Title Impact of Bicycle Boxes on Safety of Cyclists: Case Study in Montreal, Canada
Abstract This paper presents a methodology to evaluate the effectiveness of a bicycle treatment (bike boxes) at intersections using a before-after surrogate safety analysis based on longitudinal video-data analysis. As a surrogate safety measure, cyclists' red-light violations are quantified for two periods before and two periods after the installation of a bicycle box at a signalized intersection in Montreal. For this purpose several hours of video were collected before and after the installation of the treatment. Based on the video data, red-light violations and potentially associated factors were collected for each cyclist that crossed the intersection, such as sex, age, group size, use of helmet, whether a cyclist stopped before crossing, vehicle-cyclist gap, etc. Violations with a short vehicle-cyclist gap were classified as dangerous (i.e., those situations in which cyclists pass the intersection during the red phase with a small vehicle gap). For the data analysis, a multinomial logit regression technique was used to identify the factors that increase or decrease the probability of cyclist violations as well as their changes over time. Both raw estimates and model estimates show that the presence of a bicycle box has a significant impact on the total number of cyclists' violations; however, the impact on the number of dangerous violations is not clear. More video data from other intersections before and after the treatment implementation is required to validate these preliminary conclusions. Moreover, the video-data generation and surrogate approach proposed here can be applied to the evaluation of other bicycle treatments.

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Sponsoring Committee ANB25, Highway Safety Performance
Session Number 289
Session Title Highway Safety Performance
Paper Number 13-4943
Paper Title Safety-Effectiveness of Various Types of Shoulders on Rural Two-Lane Roads in Winter and Nonwinter Periods
Abstract There has been growing recognition of the quantitative effects of various roadway designs and traffic control strategies on safety. Meanwhile, there is increasing interest in measuring the variances of safety effectiveness in different periods of the year for similar roadway designs or similar traffic control strategies. This study tried to address the variances of safety effectiveness between the winter and non-winter periods for the ten most common shoulder designs in Kansas. Traffic and geometric data were collected on 6,510 miles (10,477 km) of rural two-lane highways in Kansas. A cross-sectional approach was applied to develop winter period safety performance functions (SPFs), non-winter period SPFs and SPFs aggregated at an annual level in which shoulder designs were treated as independent variables. A variance test was conducted based on these SPFs to investigate the variances of safety effectiveness between the two different periods. It was found that wider and upgraded shoulders offer significant less safety benefit in reducing total crash number during winter periods than during non-winter periods. The indexes of safety effectiveness for the winter period are larger than those for the non-winter period by between 13 to 25 percent. However, winter weather appears not to significantly diminish wider and/or upgraded shoulders safety benefit in reducing crash severity and the number of shoulder related crashes. The results demonstrate that treating the winter and non-winter data equally is likely to bias a shoulder's estimated safety effectiveness in total crashes.

7 Papers on surrogate measures of safety

Emerging research methods relate to surrogate measures of safety and their validation through field measurements, computer simulation, and driving simulators.

The Subcommittee identified forty five papers dealing with surrogate measures of safety. These papers are scattered across various sessions and they supplement more traditional approaches to safety analysis.

Traffic conflict continues to be the most widely used surrogate, as appeared in eleven papers (*Berthaume and Knodler; Conway et al.; Habtemichael and Picado-Santos; Peesapati et al.; Pratt et al.; Sayed et al.; St-Aubin et al.; Wang and Stamatiadis; Yang and Cherry; Zaki et al.; Zhang et al.*), while safety indices have been used in only two papers (*Mohamed and Saunier; Kourtellis et al.).* Not necessarily used as surrogate measures, violation and behavior related measures received great attention, as appeared in eighteen papers this year (*Ardeshiri and Jeihani; Bai et al.; Berthaume and Knodler; Chen and Tarko; Deng* et al.; *Dulaski; Greaves and Fifer; Ghods and Saccomanno; Hamaoka et al.; Habtemichael; Haqueet et al.; Job et al.; Khatoon; Kourtellis et al.; Richfield and Hourdos; Supernak et al.; Wang et al.; Zaki et al.; Zangenehpour et al.).*

In terms of data source, image processing seems to be the most popular methods, with fifteen papers using image based data (*Ahmed and Abdel-Aty; Bai et al.; Berthaume and Knodler; Llorca et al.; Guido et al.; Peesapati et al.; Regue and Hernandez; Richfield and Hourdos; Sayed et al.; Supernak et al.; St-Aubin et al.; Wang et al., 13-2395; Zaki et al.; Zangenehpour et al.; Zhang*). Simulation is also very popular, with nine papers using simulation (*Deng et al.; Ghods and Saccomanno; Guido et al.; Habtemichael and Picado-Santos; Haque et al.; Regue and Hernandez; Wang and Stamatiadis;Wojtal and Rilett*). Other methods include survey, which was used by six papers (*Ardeshiri and Jeihani; Job et al.; Kang and Fricker, 13-1677; Kang and Fricker, 13-0164; Kourtellis et al.; Wang et al., 13-2395; Yang and Cherry), loop detector data, which was used by three* papers (*Xu et al., 13-1715; Xu et al., 13-4996; Regue and Hernandez*), GPS data, which was used by two papers (*Greaves and Fifer; Guido et al.*), and finally data from naturalistic driving, which was used by one paper (*Wu and Jovanis*).

The abundant of papers for this year is due to the great attention in some specific areas. Pedestrian and cyclist safety is the most studied area for this year, with nineteen papers (*Bai et al.; Berthaume and Knodler; Conway et al.; Deng* et al.; *Dulaski; Hamaoka et al.; Kang and Fricker, 13-1677; Khatoon; Kourtellis et al.; Salamati et al.; Sando et al.; Sayed et al.; Supernak et al.; Pratt et al.; Wang et al., 13-2395; Yang and Cherry; Zangenehpour et al.; Zaki et al.*). Intersection safety is another hot topic, with six papers identified dealing with motor vehicle crashes (*Haqueet et al.; Li; Peesapati et al.; Wojtal and Rilett; Zhang et al.)* and seven being pedestrian or cyclist related (*Bai et al.; Hamaoka et al.; Pratt et al.; Supernak et al.; Wang et al., 13-2395; Zaki et al.; Zangenehpour et al.*). Signage and control is also a popular topic, attracting nine papers (*Ardeshiri and Jeihani; Ghods and Saccomanno; Deng* et al.; *Habtemichael and Picado-Santos; Kang and Fricker, 13-0164; Li; Richfield and Hourdos; Salamati et al.; Supernak et al.*). As the widespread of roundabout in the U.S., there are five papers in roundabout safety for this year (*Berthaume and Knodler; Richfield and Hourdos; Salamati et al.; St-Aubin et al.*). Following the trend from the last year, the estimation of real time risk has seen six papers this year (*Aron et al.; Ahmed and Abdel-Aty; Mohamed and Saunier; Xu et al., 13-1715; Xu et al., 13-4996; Zhang*). Speed and related topics were studied in seven papers (*Ardeshiri and Jeihani; Chen and Tarko; Dell'Acqua et al.; Ghods and Saccomanno; Greaves and Fifer; Job et al.; St-Aubin et al.; Wojtal and Rilett*).

Finally, five papers carried out before after study (*Greaves and Fifer; Kang and Fricker, 13-0164; Richfield and Hourdos*; *Sando et al.;* Zangenehpour et al.), two paper studied nighttime crash (*Hamaoka et al.; Llorca et al.*), two dealt with crash severity (*Yang and Cherry; Xu et al., 13-1715), and one dealt with trucks (Ghods and Saccomanno*).

Authors	Mohamed M. Ahmed, University of Central Florida Mohamed A. Abdel-Aty, University of Central Florida
Sponsoring Committee	ANB20, Safety Data, Analysis and Evaluation
Session Number	724
Session Title	Safety: Performance, Data, and New Advances, Part 1
Paper Number	13-0410
Paper Title	Application of Stochastic Gradient Boosting Technique to Enhance Reliability of Real-Time Risk Assessment Using Automatic Vehicle Identification and Remote Traffic Microwave Sensor Data
Abstract	This study proposes a recent promising machine learning technique to enhance the reliability of real-time risk assessment on freeways. Stochastic Gradient Boosting (SGB) is utilized to identify hazardous conditions based on traffic data collected from multiple detection systems; automatic vehicle identification (AVI) and remote traffic microwave sensors (RTMS), real-time weather stations and roadway geometry. SGB's key strengths lie in its capability to fit complex nonlinear relationships, handling different types of predictors and accommodating missing values with no need for prior transformation of the predictor variables or elimination of outliers, which is the case of real-time applications. Boosting multiple simple trees together overcomes the drawback of single tree models of poor prediction accuracy and provides fast and superior predictive performance. In this paper, three models were calibrated; full model that is augmenting all available data and another two models to explicitly compare between the prediction performance of traffic data that are collected from different sources (AVI and RTMS) at the same location. The results from the preliminary analysis as well as the calibrated models indicate that crash prediction from AVI is comparably equivalent to RTMS data. Moreover, the full model achieved superior classification accuracy identifying about 89% of crash cases in the validation dataset with only 6.5% false positive rate. Because of the superior classification performance of SGB and its minimal required data preparation, SGB is recommended as a promising technique for real-time risk assessment application

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Sponsoring Committee	ABJ30, Urban Transportation Data and Information Systems - ADB30, Transportation Network Modeling - ABJ35, Highway Traffic Monitoring - AHB15, Intelligent Transportation Systems - AHB65, Operational Effects of Geometrics - ANB10, Transportation Safety Management - ANB20, Safety Data, Analysis and Evaluation -ANB40, Traffic Law Enforcement - ANB20(5), Traffic Speed and Safety - Cross-cutting Issues
Session Number	438
Session Title	Safety: Performance, Data, and New Advances, Part 2
Paper Number	13-5306
Paper Title	Impact of Dynamic Speed Display Sign on Speed Limit Compliance on Multiple Roadway Classes
Abstract	This study investigates the effect of dynamic speed display signs (DSDSs) on drivers' speed-related behavior. A survey questionnaire regarding drivers' attitudes to a DSDS on different road classes was distributed to supplement a wide-range speed data collection upstream and downstream of the DSDS locations on multiple road classes with different speed limits: 25, 35, and 45 mph. Conventional statistical analysis, regression model, and Bayesian network were applied to assess the DSDS's effectiveness with reducing speed and to develop a speed compliance model. To investigate the short-term and long-term effects of the DSDS and the effective distance, speed data was collected in different periods after the installation and further downstream of DSDS locations. The effect of road class, school zone, DSDS size, DSDS operation duration, distance from DSDS, and other ambient conditions on drivers' speed compliance are explored and discussed.

