INFORMING THE SELECTION OF COUNTERMEASURES BY EVALUATING, ANALYZING, AND DIAGNOSING CONTRIBUTING FACTORS THAT LEAD TO CRASHES

FINAL IMPLEMENTATION OF RESEARCH FINDINGS AND PRODUCTS

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The research reported herein was performed under NCHRP Project 22-45 by Exponent, Inc., with the Texas Transportation Institute (TTI) of Texas A&M serving as a research partner.
This report provides an implementation approach for a study to develop new tools for diagnosing the contributing factors leading to crashes and selecting appropriate countermeasures in modally diverse contexts. The tools themselves highlight those significant contributors to crashes that could be addressed through roadway planning, design and/or operations. A key principle of the Safe System approach is that “Drivers make mistakes;” accordingly, the tools developed provide diagnostic frameworks and procedures to aid the practitioner identify the sources of typical road user errors. These include issues around perception-response time (PRT), meeting road users’ expectations, meeting road users’ visibility needs, and assessing the demands and workload placed on users by a given facility. The report also provides decision trees that aid the practitioner in identifying and selecting countermeasures in a manner that links their features and benefits to the underlying contributing factors observed within the crash data or the facility itself. The decision trees address a variety of crash types, roadway segments, and contributing factors. A key focus of the tools was to further practitioner understanding of how to balance tradeoff decisions in a given modal and facility context, and to emphasize the need for evaluations at all stages of the diagnostic assessment and countermeasure selection process.
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Acronyms and Abbreviations

AASHTO  American Association of State Highway and Transportation Officials
CDC    Center for Disease Control
DOT    Department of Transportation
EMS    Emergency Medical Services
HFG    Human Factors Guidelines
ITE    Institute of Transportation Engineers
NASEMSO National Association of State EMS Officials
NCHRP  National Cooperative Highway Research Program
NHTSA  National Highway Traffic Safety Administration
NSA    National Sheriffs’ Association
SAMHSA Substance Abuse and Mental Health Services Administration
SHSO   State Highway Safety Offices
TRB    Transportation Research Board
Section 1.0 Introduction

Successful safety management practices require a thorough understanding of the factors contributing to motor vehicle crashes. The continuous advancements in the science of data-driven safety analysis, as well as the countermeasures and technologies available for addressing crashes, create challenges in maintaining a safety workforce that is proficient in the state of the practice. In many cases, transportation agencies (including State Departments of Transportation [DOT]) continue to use approaches such as descriptive statistics and anecdotal information to perform the diagnostic assessment without a thorough understanding of the expectations for a given context or road type. Additionally, choosing an effective countermeasure requires an examination of the human factors, behavioral factors, future development, prevailing or predicted crash types, and mix of road users to determine the most appropriate treatments to apply. Doing so allows the selected countermeasure to reduce crashes to the greatest extent possible. However, in many cases, practitioners have limited understanding of the potential for a treatment selection to affect other road users. For instance, installing a turn lane might also increase vehicle speeds or pedestrian crossing distance. A better understanding of these relationships and tradeoffs should inform design choices and ultimately result in safer roadways for all road users.

Research is needed to develop diagnostic tools that leverage crash, roadway, traffic volume, human factors, behavioral, socioeconomic, and demographic data, as well as non-traditional data sources in order to advance the state of the practice in crash diagnostics and countermeasure selection that considers both modal priorities and facility context. It is common to characterize traffic safety plans as the 4Es of highway safety – engineering, education, enforcement, and emergency medical services. The evaluation (the 5th E of safety), analysis, and diagnosis of these aspects of crashes in modal and facility contexts should significantly improve the selection and design of countermeasures.

A number of useful guides and tools are available to partially address this research gap. What is lacking from the practitioner’s toolbox is an integrated set of procedures, methods, and tools for conducting comprehensive diagnostic assessments of the contributing factors to crashes and for identifying matching countermeasures with a potential to improve safety performance and provide a meaningful return on investment to State DOTs.

