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Core Competencies for Key Safety Analysis

FINAL REPORT

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LIST OF ACRONYMS / ABBREVIATIONS

Acronym / Abbreviation	Definition
AI	Artificial Intelligence
AR	Augmented Reality
AV	Automated Vehicles
CAVs	Connected and Autonomous Vehicles
CDC	Center for Disease Control
CMF	Crash Modification Factor
CTPP	Census Transportation Planning Products
FARS	Fatality Analysis Reporting System
FAST	Fixing America's Surface Transportation
FHWA	Federal Highway Administration
GES	General Estimate System
HSIS	Highway Safety Information System
IoT	Internet of Things
ITE	Institute of Transportation Engineers
ITS	Intelligent Transport Systems
LEHD	Longitudinal Employer Household Dynamics
LTAP	Local Technical Assistance Program
NCHRP	National Cooperative Highway Research Program
NHI	National Highway Institute
NHTSA	National Highway Traffic Safety Administration
NPMRDS	National Performance Management Research Data Set
RSP	Road Safety Professional
SPF	Safety Performance Function
TPCB	Transportation Professional Certification Board
U.S.	United States
USDE	United States Department of Energy
USDOT	United States Department of Transportation
V2X	Vehicle-to-Everything
VR	Virtual Reality

CHAPTER 1. INTRODUCTION AND OVERVIEW

According to data from the National Highway Traffic Safety Administration (NHTSA), 36,560 people died from traffic crashes in 2019, a 3.1-percent increase over 2015 values *(1).* The total estimated cost of United States motor-vehicle fatalities in 2019 was $442 billion *(2).* Safety has been identified as one of the major themes in the Federal Highway Administration's (FHWA) Fixing America's Surface Transportation (FAST) Act. The overall goal of improving safety is to reduce crashes and prevent injuries. Safety improvement is also prominent in other key tactical goals in the engineering profession. Transportation safety engineers support these objectives by developing or improving analytical methodologies that offer crucial safety improvements.

The development of a competent and knowledgeable safety workforce is an essential objective of the transportation safety community. Retirements among experienced professionals can be expected to leave a gap in the knowledge base of the workforce and lead to slower progress towards building a safe, secure, and effective transportation system. It is critical to the success of any workforce development effort to ensure that professionals with safety training are entering the field. To accomplish that goal, it is important to determine the core competencies needed for safety professionals that provide the necessary groundwork for safety education and development.

For the purposes of this report, the core competencies exemplify the minimum set of essential knowledge, skillsets, and capabilities required to operate effectively and efficiently in the highway safety area. Previously, researchers conducted two studies to determine the core safety learning competencies and available resources for essential workforce development. National Cooperative Highway Research Program (NCHRP) Research Digest 302 identified five key core competencies in a 2006 report *(3).* The NCHRP 20-07 (Task 290) report further addressed the requirements for training of transportation professionals on the required knowledge and related tools for advancing the practice of highway and road safety *(4).* This second report listed 184 courses that may be incorporated into training to promote development in the safety workforce. There is a need to update the training information provided in the 2011 report. In addition, the transportation safety community requires a template tool or framework that can be used to determine the available resources and their linkage to core competencies for safety analysis. This core competency tool or framework, presented in this report, is expected to help transportation professionals, including highway agencies, municipalities, consultants, and academics, develop an adequately prepared safety workforce. The development of this workforce is the focus of this research effort.

RESEARCH OBJECTIVE

The objectives of this research were to:

- Compile a research synthesis on education and training opportunities related to key safety analysis,

- Develop a user-friendly tool for transportation agencies to assess their workforce development needs based on key core competencies, and
- Provide a useable template for highway agencies to identify effective and efficient training and education opportunities.

REPORT ORGANIZATION

The remainder of this report is organized in the following manner. Chapter 2 provides the synthesis of existing resources related to education and training opportunities for key safety analysis. Chapter 3 introduces the framework and describes the resulting workforce assessment tool. Chapter 4 then provides conclusions and future recommendations. The report concludes with a reference and appendix section.