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Sponsoring Committee	ANB20, Safety Data, Analysis and Evaluation
Session Number	725
Session Title	Safety: Performance, Data, and New Advances, Part 2
Paper Number	13-4638
Paper Title	Traffic Indicators and Accidents: Case of Motorway Network in the South of France
Abstract	The purpose of this paper is to study traffic conditions that precede the occurrence of road accidents, and to point out the relation between traffic conditions and accidents. It is to combine traffic variables into indicators; then to constitute different sets of traffic conditions and accidents; and, according to the obtained results, to highlight the variations in the accident risk according to different categories of analysis; and finally to propose to use some indicators in certain contexts in order to predict potential danger, and then warn drivers. Here a traffic database (including individual speeds and headway) is analyzed in relation with the accidents occurred. The proportion of vehicle-kilometers when an accident occurs, in the case of high values of the indicator, has been matched with the same proportion in the case of low values. A tentative to take into account changes in kinematics variables due to local conditions and traffic conditions has been made. The results contribute to validate the link between accident and some indicators, based on occupancy, speed and relative speed.

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Sponsoring Committee ANB75, Roundabouts
Session Number 626
Session Title Roundabouts: Smarter Intersections
Paper Number 13-5255
Paper Title Detailed Driver Behavior Analysis and Trajectory Interpretation at Roundabouts Using Computer Vision Data
Abstract With recent and important upgrades to North American intersection design guides, roundabouts are gaining popularity as a method of reducing road conflicts, streamlining flow, and curbing excessive speeding of busy intersections. The current design approach, however, makes use of spot-mean speed measures and design criteria which do not take into account yielding behaviour and acceleration/deceleration which may be affected by regional driving culture and local roundabout design. This research paper introduces the methodology being developed for the detailed analysis of driving behaviour, trajectory interpretation, and conflict measures in modern North American roundabouts from video data extracted by means of computer vision. The analysis explores the methods used to prepare microscopic speed maps, compiled speed profiles, lane-change counts, and gap time measures. It also introduces and discusses the interpretation of trajectories at the scale of roundabout merge sections instead of looking at safety from the point of view of a roundabout as a unified system. The research finds significant variation in distributions of speed across five case study roundabouts in the province of Québec, Canada which may be explained by regional differences in design and road use. It also reports aggressive gap times and polarised (uneven) traffic flow as a contributing factor to speed.

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-3465
Paper Title Study on Pedestrian Red Light Crossing Violation Behaviors: Observation at Four-Phase Signalized Intersections in Shanghai, China
Abstract Pedestrian violation is a major cause of traffic accidents involving pedestrians. The research objectives were to investigate the relationship between crossing time gap and pedestrian violation and to provide a qualitative and quantitative analysis of the effects of human factors and external environmental factors on red light crossing behavior. Pedestrian red light crossing gap was collected by video cameras and it was assigned as rejected and accepted data to distinguish between normal crossing and violating crossing. Two methods were used to acquire the RLC critical gap. A multiple linear regression model was introduced, and variables revealing personal characteristics, traffic conditions, and trip features were defined as covariates to describe the effects of internal and external factors. The study concluded that Harder¡¯s method is good for getting the RLC critical gap and when time gap is larger than 6.12s violations become more and more. The pedestrian RLC time gap is related with weather, age, group size and violating whether at the beginning of red light time, and it is not related with gender, violation stage and other factors. To improve the safety condition of the intersection well signalized timing and good management are dire in need.

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Sponsoring Committee ANB75, Roundabouts
Session Number 542
Session Title All You Wanted to Know About Roundabouts: Capacity, Safety, Trucks, and Modeling
Paper Number 13-4216
Paper Title Hazardous Bicycle Maneuvers at Single-Lane Roundabouts in Massachusetts: A Conflict and Events Study
Abstract Roundabouts have been known to relieve congestion, reduce travel times, and decrease accident rates. Studies indicate that despite reducing the total crash rate, roundabouts show a significant increase in the proportion of crashes that involve a cyclist. These crashes are primarily due to cyclists who create a bicycle lane through the roundabout. The purpose of this study is to determine if cyclist safety should be of particular concern in roundabouts in Massachusetts, specifically whether or not cyclists and/or vehicles are performing maneuvers outlined in previous studies to be major contributors for cyclist-based crashes. A custom conflict/event and compliance study was designed. Preliminary studies were performed at a roundabout located at the University of Massachusetts, Amherst. Subsequent studies were performed at various roundabout locations throughout Massachusetts. This study recorded all bicycle movements and any observed bicycle/vehicle interactions, tracking specific maneuvers that could create a hazardous or unsafe situation. The number of bicycles that performed unsafe maneuvers was compared to the total number of bicycles observed traversing the roundabout. This study confirms that some cyclists who use the roundabout at the University of Massachusetts Amherst operate in an unsafe manner or in a way defined to be a leading cause of accidents involving a bicycle in a roundabout (32% of all observed cyclists). Similar results were found at other roundabouts throughout Massachusetts (33% of all observed cyclists). Possible solutions were postulated.

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Sponsoring Committee ANB40, Traffic Law Enforcement
Session Number 572
Session Title Traffic Law Enforcement Applications to Enhance Officer Safety, Efficiency, and Highway Safety
Paper Number 13-0927
Paper Title Police Enforcement Strategies and Speed Reduction in Work Zones
Abstract Highway work zone safety is a nationwide concern and it will likely draw ever increasing attention as the number of highways that require renovation or maintenance increases. In an effort to improve work zone safety now and in the future, the Indiana Department of Transportation (INDOT) recently established a special fund for work zone speed enforcement and further commissioned the authors of this study to help them achieve the maximum safety benefits within their budget constraint. A previous study by the authors modeled the crash frequency in Indiana work zones with various features, which provided the potential for safety improvement. In this study, the focus is on evaluating the effectiveness of police enforcement strategies in reducing driving speed in work zones. These results will be eventually included in a comprehensive method for optimizing enforcement strategies and resource allocation to improve work zone safety. Different combinations of stationary police enforcement, with or without supplemental variable message signs (VMS), were evaluated in six work zone sites. The authors conducted data collection using experiment design techniques and multilevel linear modeling for the data analysis with the goal of finding the best way to estimate the effectiveness of enforcement strategies. The developed statistical model allows predicting

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Sponsoring Committee ANF20, Bicycle Transportation
Session Number 494
Session Title Cycling Infrastructure and Safety
Paper Number 13-4545
Paper Title Characteristics of Multimodal Conflicts in Urban On-Street Bicycle Lanes
Abstract In urban areas, bicycles traveling in bicycle lanes encounter a variety of obstructions, including pedestrians and various types of motor vehicles. While previous studies have focused on identifying the frequency of such events, the goal of this study is to characterize these conflicts. In order to evaluate specific characteristics that may influence the frequency of specific conflict types, including bicycle lane designs, curb regulations, and land uses, field data collection was performed in the Manhattan and Brooklyn boroughs of New York City. This paper describes a method for evaluating the frequency of conflicts between bicycles traveling in on-street bicycle lanes and various other transportation modes, and for identifying factors that may impact these frequencies.

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Giovanni Coraggio, Province of Salerno, Italy
Sponsoring Committee AFB30, Low-Volume Roads
Session Number 571
Session Title Systematic Identification of Safety Issues on Low-Volume Roads and Their Relationship to Geometry
Paper Number 13-1946
Paper Title Safety Data Analysis: Case Study of State Highway “Tirrena Inferiore”
Abstract The road safety has become a priority field worldwide and one of the major factors describing the transport system’s state with its positive and negative changes. Many studies on driver speed behaviour are found in the scientific literature, and researchers have addressed roadway alignment consistency for travel safety in context with real operating speeds. This paper illustrates an experimental analysis conducted on the State Highway “Tirrenia Inferiore” in Southern Italy without spiral transition curves between geometric tangent and circular elements on the horizontal alignment, to check a new prediction consistency model. Two consistency measures were developed and compared with the results available in scientific literature: the first was the relative area bounded by the speed profile and the average weighted speed; the second was the standard deviation of operating speeds in each design element along the entire road investigated. Combining these two previous measures and following an extensive sensitivity analysis, a consistency model was developed and thresholds for good, acceptable and poor road consistency can be proposed. The consistency prediction model was related to numbers of crashes occurred from 2003 to 2010. It was found that as design consistency increased, number of crashes decrease significantly. Consistency model can be use for this purpose during the geometric design process or during the evaluation process for two-lane rural highways.