Specifically, existing guides and tools: (1) do not provide adequate coverage of key contributing factors such as human factors and driver behavior, (2) are hard-to-understand, hard-to-use, and generally not designed to be ‘practitioner ready’, and (3) do not yield ‘actionable’ outcomes that include both a clear description of how proposed countermeasures will increase road user safety and the design/behavioral tradeoffs associated with the countermeasures.

To address these concerns, the objectives of the current project (National Cooperative Highway Research Program [NCHRP] 22-45) were to: (1) develop new methods and tools for diagnosing contributing factors leading to crashes that will aid practitioners in selecting appropriate countermeasures in modally diverse contexts, and (2) address a wide variety of contributing factors leading to crashes (e.g., roadway, technological, behavioral, human factors, socioeconomic, demographic, weather, and land use) in order to further practitioner
understanding of how to most effectively balance tradeoff decisions in a given modal priority and facility context.

1.1 Project Tasks

The tasks associated with this project are shown in Figure 1.

Figure 1. NCHRP Project 22-45 Tasks.
1.2 Summary of the Report

This technical memorandum discusses the implementation of the research finding and products from this project, and is conducted as part of Task 10: Develop and Submit Final Deliverables. The purpose of Task 10 was to summarize the objectives, methods, findings, conclusions, and implementation steps associated with the project.
Section 2.0 Implementation of Research Findings and Products

2.1 Overview

The project team’s general approach to the project and to our technical activities has been on developing effective safety management products that have high actual and perceived value to the intended practitioner community. The research products from this project are intended to support practitioners as they diagnose the contributing factors that lead to crashes, and to help them identify and select effective countermeasures for these crashes. They can be used to assess and diagnose crashes both at the national level to address broad trends in crashes, as well as at the local level to address crash clusters that could occur at specific locations. Since so many crashes include human error as a contributing factor (over 90% across many studies; see Treat et al., 1979; Wierwille et al., 2002; Singh, 2015; Dong & Wood, 2023), a key focus of the products has been to:

- describe the ways in which human factors issues lead to crashes,
- assist practitioners in distinguishing between crashes involving human factors issues versus those involving aberrant driver behavior, and
- provide guidance on the selection of countermeasures aimed at promoting roadways with improved safety performance for all road users.

The key deliverable from this project is “Diagnostic Assessment and Countermeasure Selection: A Toolbox for Traffic Safety Practitioners” (aka the “toolbox”). The report is organized in relatively short sections to aid rapid ‘search and find’ activities on the part of the user. These sections contain focused discussions on specific topics and include objectives, background materials, examples, and tools in the form of diagnostic questions to aid crash diagnoses, as well as flowcharts to aid in countermeasure selection. Thus, users can obtain benefits from a mix of both: (1) background knowledge that can further their understanding of key concepts and related research and concepts, and (2) practical tools that identify key concepts and questions that can frame and guide the diagnostics process, and decision trees to aid in countermeasure selection. This document is not a standard and is intended to augment – not replace – the many resources that are already available on these topics.

Below, we discuss the anticipated research results and our implementation plan for this project with respect to several key elements, including:

- Key products expected from this research,
- Recommendations for putting this research into practice,
- Institutions and individuals who might take leadership in deploying the research,
- Potential impediments to successful implementation and recommended actions to address these impediments, and
- Methods of identifying and measuring the impacts associated with implementation of the findings/products.

Key products expected from this research. The research provides the following products:
1. The new methods and tools for diagnosing contributing factors leading to crashes that will aid practitioners in selecting appropriate countermeasures in modally diverse contexts. This refers to the primary deliverable from this project: “Diagnostic Assessment and Countermeasure Selection: A Toolbox for Traffic Safety Practitioners”

2. Recommendations for additional research, including recommendations for maintaining and updating the new and/or enhanced methods and tools developed in this research.

3. Identification of existing resources (e.g., Model Minimum Uniform Crash Criteria, Highway Safety Manual, Model Inventory of Roadway Elements) that when next revised, could consider changes to reflect the results of this research.

4. A final report documenting the entire project and incorporating all other specified deliverable products of the research.