CHAPTER 2. SYNTHESIS OF INFORMATION RELATED TO SAFETY ANALYSIS EDUCATION AND TRAINING OPPORTUNITIES

INTRODUCTION

The term "core competencies" refers to 'critical capabilities or resources' needed to be successful in a particular area. As applied to transportation safety, "core competencies" include a knowledge base, a basic set of skills, and an analytical capability to make key transportation safety decisions. Gross and Jovanis (*5*) conducted a survey of universities and related institutes in the United States to assess the existing college-level courses in transportation safety and associated topics. This study focused on safety-related content in the transportation courses of civil engineering departments and injury prevention courses of public health programs. The findings of the Gross and Jovanis study showed that there is an evolving need for core competencies to be addressed in highway safety courses that are offered at the university level.

The core competencies do not represent *all* of the knowledge and skills necessary for a safety professional to be successful. Instead, they represent the core components that one must know in the overall field of transportation safety. Other relevant knowledge and skills needed include an understanding of statistics and evaluation processes, public affairs, engineering judgment, effective communications, and social marketing. Upon examination of a typical course syllabus, core competencies are similar to the identified key learning modules as presented by other disciplines in similar fields. Different sectors of transportation safety such as engineering, road user behavior, public policy, and injury prevention require this core understanding of key knowledge and skillsets. Gross and Jovanis (*5*) identified five core competencies required for transportation safety professionals. A brief overview of each core competency is provided in the next section.

CORE COMPETENCIES

Core Competency 1: Multidisciplinary Nature of Safety

Highway safety is a very complex, interdisciplinary, and multimodal discipline requiring engineers to have a fundamental understanding of engineering, psychology, economics, and human behavior. The first core competency provides a comprehensive perspective for studying highway safety as a complex multidisciplinary field. This multidisciplinary core competency is composed of several key issues, as summarized in Table 1.

Table 1. Multidisciplinary Safety Expertise -- Core Competency

Describe	Identify	Explain	Recognize
Describe highway safety as a complex, **interdisciplinary, multimodal discipline** devoted to reducing traffic crashes and crash-related injuries	Identify, value, and operate **science-based highway safety research** and its application as fundamental to achieving further improvements in highway safety	Explain how **effective safety management** can be used to prevent crash severity	Recognize the **effectiveness of countermeasures**, and combination of a group of countermeasures
Describe the **demographic information** and associated **trends** underlying the need for comprehensive and integrated highway safety management	Identify how **key contributing factors** interact and determine clusters of contributing factors and their association patterns	Explain the **"Four E's" of traffic safety**: engineering, education, enforcement, and emergency medical services.	Recognize how highway **user decision making** is influenced by highway design, transportation planning, traffic operations, and vehicle design
Describe the **classification** of highway crash and injury severity factors and their relationship to the crash event by using models such as the Haddon Matrix (see Table 2).	Identify and demonstrate **opportunities to improve safety** through collaboration with individuals from diverse backgrounds		Recognize the **barriers that hinder collaboration** across and within institutions

Table 2 presents an example of a Hadden Matrix where the pre-crash, crash, and post-crash circumstances are categorized by human, vehicle or equipment, physical, and socio-economic crash influences.

Table 2. Haddon Matrix for an Urban Area

Period	Human	Vehicle/Equipment	Physical Environment	Socio-Economic
Pre-Crash	Poor vision or reaction time, alcohol, speeding, risk taking	Failed brakes, missing lights, lack of warning systems	Narrow shoulders, ill-timed signals	Cultural norms permitting speeding, red light running, driving under influence
Crash	Failure to use occupant restraints	Malfunctioning safety belts, poorly engineered air bags	Poorly designed guardrails	Lack of vehicle design regulations
Post-Crash	High susceptibility, alcohol	Poorly designed fuel tanks	Poor emergency communication systems	Lack of support for emergency medical services and trauma systems

Source: Herbel, Laing, and McGovern, 2010 (6)

Subjects associated with some of the skills that comprise the multidisciplinary core competency are generally present in highway safety engineering courses. However, the depth of understanding conveyed as part of this core competency can be expected to vary and, in many cases, will require more in-depth or advanced skillsets.