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-3341
Paper Title Pedestrian Crossings at Midblock Locations: Comparative Study of Existing Signal Operations
Abstract The increasing accidents happen at mid-block crossings (MBCs) have led traffic engineers to consider treatments to make crossings safer. One common method is to install signalized MBCs. Until now, there are four mature signal control systems at MBCs that currently used in the U.S. , Great Britain and some other countries which are pedestrian actuated (PA), pedestrian light controlled (PELICAN), high intensity activated crosswalk (HAWK) and pedestrian user-friendly intelligent (PUFFIN). Efficiency evaluation of these methods also has been carried out, however, most of the previous studies based on the hypothesis that pedestrians proceed under green signal, but in reality it is very common to see pedestrians enter crossings during pedestrian clearance interval, which is supposed to weaken the effectiveness and safety at crossings. With a strictly calibrated VISSIM model and SSAM software, the research explores how signalization schemes, pedestrian clearance interval violation rates, traffic flow and geometries affect the efficiency and safety of all road users at MBCs, in order to provide traffic engineers some guidance to select proper methods. Based on a Pearson-correlation analysis and multiple linear regression model, it is found that pedestrian signal violation during clearance interval can slightly reduce pedestrian delay, but results in a rapid increase on pedestrian-vehicle conflicts, especially for HAWK. The final results show that PA leads to high delay of both pedestrians and vehicles but less conflicts, PELICAN is beneficial for vehicular traffic by reducing vehicle delay but unbeneficial for pedestrian traffic since pedestrian delay is always high. HAWK and PUFFIN are better than the above two methods from balancing safety and efficiency for all road users. HAWK has a satisfactory performance at low pedestrian flow but it attributes to more conflicts when pedestrian flow increase up to “middle” and “many”, especially when pedestrian clearance interval violation rate is high. However, PUFFIN has a better performance than HAWK from both perspectives when pedestrian volume is “middle” and “many” .

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-2975
Paper Title Stepping off the Curb to Increase Drivers’ Yielding Behavior at Midblock Crosswalks
Abstract Interaction between pedestrians and drivers can be witnessed everywhere in the road network, particularly at intersections and mid-block crossings. At unsignalized mid-block crosswalks, drivers typically don’t expect pedestrians, and as a result, pedestrian safety may be compromised. The yielding behavior is affected by various aspects of the roadway and driving environment, including vehicle dynamics, pedestrian’s behavior, roadway function and design. Traditional roadway design indicates that if a driver has adequate sight distance to the crosswalk, then he or she should stop for the pedestrian. This paper focuses on two discrete crossing behaviors - pedestrians standing on the curb; and the other was that pedestrians had stepped off the curb. The data were collected in Boston, MA during the AM and PM peak on a typical weekday. The results show that fewer drivers yielded to pedestrians who were standing on the curb, versus those that were standing in the crosswalk (8.5% of the drivers yielded to pedestrians on the curb and 21.7% yielded when pedestrians had stepped off the curb). Regardless of pedestrian location, more drivers yielded the right of way during the AM peak as compared to the PM peak.

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Sponsoring Committee ABJ30, Urban Transportation Data and Information Systems - ADB30, Transportation Network Modeling - ABJ35, Highway Traffic Monitoring - AHB15, Intelligent Transportation Systems - AHB65, Operational Effects of Geometrics - ANB10, Transportation Safety Management - ANB20, Safety Data, Analysis and Evaluation -ANB40, Traffic Law Enforcement - ANB20(5), Traffic Speed and Safety - Cross-cutting Issues
Session Number 438
Session Title Speed Data Needs and Methodologies
Paper Number 13-2329
Paper Title Safety Implications of Truck and Car Speed Limits for Two-Lane Highway Operations
Abstract The safety implications of car-truck speed limits have not been adequately researched, and this has been especially true for two-lane highways. On two-lane highways speed controls can have a significant effect on rear-end and head-on vehicle interactions. This paper uses simulation to assess the effect on safety of different speed control strategies applied to two-lane highway operations. Two different types of speed control strategies are considered: uniform speed limit (USL) and car-truck differential, which is introduced in two different ways: discretionary differential car and truck posted speed limits (DSL) and mandated truck speed limiters (MSL). Safety implications are considered using three overtaking-related indicators: Number of vehicles overtaking (NOT), 2) Percentage time spent in “desire to overtake mode” (PTDO), and 3) Average Time-to-Collision (TTC) with the on-coming vehicle prior to returning back to the original lane. Vehicle interactions affecting safety are estimated through the application of a calibrated microscopic traffic simulation model to a 6Km straight segment of two-lane highway with zero and -3% grade. Differential speed strategies (DSL and MSL) were observed to have a slight increase in the total number and rate of overtaking maneuver in comparison to the uniform control strategy (USL). DSL strategies significantly increased the number and rate of car-truck overtakes over the range of volumes considered in the simulation, suggesting a negative effect on safety. At the same time the number of car-car overtakes were reduced suggesting a positive effect on safety. No considerable effects were observed concerning differential speed control strategies and average TTC and PTDO for the studied cases. The number of overtakes were found to be higher on the level segment than the downgrade segment for the control strategy; although, not very significant for MSL. Car-Car and Car-Truck overtakes appeared to be consistently higher in level section than the grade section; however, this was opposite where the MSL strategy was considered.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-1128
Paper Title Exploring Behavioral Responses of Motorists to Risk-Based Charging Mechanisms
Abstract This paper reports on the behavioural response of motorists to a variable rate charging scheme designed to encourage safer driving practices and reduce exposure to crash-risk – specifically kilometres driven, night-time driving and speeding. The study involved a five-week 'before' period of GPS monitoring to establish how motorists drove normally, followed by a five-week 'after' period of GPS monitoring in which charges were levied and changes assessed. Incentives were paid to motorists for the difference in the charges between the two five-week periods. Vehicle kilometres travelled (VKT) were reduced by ten percent, although the sample was evenly split by those increasing VKT compared to those decreasing VKT. The proportion of distance speeding fell by 4.7 percent, which when coupled with decreases in VKT, implied a net reduction of kilometres spent speeding of over 40 percent. Three-quarters of the sample reduced their speeding. Exit interviews with a cross-section of participants highlighted the practical difficulties of reducing kilometres, but (more encouragingly) reinforced the potential to reduce speeding.

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Alessandro Vitale, University of Calabria, Italy
Frank Saccomanno, University of Waterloo, Canada
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Sponsoring Committee ABJ30, Urban Transportation Data and Information Systems - ABJ35, Highway Traffic Monitoring
Session Number 353
Session Title New Approaches to Vehicle Detection and Classification
Paper Number 13-2475
Paper Title Evaluating Accuracy of New Algorithm for Extracting Vehicle Tracking Data from Videotaping
Abstract A methodology for tracking moving vehicles is presented that overcomes many of the practical limitations of current video taping applications many resulting from traffic and site conditions for the road segment being video-taped. The algorithm presented in this paper provides a sound inexpensive procedure for extracting vehicle tracking data with minimum video taping restrictions. This is achieved through a comprehensive filtering of videotaped images, removal of background distortions, reduced impact of image occlusion, identification and construction of blobs from pixel features, and an accurate link to fixed representative reference points inside of the video frame (Ground Control Points or GCP). The tracking algorithm has been applied to a sample of video-taped vehicle trajectories with parallel GPS geo-referenced information to investigated the effect of placement of GCP and video camera angle on error in vehicle tracking. The number of GCP and the deflection angle from the perpendicular camera sightline to the roadway have a significant effect on the accuracy of the detected vehicle trajectories. Slightly higher errors were noted for a small number of GCP. Accuracy in the tracking algorithm is important for the calibration and validation of microscopic traffic simulation models.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 438
Session Title Speed Data Needs and Methodologies
Paper Number 13-0138
Paper Title Safety and Operational Benefits of Variable Speed Limit Under Different Traffic Conditions and Driver Compliance Levels
Abstract Control of traffic by Variable Speed Limit (VSL) has been researched for a long time but there is lack of consensus on the safety and operational benefits of VSL and on the impact of driver compliance. The objective of this paper is to provide quantitative evaluations of these benefits and show the importance of driver compliance to VSL which ultimately narrows down the lack of consensus. Combination of VISSIM and Surrogate Safety Assessment Model (SSAM) was used in the study. SSAM analyzes the trajectories of simulated vehicles and detect possible conflicts along their journey. To support the safety analysis of this study, an attempt was done to correlate the simulated vehicle conflicts with historic crashes. Three scenarios of traffic conditions were considered, namely: 1) heavily congested, 2) lightly congested, and 3) non-congested. Each scenario is further examined under four driver compliance levels, including: 1) low compliance, 2) medium compliance, 3) high compliance, and 4) very high compliance. The results confirmed that VSL has safety and operational benefits on motorway traffic. VSL has the highest safety benefits during highly congested traffic conditions followed by lightly congested and least during non-congested conditions. Moreover, the system has the highest operational benefits during lightly congested traffic conditions, little during non-congested and no benefit during heavily congested conditions. It was also found that the safety benefits of VSL are not at the expenses of increase in travel time. However, these benefits showed significant variations depending on the level of compliance to the system. The study concludes that the success of VSL is highly dependent on the level of driver compliance.

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-2793
Paper Title Study on Confirmation by Pedestrians of Approaching Right- or Left-Turning Vehicle While Crossing at Crosswalk
Abstract In this study head-turning behavior is analyzed to understand where is the best location for the pedestrian to confirm the approaching vehicle in crossing the crosswalk. From the result of the head-turning frequency, it is found that head-turning frequency is increasing towards the entry of the crosswalk and the conflict point. Moreover, results by the analysis of different attributes, head-turning frequency at nighttime or of the elderly person tends to be low; and head-turning was performed more at the conflict point. These results might show that there is a need to provide the information about approaching vehicle. In the pattern that vehicle approaches behind the research participants, head-turning frequency is low; and this imply the need of information for the pedestrians. By the result of the comparison with the different experiment settings, it is found that the position where pedestrian just enter the crosswalk is the best location to confirm the approaching vehicle in the 3 kinds of cases, such as elderly person (having difficulty in crossing), nighttime (restricted visibility), wearing headphones (restricted hearing sense). Moreover, many head-turning behavior were performed at the middle of crosswalk in the case that start position of research participant is R and right-turning vehicle is approaching, and this could be an appropriate confirming action. From the result described above, there exist many critical locations for the crossing pedestrian to confirm the approaching vehicle in a safe manner.