5. An electronic presentation (i.e., PowerPoint) with speaker notes describing the project background, objective, research method, findings, and conclusions that can be tailored for specific audiences.

6. A stand-alone technical memorandum document titled “Implementation of Research Findings and Products” will: (a) provide recommendations on how to best put the research findings/products into practice; (b) identify possible institutions that might take leadership in applying the research findings/products; (c) identify issues affecting potential implementation of the findings/products and recommend possible actions to address these issues; and (d) recommend methods of identifying and measuring the impacts associated with implementation of the findings/products.

2.2 Recommendations for Implementation

**Recommendations for putting this research into practice.** We offer the following recommendations for putting the research products from this project into practice.

- **Make results available as early as possible to State DOTs.** Safety practitioners cannot use a product that they do not have or do not know about. As soon as practical and possible, hardcopy and electronic formats of the updated “toolbox” should be made available and disseminated to the roadway design/safety community. The materials should aid implementation at the State DOT level.

- **Develop flyers, brochures, videos, and research notes on the “toolbox”.** In addition to the full, final product, the NCHRP should develop short 1–2-page flyers, brochures, etc. that describe the 22-45 project and products; these can be distributed at meetings and conferences – at both the state and federal levels – to heighten awareness of the project. In addition, NCHRP can develop 5-to-10-minute videos that demonstrate processes and provide example of how to perform diagnosis and countermeasure selection procedures. The project can also be discussed in relevant Transportation Research Board (TRB) and DOT newsletters.
• **Present findings at relevant conferences and meetings.** As discussed above, the methods and results of this research should be presented and discussed at future TRB, American Association of State Highway and Transportation Officials (AASHTO), Institute of Transportation Engineers (ITE), or Human Factors conferences or meetings. Forums for these discussions include workshops at the TRB annual meeting, committee meetings, lecture sessions, and technical panels.

• **Conduct TRB webinar to introduce the “toolbox” to practitioners.** While many potential users of the products from this research cannot attend national or regional conferences, they can still attend webinars. Webinars are a useful means to introduce new products such as the “toolbox” to the practitioner community, and we recommend organizing and conducting a TRB-sponsored webinar as soon as this research product is available. We would recommend a 2-hour webinar that includes a shortened version of the slides presented at the February 2023 Practitioner Workshop.

• **Conduct pilot studies.** The key research products from this project are already “practitioner ready” and should be transitioned into a pilot study with 3-4 willing State DOTs as soon as possible. Key steps for the pilot studies could include: (1) outreach and recruitment, (2) develop details plans for participating states, (3) train practitioners from the State DOTS, (4) provide on-going technical support during the pilot studies, (5) evaluate the efficacy of the research products.

• **Seek out feedback from users on the research products from Project 22-45.** NCHRP should vigorously seek out honest, objective feedback from practitioners and others on the value and utility of the products developed in this project. This kind of feedback was obtained from users of the Human Factors Guidelines (HFG; see Campbell et al., 2012) and proved invaluable for improving the final guidelines. Types of feedback might include surveys of users of the “toolbox”, formal evaluations of the value of the “toolbox”, interviews with users, feedback on webinars/workshops, and pilot studies at the state level to assess the “toolbox.”

**Institutions and individuals who might take leadership in deploying the research.** The project team, panel members, NCHRP, and interested individuals from FHWA, National Highway Traffic Safety Administration (NHTSA), and AASHTO should be involved in developing multi-level approaches to implementation that match the objectives of the project and the intended audience/application. As products emerge from the project, some of the implementation activities should be taken up with the State DOTs. In this regard, the practitioners from the Task 3 requirements analysis and the Task 8 workshop can serve as ‘ambassadors’ to the larger end-user community to help promote the products. The Task 3 requirements analysis activity and the Task 8 workshop will provide input, recommendations, insights, and feedback on many aspects of this project, from delivery methods, to content, to final training materials. Thus, there will be a built-in audience familiar with the project and interested in seeing the results applied to real world roadway design practice.