Core Competency 2: History and Institutional Setting for Safety Management

To enhance the safety of a facility, the individual assessing the safety can benefit from understanding the historical and institutional context of the roadway. Some of the key skills associated with this type of learning objective are presented in Table 3.

Table 3. Legislative and Roadway Safety History -- Core Competency

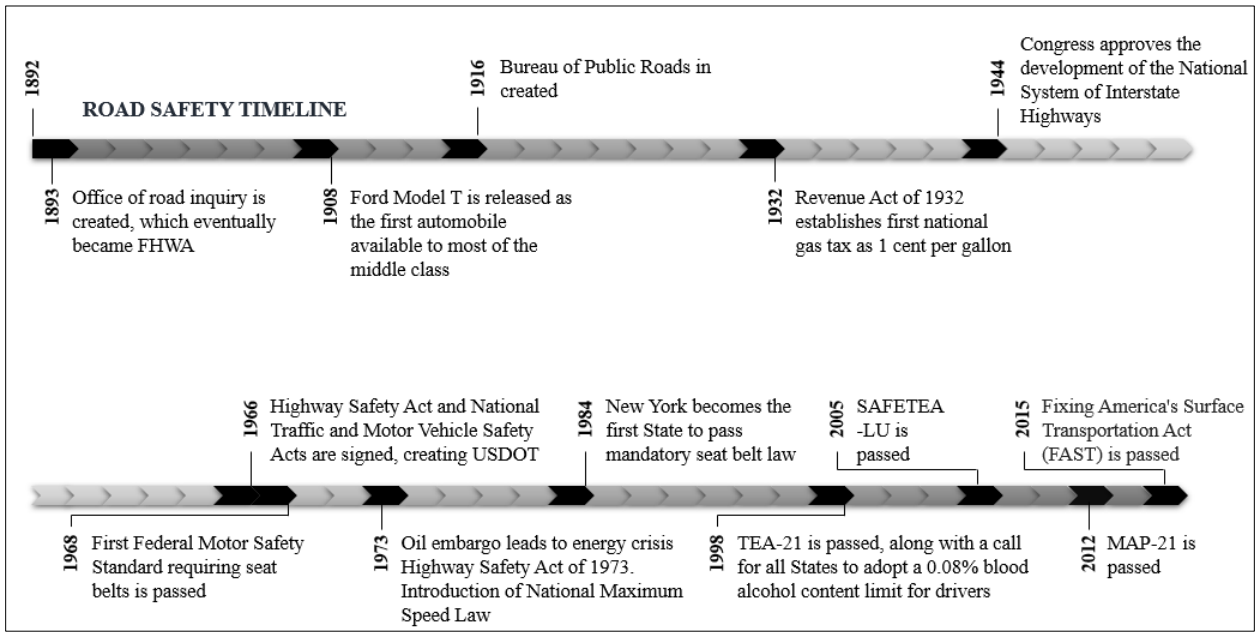
Describe	Identify	Explain
Describe the **institutional roles and responsibilities** within which safety is managed	Identify the **safety aspects** of major **transportation legislation**	Understand the **historical figures, benchmarks, and decisions** underlying highway safety
List and describe the **goals of interest groups** with a stake in safety-related policy, legislation, and investment decisions		

The legislative and roadway safety history content may vary over time, but at a minimum, this information should address issues associated with safety-focused legislation, operations-focused legislation that has impacted safety, and historic timeline information that depicts the evolution of roadway safety in the United States. The following paragraphs and companion graphic represent the type of information that should be incorporated as part of this core competency content.