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Sponsoring Committee AND10, Vehicle User Characteristics
Session Number 544
Session Title Human Factors Issues in Roadway Design and Traffic Operations
Paper Number 13-1710
Paper Title Examination of Distracted Driving and Yellow Light-Running: Analysis of Simulator Data
Abstract Driving on an approach to a signalized intersection while distracted is particularly dangerous, as potential vehicular conflicts and resulting angle collisions tend to be severe. Given the prevalence and importance of this particular scenario, the decisions and actions of distracted drivers during the onset of yellow lights are the focus of this study. Driving simulator data were obtained from a sample of 58 drivers under baseline and handheld mobile phone conditions at the University of Iowa - National Advanced Driving Simulator. Explanatory variables included age, gender, cell phone use, distance to stop-line, and speed. Although there is extensive research on drivers' responses to yellow traffic signals, the examination has been conducted from a traditional regression-based approach, which does not necessary provide the underlying relations and patterns among the sampled data. In this paper, we exploit the benefits of both classical statistical inference and data mining techniques to identify the a priori relationships among main effects, non-linearities, and interaction effects. Results suggest that novice (16-17 years) and young drivers' (18-25 years) have heightened yellow light running risk while distracted by a cell phone conversation. Driver experience captured by age has a multiplicative effect with distraction, making the combined effect of being inexperienced and distracted particularly risky. Overall, distracted drivers across most tested groups tend to reduce the propensity of yellow light running as the distance to stop line increases, exhibiting risk compensation on a critical driving situation.

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Sponsoring Committee ABJ30, Urban Transportation Data and Information Systems - ADB30, Transportation Network Modeling ()
ABJ35, Highway Traffic Monitoring - AHB15, Intelligent Transportation Systems - AHB65
Operational Effects of Geometrics - ANB10 Transportation Safety Management - ANB20, Safety Data, Analysis and Evaluation - ANB40, Traffic Law Enforcement - ANB20(5), Traffic Speed and Safety - Cross-cutting Issues
Session Number 438
Session Title Speed Data Needs and Methodologies
Paper Number 13-5247
Paper Title Community Perceptions and Beliefs Regarding Low level Speeding and Suggested Solutions
Abstract Speeding is the single largest behavioural contributor to road traffic deaths and injuries in Australia and the developed world, and the management of speed is critical to the success of the safe systems approach. Analyses of the contribution of various levels of speeding to the death and serious injury are reviewed, demonstrating that low level speeding (within 10km/h of the speed limit) is a major contributor to death and injury. However, speeding, especially low level speeding, remains socially acceptable and commonly practiced by most Australians and is broadly accepted and practiced by drivers throughout the world. This paper reviews evidence of attitudes and beliefs which engender low level speeding from surveys and social media, to suggest policy revisions which may help address this behaviour and its social acceptability, including low tolerances on speed enforcement, escalating penalties for repeat offending as occurs with drink-driving (driving with an alcohol level above the legal limit), and penalties more aligned with real risks compared with other risky behaviours. These policies not only directly address low level speeding through deterrence, but also send messages which counter currently held unhelpful beliefs. Additional messages on the accuracy of speedometers and speed detection devices, and the costs of low level speeding to the community, may also be helpful.

Authors Lei Kang, Purdue University
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Sponsoring Committee ANF20, Bicycle Transportation
Session Number 494
Session Title Cycling Infrastructure and Safety
Paper Number 13-1677
Paper Title Bicycle Route Choice Model That Incorporates Distance and Perceived Risk
Abstract In this study, we have developed a procedure to estimate bicycle link cost function parameters for use in a bicycle route choice model. A practical estimation procedure was established by formulating a bi-level optimization problem. Based on bicycle commuters' revealed preference route choices to a university campus, a linear function with an interaction cost term was found to be the best model specification. Other models that incorporated both distance and risk terms were almost as good. Model forms that used only distance or only risk were clearly inferior, indicating the importance of using both factors. In order to investigate the relative importance of travel distance and risk concern, an elasticity ratio test was conducted. The results indicate that, for our database, travel distance is more important in route choice decisions. However, when perceived risk, as represented by link Bicycle Compatibility Index, reaches high levels, the role of the risk factor in bicycle route choice becomes almost as important as the distance factor. Bicyclists are then more likely to trade off increased distance for decreased perceived risk. The bi-level optimization method described in this paper provides a practical way to approximate bicyclist route choice behavior using a simple measure (distance) and the well-recognized Bicycle Compatibility Index. The resulting model can guide investments in bicycle facilities.

Authors Lei Kang, Purdue University
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Sponsoring Committee ANF20, Bicycle Transportation
Session Number 494
Session Title Cycling Infrastructure and Safety
Paper Number 13-0164
Paper Title Evaluation of Impacts of Share the Road Sign on Driver Behavior Near Bicyclists
Abstract The interaction of motorists and bicyclists, particularly during passing maneuvers, is an area of concern to the bicycle safety community as there is a general perception that motor vehicle drivers often do not share the road effectively with bicyclists. One potential countermeasure to address this concern is the use of a bicycle warning sign with a "Share the Road" plaque. This paper presents the results of a controlled field evaluation of this treatment, which involved an examination of driver behavior while passing bicyclists. A series of field studies were conducted concurrently on two segments of a high-speed, rural two-lane highway. These segments were similar in terms of roadway geometry, traffic volumes, and other relevant factors, except that one segment included centerline rumble strips while the other did not. A before-and-after study design was utilized to examine changes in motor vehicle lateral placement as they relate to the presence of the sign treatment. The signs were found to reduce the proportion of motor vehicles that passed bicyclists in the central lane position, providing evidence that the sign is effective in shifting motor vehicles away from the right edge of the travel lane. However, the sign treatment did not significantly affect the physical buffer distance between the bicyclists and passing motorists or the proportion of motor vehicles that crowded bicyclists as they passed. Vehicle type, bicyclist position, and the presence of centerline rumble strips or opposing traffic were also found to affect lateral placement during passing maneuvers.

Authors Mariya Khatoon, Indian Institute of Technology
Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-4086
Paper Title Modeling of Pedestrian Unsafe Road Crossing Behavior: Comparison at Signalized and Nonsignalized
Abstract Background: Many pedestrians are found to indulge in unsafe road crossing at both the signalized and non-signalized crosswalks. Objective: To study and compare unsafe pedestriansâ€™ crossing behaviour at a signalized and/or a non-signalized crosswalk. Method: F and t tests are performed to observe which crosswalk has the larger mean and variance of the available gap-size in the traffic flow and waiting time of pedestrians. Logistic regression models are fitted to examine the pedestriansâ€™ risk and unsafe road crossing behavior at two crosswalks. Results: Mean and variance of available gap size and waiting time to pedestrian at a signalized cross walk is larger than a non-signalized crosswalk. At a signalized crosswalk, probability of crossing by a pedestrian with the gap size less than the adequate gap size is about 98%; and at a non-signalized crosswalk it is about 95%. At a signalized crosswalk only gap size parameter is significant. However, at a non-signalized crosswalk other predictor parameters (such as gender of the pedestrian, whether alone or in a group, type of the conflicting vehicle and traffic volume) are significant in determining the pedestrian road crossing behavior. The odds of an unsafe road crossing by a pedestrian at a signalized crosswalk is about 1.7 times higher than that at a non-signalized crosswalk. Conclusion: Pedestrians unsafely cross roads when gaps are available within the traffic flow, at both signalized and non-signalized crosswalks. Thus gap size is a significant parameter to determine the pedestriansâ€™ unsafe road crossing behaviour at both crosswalks.