Potential audiences and markets for the products generated in this research project include practitioners from many diverse fields with responsibility for roadway safety management.
including safety engineers, planners and designers, traffic operations staff, highway designers, traffic engineers, behavioral experts, public health professionals, law enforcement, and State/local policy makers. Institutions reflecting this market include a wide range of transportation, safety, health, and related organizations such as:

- State Highway Safety Offices (SHSOs)
- Federal Highway Administration (FHWA)
- National Highway Traffic Safety Administration (NHTSA)
- Federal Motor Carrier Safety Administration (FMCSA)
- National Sheriffs’ Association (NSA)
- Centers for Disease Control (CDC)
- Substance Abuse and Mental Health Services Administration (SAMHSA)
- National Association of State EMS Officials (NASEMSO)

**Potential impediments to successful implementation.** We believe that there are three potential impediments to moving the results of this research into practice in the real world: 1) a lack of perceived value, 2) limited availability of the research products, and 3) uncertainties about how to use and apply the materials. Each of these impediments, and some ideas for how to address them, is discussed below.

- **Lack of perceived value.** It is clear that highway safety management community has a number of reference sources available to them and unless they perceive the methods and tools for diagnostic assessment and countermeasure selection developed in this project to contain valuable, useful information, it may not be used on a regular basis. Indeed, this exact problem is what has plagued many similarly-motivated products in the past. For the current project, this underscored the need to develop the methods and tools with end-user needs and requirements firmly in mind, and to develop materials with high real and perceived value. As discussed above, several activities can be initiated to highlight the availability and value of the “toolbox,” including make results available as early as possible, develop flyers, brochures, and research notes on the “toolbox,” and present findings at relevant conferences and meetings.

- **Limited availability of the research products.** Clearly, in order to be used in practice, the methods and tools developed in 22-45 must be made readily available to the widest audience possible, and in as many forms as economically feasible. Potential users need to be both aware of the existence of the materials and be given access to them in a form that is consistent with their work practices. Communicating the availability of the materials, as well as the content of the materials, and the methods used to develop them, will be crucial to “spreading the word” about the results of this project. Planning outreach activities associated with the project (e.g., webinars, workshops, State-level ‘lunch-n-learns’, pilot studies) can also serve to inform users about the availability of these materials.

- **Uncertainty about how to use and apply the research products.** A critical issue that threatens successful implementation and adoption of safety management tools (in general) is an uncertainty on the part of users as to exactly when, how, and where to apply the research
products. This is clear from our past HFG pilot studies with 5 State DOTs (completed as part of Project 17-47), the recent HFG workshop training, and the on-going State DOT assistance being completed as part of 20-07(334). We have tried to address this issue in the “toolbox” with a “how to use” section in Section 1 of the document, as well as “toolbox” contents that facilitate ease-of-use.

**Methods of identifying and measuring the impacts associated with implementation of the findings/products.** The findings and activities of this research project could provide a number of opportunities for tangible and measurable improvements in the practice of diagnostic assessment and countermeasure selection. Following the successful completion of this project, the progress and consequences could be judged by the following criteria:

- *Evaluation of the “toolbox” by the user-community.* Since the primary results from this project have both an intended use and an intended target audience, perceptions, case studies, and feedback from the user-community will be key to determining whether or not the “toolbox” is a success. User evaluations on the overall value of the “toolbox”, the value of individual sections, and feedback on where and how often the products from this research have been used, will provide useful information on the progress and consequences of implementation.

- *Objective indices of interest and application.* Number and nature (domain, connect time, content viewed) of web site “hits”, workshop/lecture attendance, hardcopy requests.

- *State-level application of the “toolbox.”* The results from this research provide limited benefits if not applied at the state level, given the states’ responsibilities for roadway design. Following completion of the project, its success could hinge on the number of states actively using the “toolbox” to design roadways.

- *“Promotion” of the “toolbox”.* Clear indications of the quality, applicability, and value of the “toolbox” will be if the “toolbox” is – in one form or another - adopted for use by AASHTO, or otherwise “promoted” to a recommended practice or design standard.
Section 3.0 References