Example Content for the Legislative and Roadway Safety History Core Competency:
In 1964, the United States faced a sudden rise in traffic fatalities. Non-prioritization of highway safety consciousness led to 47,700 deaths on the nation's highways, an increase of 10 percent from the previous year. On September 9, 1966, President Lyndon B. Johnson signed the National Traffic and Motor Vehicle Safety Act of 1966 and the Highway Safety Act of 1966. Based on this legislation, the United States Department of Transportation (USDOT) was developed, and the Bureau of Public Roads was transformed into the FHWA.

It is evident that discussions on Core Competency 2 are limited in conventional safety-related engineering courses. However, a simplified version of this core competency can be developed to provide learners a general history of the key safety legislation acts and their effects since 1893. A timeline of road safety in the United States (until 2012) is shown in Figure 1.

Public state and federal agencies, along with many other influencers, play an important role in policy formulation, legislation, and investment decisions. Andersson and Patterson (*7*) discussed the negative lock-in effect observed in Sweden after the "Vision Zero" law was passed by the government for reducing roadway fatalities. Wetmore (*8*) noted how most of the blame was put on the driver in the case of a crash during the latter half of the 20th century and how all the policies were focused on controlling driver behavior. The history of the improvement of air bags and other technologies was discussed while keeping the actions of government officials, insurance companies, and other stakeholders in perspective.



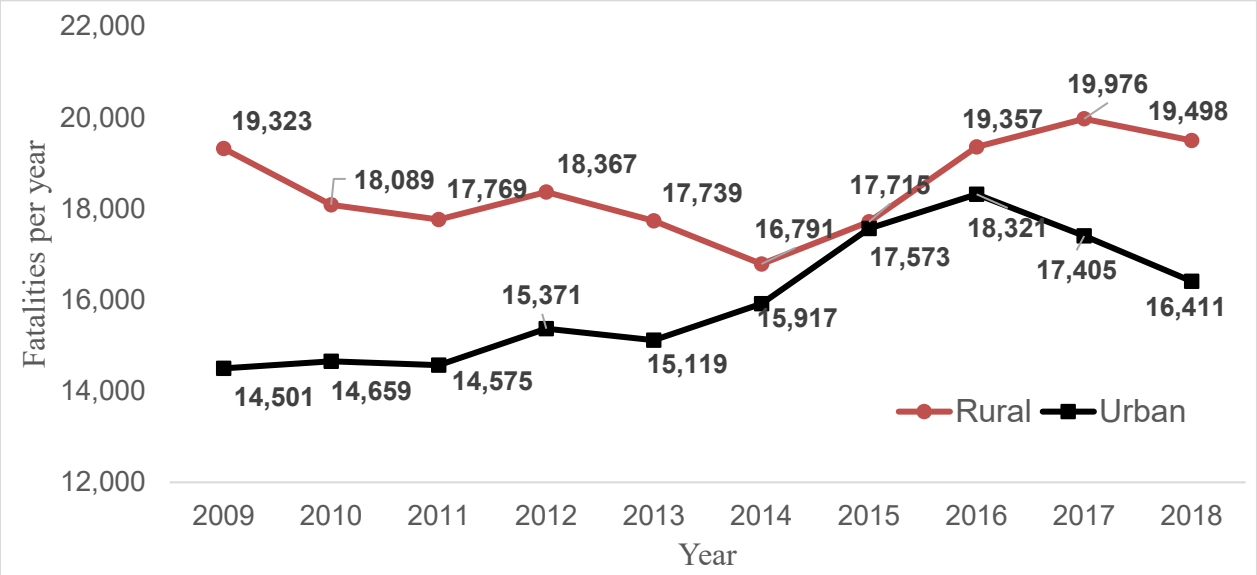
Source: Graphic adapted from on FHWA 2020 (9)

Figure 1. Timeline of Road Safety in the United States

Core Competency 3: Origins, Characteristics, and Use of Crash Data

Understanding traffic crash data and associated analysis are important for transportation professionals. Crash data analysis is one of the core components of transportation safety engineering. Although there have been substantial advancements in traffic safety analysis in recent years, the number of fatalities due to traffic crashes is still excessively high.