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Sponsoring Committee AFB10, Geometric Design
Session Number 222
Session Title Safety Implications of Highway Geometric Designs
Paper Number 13-0953
Paper Title Observations of Daytime and Nighttime Passing Maneuvers on Two-Lane Rural Road in Spain
Abstract Passing is one of the most complex maneuvers on two-lane rural roads, thus it has important effects on road safety and traffic operation. It is affected by driving behavior, road geometry, traffic volume, traffic composition as well as other external factors. This research was developed to compare passing process under daytime and nighttime conditions. An experimental methodology was designed to collect video data of passing maneuvers at a two-lane rural road segment located in the surroundings of Valencia (Spain). Two methods were used: firstly, external observations with six video cameras of four passing zones; secondly, an instrumented vehicle equipped with video cameras and laser rangefinders, which was drivenove slightly below the operating speed along a longer road segment of the same road in order to be passed by other vehiclesdrivers. A total of 291 maneuvers were observed; up to 20% of them during night. A macroscopic analysis shows that approximately 17% of passes are under nighttime conditions, although passing frequency and passing demand decrease during night. Besides, individual behavior of drivers which pass is different at nighttime compared with daytime. Maneuvers limited by the presence of an opposing vehicle are performed faster at night, even if accepted gaps are longer. In this case, a more difficult perception of distances to opposing vehicles and of their speeds explains the differences. On the other hand, maneuvers limited by sight distance (without a visible opposing vehicle) are slower during night. This matches a traditional hypothesis, which assumed that passing at night is safer since headlights from opposing vehicles anticipate their position before being seen.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4647
Paper Title Motion Prediction Methods for Surrogate Safety Analysis
Abstract The purpose of this paper is to study traffic conditions that precede the occurrence of road accidents, and to point out the relation between traffic conditions and accidents. It is to combine traffic variables into indicators; then to constitute different sets of traffic conditions and accidents; and, according to the obtained results, to highlight the variations in the accident risk according to different categories of analysis; and finally to propose to use some indicators in certain contexts in order to predict potential danger, and then warn drivers. Here a traffic database (including individual speeds and headway) is analyzed in relation with the accidents occurred. The proportion of vehicle-kilometers when an accident occurs, in the case of high values of the indicator, has been matched with the same proportion in the case of low values. A tentative to take into account changes in kinematics variables due to local conditions and traffic conditions has been made. The results contribute to validate the link between accident and some indicators, based on occupancy, speed and relative speed.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-3215
Paper Title Estimating Rear-End Accident Probabilities at Signalized Intersections: Comparison Study of Intersections With and Without Green Signal Countdown Devices
Abstract Rear-end accidents are the most common accident type at signalized intersections, since the diversity of actions taken increases due to signal change. Green signal countdown devices (GSCD), which have been widely installed in Asian countries are thought to have the potential of improving capacity and reducing accidents, but some negative effects on intersection safety have been observed in practice, for example, an increase of rear-end accidents. Based on the field observation and data collection at four adjacent intersections along an arterial in Suzhou, China, in which two are GSCD intersections, a total of 3350 samples of timestamps associated with 557 vehicles have been collected. A microscopic modeling approach has been applied to estimate the rear-end accident probability during phase transition interval. The rear-end accident probability is determined by the probabilities: (1) a leading vehicle makes a ¡°stop¡± decision, which is formulated by using a binary logistic model and (2) the following vehicle fails to stop in the available stopping distance, which is closely related to the critical deceleration used by the leading vehicle. Based on Monte-Carlo simulation results, rear-end probabilities at GSCD intersections and NGSCD intersections have been compared, it shows that the installation of GSCD devices creates a double-edge sword to vehicle safety and the negative effects are thought to be greater. Though GSCD devices can reduce rear-end accident probability for vehicles that have no difficulties to make stop/go decisions when approaching the stop line during phase transition interval, they increase rear-end accident probability for vehicles that stop/go decision is not easy to make. Further, correlation between speeds and rear-end accidents has been investigated, the results reveal that too low speeds are more likely to provoke rear-end accidents at certain sections of the approach lane during phase transition interval. Based on the above research findings, we recommend that GSCD devices should be cautiously installed and too low speed at approach lanes during phase transition interval should be avoided by speed management and traffic education.

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-3370
Paper Title Effect of Left-Turn Operational Mode on Pedestrian Safety: Development of Models and Guidelines
Abstract Pedestrian safety is a growing concern at signalized intersections. Pedestrians crossing a street at an intersection are exposed to interactions with turning vehicles, and these interactions sometimes result in crashes. Conflicts and crashes can be reduced by implementing protected turn phases. However, the inclusion of protected turn phases in a traffic signal cycle typically causes an increase in vehicular delay, which tends to offset the benefit of reduced crashes. Left-turn operational mode (permissive, protected-permissive, or protected) is typically chosen based on vehicular traffic concerns like volumes of left-turning and conflicting through vehicles, lane geometry, and sight distance. Historically, pedestrian safety has not been considered as a factor in selecting left-turn operational mode. Pedestrian safety models have been calibrated using field data. The models allow pedestrian-vehicle conflict frequency and pedestrian compliance with signal indications to be estimated based on volumes and site conditions. These models, along with vehicular delay analysis, form the basis for pedestrian-safety-based guidelines that were developed for choosing left-turn operational mode. The guidelines are based on identifying threshold conditions for which a change in left-turn mode results in a reduction in road-user costs.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-0839
Paper Title Evaluation of Postencroachment Time as a Surrogate for Opposing Left-Turn Crashes
Abstract Highway safety evaluation has traditionally been performed using crash data though this method has limitations in terms of timeliness and efficiency. Previous studies show that the use of surrogate safety data allows for faster evaluation of safety in comparison to the significantly longer time horizon required for collecting crash data. However, the predictive capability of surrogate measures is still an area of ongoing research. Previous studies have often resulted in inconsistent findings for the relationship between surrogates and crashes, one of the primary reasons being inconsistent definitions of a conflict. This study evaluates the effectiveness of Post Encroachment Time (PET) as a surrogate measure for evaluating the propensity of crashes between left-turning vehicles and opposing through vehicles at 4-legged signalized intersections. The primary method of data collection is through video recording with post-processing using custom semi-automatic video processing software to reduce the video to a useable format ready for analysis. The study evaluates the effectiveness of PET as a surrogate measure by comparing three variations of PET measures with crash history. This comparison shows that a threshold value of PET plays an important role in establishing its correlation with crashes with the best results at a threshold as low as one second.

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Sponsoring Committee AFB10, Geometric Design
Session Number 222
Session Title Safety Implications of Highway Geometric Designs
Paper Number 13-2097
Paper Title Safety Impacts of Increasing Lengths of Left-Turn Lanes
Abstract Left-turn lanes can improve the safety and operation of intersections by providing space for deceleration and storage of turning vehicles. The length of the lane is critical in the design of left-turn lanes. Insufficient length may result in left-turn lane overflow which seriously impacts the safety of the intersection. The objective of this research is to determine the safety impacts of increasing storage lengths of the left-turn lanes. To achieve the objective of this research, field study was conducted at the intersections with different geometric, signal timing, and traffic flow conditions. Two approaches were employed to determine the safety benefits of increased storage lengths of left-turn lanes: 1) accident data analysis, and 2) simulation-based safety analysis. The research concludes that extending the length of left-turn lane to eliminate the left-turn lane overflow problem can significantly reduce the risk of rear-end accidents.

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Sponsoring Committee ABJ30, Urban Transportation Data and Information Systems - ABJ35, Highway Traffic Monitoring
Session Number 353
Session Title New Approaches to Vehicle Detection and Classification
Paper Number 13-3911
Paper Title Using Signature-Based Vehicle Reidentification to Measure Lane-Changing Maneuvers
Abstract This paper provides insight to lane change maneuver data by employing a real-time vehicle re-identification and classification system capable of producing individual vehicle matches and classes based on inductive signatures during congested and uncongested conditions. Vehicle re-identification results for a 0.66 mile multilane freeway segment are compared to manually matched vehicle pairs from video data. Examination of lane change probabilities show that re-identification is capable of reproducing lane change maneuvers with minimal error (root mean square error = 0.0162 and correlation coefficient= 0.927). Differences in lane change probability by level-of-service (LOS), vehicle class, and segment type are also examined. Results show that there is variability in lane change probability by LOS and vehicle class. Although other studies have quantified lane change behavior using vehicle re-identification, none has been successful in obtaining measures during congestion and for separate vehicle classes. Not only would the information gathered from this research be useful in calibrating microsimulation models but also could be used as the basis of real-time traffic calming strategies designed to reduce lane changing at the onset of congestion. In addition to an evaluation of merging behavior using re-identification, improvements to the current re-identification methodology based on lane changing to increase correct classification rates are proposed.

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Sponsoring Committee ANB75, Roundabouts
Session Number 626
Session Title Roundabouts: Smarter Intersections
Paper Number 13-4568
Paper Title Effect of Signs and Striping on Roundabout Safety: Observational Before-and-After Study
Abstract This paper presents the study of the impact on driving behavior changes made to striping and signing at a two-lane roundabout located Richfield, Minnesota. After its completion, this roundabout exhibited an abnormal amount of crashes. In response to this, local engineers experimented with changes in the roundabout's signs and striping, as roundabout design regulations are relatively lax and non-specific in contrast to ones for standard signalized intersections. An observational study was conducted that reduced 156 hours of before and after video records of the roundabout into a database of all the violations committed by drivers. Along with the observational data, crash report records were analyzed and demonstrated that improper turns and failing to properly yield account for the majority of collisions. The changes implemented in the approaches to the roundabout and specifically the extension of the solid line reinforced the message to the drivers that they must select the correct lane before approaching the roundabout entrance. Although choosing the correct lane does not directly address yielding violations, it does reduce the occurrence of drivers conducting an improper turn, and to some extent reduces the need for a driver to change lanes within the roundabout. The implemented changes produced a reduction of 55% in per capita occurrences of improper turns, and a 59% per capita reduction of drivers choosing the incorrect lane.

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Sponsoring Committee ANB75, Roundabouts
Session Number 542
Session Title All You Wanted to Know About Roundabouts: Capacity, Safety, Trucks, and Modeling
Paper Number 13-0419
Paper Title Event-Based Modeling of Driver Yielding Behavior to Pedestrians at Two-Lane Roundabout Approaches
Abstract Unlike other types of controlled intersections, drivers do not always comply with the "yield to pedestrian" sign at the roundabouts. This paper aims to identify the contributing factors affecting the likelihood of driver yielding to pedestrians at two-lane roundabouts. It further models the likelihood of driver yielding based on these factors using logistic regression. The models have been applied to 1150 controlled pedestrian crossings at entry and exit legs of two-lane approaches of six roundabouts across the country. The logistic regression models developed support prior research that the likelihood of driver yielding at the entry leg of roundabouts is higher than at the exit. Drivers tend to yield to pedestrians carrying a white cane more often than to sighted pedestrians. Driver traveling in the far lane, relative to pedestrian location, have a lower probability of yielding to a pedestrian. As the speed increases the probability of driver yielding decreases. At the exit leg of the roundabout driver turning right from the adjacent lane have a lower propensity of yielding than drivers coming from other directions. The findings of this paper further suggest that although there has been much debate on pedestrian right-of-way laws and distinction between pedestrian waiting positions (in the street versus at the curb), this factor does not have a significant impact on driver yielding rate. The regression models also quantify the effect of each of these factors on propensity of driver yielding. The models include variables which are specific to each study location and explain the impact size of each study location on probability of yielding. The models generated in this research will be useful to transportation professionals and researchers interested in understanding the factors impact driver yielding at modern roundabouts. The results of the research can be used to isolate factors that may increase yielding (such as lower roundabout design speed), and can feasibly be incorporate into microsimulation algorithms to model driver yielding at roundabouts.

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Sponsoring Committee	ANF20, Bicycle Transportation
Session Number	494
Session Title	Cycling Infrastructure and Safety
Paper Number	13-2507
Paper Title	Operational Analysis of "Sharrows" on Roadways with Narrow Lane Widths
Abstract	Sharrows are intended to encourage shared use of a facility for both bicycles and motor vehicles, as well as indentify the appropriate placement for bicyclists within the roadway. This paper analyzes the influence of several site characteristics on the operational and safety effects on bicyclists and motorists at two curbed roadway segments in Florida. Three main site variables were studied: lateral separation between vehicles and bicyclists, vehicle encroachments to the adjacent inside lane, and distance from face of curb that bicyclists track. Results suggest that installation of sharrows can increase the lateral vehicle clearance significantly. It was also observed that less restrictive lane changing conditions greatly increase the lateral separation between vehicles and bicyclists. Also, the percentage of vehicles that passed along side bicyclists with little to no encroachment was notably reduced after sharrows were placed, suggesting positive safety effects for bicyclists. Overall, operational effects for bicyclists and motor vehicles were positive with the implementation of sharrows.

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Sponsoring Committee	ANF20, Bicycle Transportation
Session Number	494
Session Title	Cycling Infrastructure and Safety
Paper Number	13-0744
Paper Title	Novel Approach for Diagnosing Cycling Safety Issues Using Automated Computer Vision Techniques
Abstract	The use of traffic conflicts for safety diagnosis has been gaining acceptance as a surrogate for collision data analysis as they provide insight into the failure mechanism that leads to road collisions. This paper demonstrates an automated proactive safety diagnosis approach for cycling safety using video-based computer vision techniques. Traffic conflicts are automatically detected and conflict indicators such as Time to collision (TTC) are calculated based on the analysis of the road-user positions in space and time. Additionally, non-conformance of vehicles to travel regulations; specified as failure to respect yielding signage at the intersection are identified. The procedure is applied for the safety analysis of a newly installed bike lane at the southern approach of a major Bridge (Burrard Bridge) in Vancouver, British Columbia. The results showed a high exposure of cyclists to traffic conflicts. Vehicle conflicts at the location were also identified and analyzed. Practical solutions to address the safety issues at the location were presented. The proposed approach overcomes shortcomings with reliance on collision data and the manual observations of traffic conflicts.

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Sponsoring Committee	ANF10, Pedestrians
Session Number	669
Session Title	Pedestrian Design, Safety, and Behavior
Paper Number	13-4970
Paper Title	Performance of Pedestrian Countdown Signal System in San Diego: Microscopic
Abstract	Results of monitoring of the San Diego's first countdown pedestrian signal (CPS) implementation are reported in this paper. A busy downtown intersection was videotaped over three weeks in order to analyze details of intersection crossing of over 5,000 pedestrians as well as to monitor corresponding vehicular traffic and traffic signal indicators. Several pedestrian categories were introduced, and their entry and exit violations were analyzed. Several factors potentially affecting pedestrian crossing behavior were examined. A multivariate analysis found the length of the crossing and vehicular traffic intensity as significant factors affecting the crossing violation rates. Crossing violation characteristics were consistent over time. On a long crossing, most pedestrians were able to effectively adjust their walking speed to complete their crossing without the exit violation, a positive result attributed to the existence of the CPS there. However, on the short crossing with light vehicular traffic, CPS was generally ineffective in preventing the entry violations from becoming exit violations.

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Sponsoring Committee	ANF10, Pedestrians
Session Number	669
Session Title	Pedestrian Design, Safety, and Behavior
Paper Number	13-2395
Paper Title	Analysis of Knowledge of Crossing Rules, Self-Reported Behavior, and Observed Behavior at Intersections
Abstract	Intersection crossing crashes are a serious problem for children in China and other countries. The objective of the study is to provide a better understanding of the relationships between children¡¯s intersection crossing knowledge and behavior to enable improvements to traffic safety education and to children¡¯s safety as they walk to and from school. We administered a Questionnaire to 225 primary school children aged 6-12 to assess their knowledge of crossing rules, self-reported crossing behavior, and we acquired 2 hours of Video recordings of children¡¯s observed crossing behavior from the same primary school as they crossed a busy intersection. We found there was large discrepancy between observed intersection behavior and knowledge of crossing rules according to gender and differed

depending on whether they crossed with adults, with classmates or alone. Also significant differences existed between observed intersection behavior and the self-reported crossing behavior. One specific gender difference was that girls¡¯ behavior of looking both ways before crossing was better than boys¡¯. We also found that when children crossed intersections alone, their behavior was generally better than when they crossed with classmates or with adults in performing risky behaviors. While we found no significant differences between children¡¯s knowledge of crossing rules and their self-reported crossing behavior. A further observation was that when children were accompanied by adults, we observed the highest frequencies of crossing against the light. However, in spite of these gender differences in behavior, we found no significant gender differences with respect to knowledge of crossing rules. The weakness in the association between intersection crossing knowledge and behavior found in this study suggests that it is not enough to teach children knowledge that describes proper behavior for keeping safe in traffic. Children should also be directly taught the proper behaviors for keeping safe in traffic, preferably in the actual setting where they will be performed. Other countermeasures recommended include educating both children and adults on proper intersection crossing behavior, and emphasizing training for boys to improve their crossing skills. Some ways to implement these recommendations are considered in the discussion of this study¡¯s findings.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-1512
Paper Title A Surrogate Safety Measurefor Simulation-Based Conflict Study
Abstract This paper proposes a surrogate measure named Aggregated Crash Propensity Index (ACPI) for simulation-based conflict studies. A Probabilistic model named Crash Propensity Model (CPM) is developed to determine the crash probability of simulated conflicts, by introducing the distributions of reaction time and maximum braking rates. This CPM is able to generate ACPI for three different types: crossing, rear-end and lane change. A field validation effort is conducted by simulating three major arterials (twelve intersections) in simulation package (VISSIM). Surrogate Safety Assessment Model (SSAM) is utilized to extract useful conflict data as the entry into CPM model to get ACPI. The Spearman rank tests indicate that ACPI is able to identify the relative safety among traffic facilities/treatments. Notably, ACPI outperforms the Highway Safety Manual (HSM) procedures in both correlation and rank tests. Both linear and non-linear regression models are well fitted for ACPI and real crash frequency, suggesting its potential to be directly linked to real crash

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-3208
Paper Title Measuring Unsafe Pedestrian Behavior Using Observational data
Abstract Florida has a severe problem with pedestrian and bicyclist fatalities. Recent trends show that Florida's pedestrian fatality rate is almost double the national average. Traditional safety programs rely on crash data to develop safety campaigns or countermeasures to increase safety. Since crash data are not readily available and a long time has to pass before meaningful data is collected, a "risk score" was developed to measure the behavior of road users at selected sites in Hillsborough and Miami-Dade counties. Surveys were conducted in June-July 2012 in two of the highest pedestrian crash and fatality counties in Florida to collect data and establish baseline conditions. The surveys included opinion surveys of pedestrians and observations of pedestrians and bicyclists, and their interaction with drivers. The locations where the surveys were conducted were selected based on site characteristics including pedestrian treatments or features, crash history, and land use. The two surveys offered insight on the difference between what people know about the law or correct behavior, and what they actually do in reality. Results pinpoint the problems and aid in deciding the focus of safety campaigns and target audience. The risk score showed that the majority of sites exhibited unsafe behavior from pedestrians, bicyclists, and drivers. The risk score has the potential to aid in measuring the effectiveness of a safety campaign launched by FDOT focused on increasing the awareness on traffic laws. This way, appropriate countermeasures or funds can be selected for the higher ranking sites first.

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-3208
Paper Title Development of Statistically Based Methodology for Analyzing Safety Treatments at Isolated High-Speed Signalized Intersections
Abstract Crashes at isolated, rural intersections, particularly those involving vehicles traveling perpendicular to each other, are particularly bad because of high speeds involved. Many transportation agencies are interested in reducing the number of crashes at these types of intersections. There are many engineering treatments to improve the traffic safety at isolated, high-speed signalized intersections. Intuitively, it is critical to know which safety treatment may be the most effective for a given set of selection criteria for a particular intersection. Without a well-defined decision methodology it is almost impossible to decide which safety countermeasure or a set of countermeasures would the best option. Additionally because of the very large number of possible intersection configurations as well as the varying amount, distribution and type of traffic, it would be impossible to develop a set of guidelines that could be used for all signalized intersections. Therefore, it was undertaken to develop a methodology whereby common countermeasures could be modeled and analyzed before being implemented in the field. Because of the dynamic and stochastic nature

of the problem it was decided to employ microsimulation tools, such as VISSIM, for analyzing the countermeasures. A calibrated and validated microsimulation model of signalized intersection was used to model two common safety countermeasures. The methodology was demonstrated on a test site located just outside of Lincoln, Nebraska. The model was calibrated to the distribution of observed speeds collected at the test site. It was shown that the methodology could be used for the preliminary analysis of the safety treatments.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4293
Paper Title Screening Naturalistic Driving Study Data for Safety-critical Events
Abstract This study responds to the need to screen events observed during naturalistic driving studies to derive a set of crashes and near crashes with common etiologies; referred to as well-defined surrogate events. Two factors are critical to the identification of these well- defined surrogate events: selection of screening criteria and the designation of a time window to be used for event search. This paper describes testing conducted using an algorithm developed in a previous paper (Wu and Jovanis, 2012b). The algorithm allows for the use of a range of search criteria to identify events with common etiology from unrefined naturalistic driving data. A range of kinematic search criteria are used to screen events including lateral and longitudinal accelerations averaged over different time windows and characterized by average as well as maximum values during a time window. The testing is conducted using data from road departure events collected during a concluded 100-car naturalistic driving study. A total of 51 non-intersection and 12 intersection-related run-off-road events are included in the testing.
Different sets of events were identified using different search criteria with different time windows. Diagnostic tools borrowed from medicine identify the best screening criteria and time windows. The methods allow for enhanced identification of well-defined surrogates using covariates such as driver attributes context and driver fatigue. The research illustrates a flexible procedure using a variety of statistical methods that are shown to effectively screen crashes and near crashes.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-1715
Paper Title Predicting Freeway Crash Likelihood and Severity with Real-Time Loop Detector Data
Abstract Real-time crash risk prediction using traffic data collected from loop detector stations is useful in dynamic safety management systems aimed at improving traffic safety through application of proactive safety countermeasures. The major drawback of most of the existing studies is that they focus on the crash risk without consideration of crash severity. This paper presents an effort to develop a model that predicts the crash likelihood at different levels of severity with a particular focus on severe crashes. The crash data and traffic data used in this study were collected on the I-880 freeway in California, United States. This study considers three levels of crash severity: fatal/incapacitating injury crashes (KA), non-incapacitating/possible injury crashes (BC), and property-damage-only crashes (PDO). The sequential logit models were developed to link the likelihood of crash occurrences at different severity levels to various traffic flow characteristics derived from detector data. The fitness and prediction capability of the forward and backward versions of the models were compared to select a better alternative. The results show that the sequential structure (forward vs. backward) does not have considerable impact on the modelı¯s fitness and predictive capabilities. More interestingly, the traffic flow characteristics contributing to crash likelihood were quite different at different levels of severity. The PDO crashes were more likely to occur under congested traffic flow conditions with highly variable speed and frequent lane changes, while the KA and BC crashes were more likely to occur under less congested traffic flow conditions. High speed, coupled with a large speed difference between adjacent lanes under uncongested traffic conditions, was found to increase the likelihood of severe crashes (KA). This study applied the 20-fold cross-validation method to estimate the prediction performance of the developed models. The validation results show that the modelı¯s crash prediction performance at each severity level was satisfactory. The findings of this study can be used to predict the probabilities of crash at different severity levels, which is valuable knowledge in the pursuit of reducing the risk of severe crashes through the use of dynamic safety management systems on freeways.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 725
Session Title Safety: Performance, Data, and New Advances, Part 2
Paper Number 13-4996
Paper Title Real-time Identification of Crash-prone Traffic Conditions under Different Weather on Freeways
Abstract Understanding the relationships between traffic flow characteristics and crash risk under adverse weather conditions will help highway agencies develop proactive safety management strategies to improve traffic safety in adverse weather conditions. The primary objective of this study is to develop separate crash risk prediction models for different weather conditions. The crash data and traffic data used in this study were collected on the I-880N freeway in California, United States in 2008 and 2010. This study considers three different weather conditions: clear weather, rainy weather and reduced visibility weather. The preliminary analysis showed that there was some heterogeneity in the risk estimate for traffic flow characteristics by weather conditions, and that the crash risk prediction model for all weather conditions cannot capture the impacts of the traffic flow variables on crash risk under adverse weather conditions.
The Bayesian logistic regressions were applied in this study to link the likelihood of crash occurrence with various traffic flow characteristics under different weather conditions. The model estimation results showed that the traffic flow characteristics contributing to crash risk were found to be different across different weather conditions. The speed difference between upstream and downstream station was found to be significant in each crash risk prediction model. And the large speed difference between upstream and downstream station in reduced visibility weather has the largest impacts on crash risk, followed by that in rainy weather. The ROC curves were further developed to evaluate the prediction performance of the crash risk prediction model under different weather conditions. It was found that the prediction performance of the crash risk model for clear weather was better than that of the crash risk model for adverse weather condtions.

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-4926
Paper Title Conflict Analysis and Crash Severity Estimation of Four Transportation Modes in China
Abstract This study attempts to analyze conflict and estimate the crash severity for users of four transportation modes in China -- automobile, motorcycle, e-bike and bicycle. Surveys were performed in Kunming and Beijing to collect self-reported crash data of these users. The surveys indicated that Beijing residents have lower crash rate than people in Kunming. Among the four modes, E-bike riders have the highest crash rate, motorcycle riders have the second highest crash rate, automobile and bicycle users have the lowest crash rate. Vehicle operators are more likely to crash with other users of the same vehicle class than with other types of vehicles. Respondents are more likely to say the crash is because of other's fault or both side's fault than admitting it is their fault. Logistic regression models were constructed to predict the crash severity level. Results show that crashes involving motorized vehicles generally are more likely to be severe than crashes involving the non-motorized vehicles. Crashes occurring in an automobile lane have higher crash severity than crashes happening in a bicycle lane or sidewalk. Crashes occurring at Beijing are less likely to be severe than crashes in Kunming. Countermeasures should focus on maintaining segregated and protected travel ways for vulnerable road user groups

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Sponsoring Committee ANF10, Pedestrians
Session Number 669
Session Title Pedestrian Design, Safety, and Behavior
Paper Number 13-2889
Paper Title Application of Computer Vision to the Diagnosis of Pedestrian Safety Issues
Abstract This paper demonstrates the potential of using computer vision techniques for solving several shortcomings associated with traditional road safety and behavior analysis. Surrogate data such as traffic conflicts provide invaluable information that can be used to better understand collision contributing factors and the collision failure mechanism. Recent advances in computer vision techniques encouraged the use of proactive safety surrogate measures such as conflicts and violations detections. The objective of this paper is to demonstrate the automated safety diagnosis of pedestrian crossing safety issues using computer vision techniques. The automated safety diagnosis is applied on a major signalized intersection in Downtown Vancouver, British Columbia. Concerns were raised regarding the high conflict rate between vehicles and pedestrians as well as an elevated number of traffic violations (i.e., jaywalking) at the intersection. This study is unique in its attempt to extract conflict indicators and detect violations from video sequences in a fully automated way. This line of research benefits safety experts as it provides a prompt and objective safety evaluation for intersections. It also provides a permanent database for traffic information that can be beneficial for a sound safety diagnosis as well as for developing safety countermeasures.

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Sponsoring Committee ANF20, Bicycle Transportation
Session Number 494
Session Title Cycling Infrastructure and Safety
Paper Number 13-2909
Paper Title Impact of Bicycle Boxes on Safety of Cyclists: Case Study in Montreal, Canada
Abstract This paper presents a methodology to evaluate the effectiveness of a bicycle treatment (bike boxes) at intersections using a before-after surrogate safety analysis based on longitudinal video-data analysis. As a surrogate safety measure, cyclists' red-light violations are quantified for two periods before and two periods after the installation of a bicycle box at a signalized intersection in Montreal. For this purpose several hours of video were collected before and after the installation of the treatment. Based on the video data, red-light violations and potentially associated factors were collected for each cyclist that crossed the intersection, such as sex, age, group size, use of helmet, whether a cyclist stopped before crossing, vehicle-cyclist gap, etc. Violations with a short vehicle-cyclist gap were classified as dangerous (i.e., those situations in which cyclists pass the intersection during the red phase with a small vehicle gap). For the data analysis, a multinomial logit regression technique was used to identify the factors that increase or decrease the probability of cyclist violations as well as their changes over time. Both raw estimates and model estimates show that the presence of a bicycle box has a significant impact on the total number of cyclists' violations; however, the impact on the number of dangerous violations is not clear. More video data from other intersections before and after the treatment implementation is required to validate these preliminary conclusions. Moreover, the video-data generation and surrogate approach proposed here can be applied to the evaluation of other bicycle treatments.

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Sponsoring Committee ANB20, Safety Data, Analysis and Evaluation
Session Number 724
Session Title Safety: Performance, Data, and New Advances, Part 1
Paper Number 13-2427
Paper Title Modeling Frequency of Traffic Conflicts at Signalized Intersections Using Generalized Linear Regression Models
Abstract The primary objective of this study was to identify the potential of using conflict prediction models to predict the frequency of traffic conflicts at signalized intersections. The opposing left-turn conflicts were selected for the development of conflict prediction models. Using data collected at thirty approaches at twenty signalized intersections where the permitted left-turn phases were used, the underlying distributions of the conflict frequency for different volume regimes in different time intervals were examined. It was found that the conflict frequency generally followed a negative binominal distribution. Different conflict prediction models were developed, including a linear regression model, an overall negative binomial model, and separate models developed for four traffic scenarios which were defined based on the volume to capacity ratio of the conflicting traffic flows. The prediction performance of different models was compared. It was found that the linear regression model was not appropriate for modeling the conflict frequency data. In addition, drivers behaved differently under different traffic conditions. Thus, the effects of conflicting traffic volumes on conflict frequency were different in different traffic conditions. The generalized linear regression models developed for different traffic scenarios provided the best estimates for the field measured conflicts.

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Sponsoring Committee AFB30, Low-Volume Roads
Session Number 571
Session Title Systematic Identification of Safety Issues on Low-Volume Roads and Their Relationship to Geometry
Paper Number 13-4724
Paper Title Unmanned Aerial Vehicle-Based Automatic Traffic Incident Detection System for Low-Volume Roads
Abstract Roundabouts have been known to relieve congestion, reduce travel times, and decrease accident rates. Studies indicate that despite reducing the total crash rate, roundabouts show a significant increase in the proportion of crashes that involve a cyclist. These crashes are primarily due to cyclists who create a bicycle lane through the roundabout. The purpose of this study is to determine if cyclist safety should be of particular concern in roundabouts in Massachusetts, specifically whether or not cyclists and/or vehicles are performing maneuvers outlined in previous studies to be major contributors for cyclist-based crashes. A custom conflict/event and compliance study was designed. Preliminary studies were performed at a roundabout located at the University of Massachusetts, Amherst. Subsequent studies were performed at various roundabout locations throughout Massachusetts. This study recorded all bicycle movements and any observed bicycle/vehicle interactions, tracking specific maneuvers that could create a hazardous or unsafe situation. The number of bicycles that performed unsafe maneuvers was compared to the total number of bicycles observed traversing the roundabout. This study confirms that some cyclists who use the roundabout at the University of Massachusetts Amherst operate in an unsafe manner or in a way defined to be a leading cause of accidents involving a bicycle in a roundabout (32% of all observed cyclists). Similar results were found at other roundabouts throughout Massachusetts (33% of all observed cyclists). Possible solutions were postulated.

8 Interacting Committees

A0030T, Special Task Force on Data for Decisions and Performance Measures
The Special Task Force (STF) coordinates the activities of, and facilitates communication among, the TRB standing committees regarding the cross-cutting issues to address the necessary data resources and infrastructure to support decision making and performance measures. The Special Task Force augments, but does not replace, the activities of the TRB standing committees in these areas. The STF reports directly to the TRB Technical Activities Council.

ABJ00, Data and Information Systems
The Data and Information Systems Section is part of the Policy and Organization Group. It consists of 11 committees and one task force that propose research, share research findings, sponsor special activities, and provide a forum for transportation professionals to discuss today's and tomorrow's data and information systems-related transportation issues. The chairs of each of these committees are members of the Data and Information Systems Section Executive Board, who along with the section chair, provide general oversight of the activities within the Section.

ABJ20, Statewide Transportation Data and Information Systems
The scope includes research and technology transfer activities pertaining to statewide transportation planning data and information systems for all modes of transportation. A primary concern is the capability of information systems to integrate various transportation related data sources into a strategic multimodal information database for statewide transportation planning. The committee serves as a forum for discussion of current planning data activities.

ABJ30, Urban Transportation Data and Information Systems
This committee is interested in the design, collection, analysis, and reporting of transportation supply and demand data needed to support urban and metropolitan transportation planning efforts. In particular, the committee is interested in developing the data requirements of new and innovative techniques for measuring and monitoring the performance of metropolitan transportation systems; and in evaluating changes in demographic and urban travel characteristics. In terms of household and other transportation surveys, the committee is concerned with the analysis, reporting, archiving, and dissemination of results and data products. The committee is interested in the effective use of census and other federal, secondary data sources in metropolitan transportation planning. The committee is concerned with advancements in information systems and information technology for the improved dissemination and sharing of knowledge about metropolitan transportation systems and urban travel behavior.

ABJ35, Highway Traffic Monitoring
This committee is concerned with all aspects of research in the fields of highway traffic monitoring, including detection, counting, classification, and in-motion weighing of highway vehicles. Its scope encompasses the full range of monitoring technology, including traffic sensors (both intrusive and non-intrusive), installation materials and techniques, signal processing algorithms, analysis and reporting techniques, and comprehensive monitoring programs. The committee is also concerned with highway monitoring standards to ensure the applicability and quality of traffic data in all its applications.

ABJ80, Statistical Methods
This committee is concerned with the appropriate application of statistical methods in the field of transportation. The committee will serve as a resource on statistical matters for all other TRB

committees or activities; will foster understanding and use of statistics through dissemination and education activities; and will identify and foster research needed in statistics for use in transportation.

ADB30, Transportation Network Modeling
The committee will promote research and information exchange in transportation network modeling, an interdisciplinary field spanning Computer Science, Logistics, Mathematics, Operations Research, Telecommunications, and Transportation Science. The committee will also focus on: the understanding and modeling of the technological and behavioral factors affecting the performance of transportation systems; modeling the interactions between the infrastructure and transportation networks; and the development and use of models to evaluate the quantity and quality of transportation facilities and services. The committee will serve as a focus for the development, adaptation, and implementation of quantitative and computer-based methodologies for the above purposes. The committee will cut across traditional modal boundaries, seeking unifying conceptual and methodological frameworks, yet highlighting modal differences. As such, it will foster effective and rapid sharing of information and experiences among researchers, practitioners, regulators and decision makers.

AFB10, Geometric Design
This committee focuses on expanding knowledge regarding highway and street geometric design elements that affect safe and efficient operations for all users and contexts. The committee develops research needs statements and communicates findings that advance design criteria, guidance, methods, and performance-based roadway design objectives. The committee facilitates domestic and international dialogues and idea exchanges between researchers and practitioners while supporting emerging and developing professionals.

AFB20, Roadside Safety Design
The scope of the committee includes identification of research needs and dissemination of research related to the design, testing, selection, placement, and in-service performance of roadside safety features such as traffic barriers; crash cushions; structural supports for luminaires, signals, and utilities; drainage structures; and other safety features located in the transportation system right-of- way. The scope includes consideration of the impact performance, degree of hazard, environmental factors, and cost-effectiveness that must be considered in the design and use of these features. The primary objective is to aid in the development of roadside safety features that provide cost-effective safety to the traveling public.

AFB30, Low-Volume Roads
This committee is concerned with all aspects of low-volume roads including planning, design, construction, safety, maintenance, operations, environmental, and social issues.

AHB15, Intelligent Transportation Systems
The Intelligent Transportation Systems (ITS) Committee is concerned with ITS systems-level issues. Such issues include conceptual system planning and design, integration of technologies and approaches from various sub-disciplines within ITS, applications to all modes of ground transportation and to facilitate intermodal integration, and evaluation of the overall impacts of ITS on the developers, users, and operators of all parts of the ground transportation system. Activities focus on the broad planning, policy, economic, social, technological, and institutional aspects of the development and implementation of ITS. The Committee also facilitates coordination of ITS-related issues with other standing committees of TRB.

AHB50, Traffic Control Devices
This committee is concerned with the development, design, application, and evaluation of traffic control devices, and their effect on traffic operation and safety.

AHB65, Operational Effects of Geometrics
This committee is concerned with geometric design as related to traffic operations and safety.

AHB70, Access Management
The committee will share the latest knowledge, expertise, and experience to facilitate leadership and partnerships to advance the state-of-the-practice in access management and its integration into established planning, policy, and design processes.

ANB10, Transportation Safety Management
The committee will be concerned with the development and coordination of integrated safety management programs to reduce death and injury on transportation systems. Areas of concern include: 1) the advancement of safety management systems, 2) research and technology to improve safety, and 3) models of safety delivery systems.

ANB25, Highway Safety Performance
This Committee deals with the advancement, integration and institutionalization of quantitative highway safety information to support transportation decision-making at all levels. The function of this committee is to foster the continual development, validation and increased knowledge of science-based methods, procedures and measures that will increase the safety of the nation's highways and roadways.

ANB30, Operator Education and Regulation
The scope of this committee covers research and development activities designed to improve the effectiveness of methods of educating and training, plus licensing and relicensing, drivers and operators of surface transportation vehicles. A special focus is on high-risk driver groups -- teens and senior.

ANB40, Traffic Law Enforcement
This committee is concerned with research relating to safety effects of enforcement activity and other traffic supervision measures, including those involving the driver and vehicle.

ANB50, Alcohol, Other Drugs, and Transportation
This committee is concerned with alcohol and other drugs as they relate to all significant modes of transportation with particular emphasis on those relationships that are common to more than one mode.

ANB60, Safe Mobility of Older Persons
Stimulate quality research and evaluation, provide a forum for interested researchers and practitioners to disseminate research and related information to those involved and interested in improving the safety and mobility of older drivers.

ANB70, Truck and Bus Safety
This committee will focus on motor carrier safety in all its aspects. This will include research and evaluation in human, roadway, vehicle, operational, organizational, and regulatory arenas as they relate to motor carrier safety.

ANB75, Roundabouts
The committee is concerned with all factors encompassing modern roundabouts. The Task Force provides focus within TRB on current issues and future research needs pertaining to modern roundabouts. It serves as a forum for discussions about roundabout research, projects, and policy for all interested stakeholders; identifies research needs and develops research problem statements to meet the needs; and facilitates the exchange of knowledge by various media, meetings, and conferences.

AND10, Vehicle User Characteristics
This committee is concerned with the needs, capabilities, and limitations of vehicle users as these considerations affect the design, operation, and maintenance of personal, commercial and public transportation systems embracing highway and rail operations. The objectives of this committee are to maximize performance, safety, comfort, and efficiency of such systems.

ANF10, Pedestrians
This committee is concerned with research on pedestrians and pedestrian facilities which will provide safe, comfortable, and efficient walking environments along sidewalks, along and across roadways, and connecting to other modes of transportation. It addresses the planning, design, operation, and maintenance of roadways as they affect use of public rights-of-way by pedestrians. It aims to integrate pedestrian considerations into broader transportation issues.

ANF20, Bicycle Transportation
This committee is concerned with all aspects of bicycling and bicyclists and criteria for bicycle facilities to assure that the bicycle rider has safe, convenient and efficient travel.

ANF30, Motorcycles and Mopeds
This committee is concerned with all aspects of motorcycles and mopeds, including the operator, the vehicle, and the transportation environment.

FA000, SHRP2 Technical Coordinating Committee for Safety
The Transportation Research Board (TRB) will manage a multi-year Strategic Highway Research Program (SHRP) II. SHRP II will focus on applied research in the following areas: (1) accelerating the renewal of America's highways; (2) making a significant improvement in highway safety; (3) providing a highway system with reliable travel times; and (4) providing highway capacity in support of the nation's economic, environmental, and social goals. TRB will administer this research program using procedures similar to those employed in the first SHRP program, carried out from 1987 to 1993, and in the existing Cooperative Research Programs to provide for competitive, merit-based selection of research contractors, research project oversight, and dissemination of research results.

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