Figure 2 shows the traffic fatalities that occurred on rural and urban roadways from 2009 to 2018. In 2019, 36,560 people died on roadways in the United States. It is essential to comprehend data shortcomings and data collection concerns before performing the actual data collection task.



Source: Figure Adapted from the NHTSA 2019 (2)

Figure 2. Traffic crashes by rural and urban facilities (2009-2018).

Crash data typically originate from police crash reports, and this information can vary by state. Crash data contain information about the crash characteristics (i.e., injury type, collision type, number of persons involved), roadway surroundings and crash timing (i.e., segment or intersection, lighting condition, time of the day), roadway characteristics (i.e., lane width, should width, median type), traffic characteristics (i.e., traffic volume, traffic flow density), vehicle characteristics (i.e., vehicle body type, vehicle speed), and person-level information (i.e., driver age, driver gender). Coordination among law enforcement and safety professionals' results in better accuracy and consistency of available data sources. The key skills associated with this core competency are identified in Table 4.

As part of the crash data competency, it is also important to understand the limitations and potential gaps in crash data. As an example, crash reporting for active transportation populations, such as individuals who may be walking or cycling, has typically been under reported. There is a need to understand how these crash data characteristics may influence safety decisions.

Table 4. Origins, Characteristics, and Use of Crash Data -- Core Competency

Describe	Assess and Use
Describe **the specialized national and local crash databases** available for safety management and how they address the data deficiencies	**Access and use traffic safety and public health data systems** for identifying and tracking crash trends, targeting high-risk groups, and planning programs at the national, state, and local levels
Describe **state and local information systems and crash data elements** that can be used for safety management	
Describe the **process by which crash data are collected**, including constraints associated with accurate, reliable field data	
For each of the information systems, describe **strengths and weaknesses** as well as opportunities for improvements	
Describe the **importance of using crash injury or fatality data** to evaluate the implications of safety management actions, policies, and programs	

There exist several national crash databases that need to be described in transportation safety courses. The Fatality Analysis Reporting System (FARS) is a national database maintained by the NHTSA comprising of yearly motor-vehicle fatality data. The General Estimates System (GES) is also a popular database maintained by NHTSA and contains representative samples of vehicle crashes reported by police. The crash reports in GES are chosen from 60 different transportation areas that reflect various diverse scenarios of geography, mileage, traffic density and population of the U.S. Unlike FARS, GES maintains data of all types of crash severities, from minor crashes to fatal crashes. The Center for Disease Control (CDC) also provides an online database that gives details on fatal and nonfatal injuries, violent deaths, and costs of injuries. For crash data analysis, new sources of data are also important in the overall analytical procedures. Table 5 through Table 8 list resources of various data resources which could be used in transportation safety analysis.

Table 5. Example Resources of Crash Data in Traffic Safety Analysis

Data	Source	Description	Link
US Fatalities	FARS	FTP Site for 1975 to 2018 Data	https://www.nhtsa.gov/node/97996/251
US General Estimates of Crash	GES	Data Covers from 1989 to 2018	https://www.nhtsa.gov/node/97996/256
New York Traffic Crash	New York City Open Data	New York Traffic Crash	https://data.cityofnewyork.us/Public-Safety/Motor-Vehicle-Collisions-Crashes/h9gi-nx95/data
Nevada Crash Data	Nevada DOT	Crash Data from 2014 to 2017	http://data-ndot.opendata.arcgis.com/datasets/c02ff49455704f0fb64fa012ff2109d3_0/data?orderBy=Crash_Date
Montana Crash Data	Montana DOT	Crash Data from 2014 to 2018	https://www.mdt.mt.gov/publications/datastats/crashdata.shtml
Texas DOT Data	Texas DOT	Open Transportation Data	http://gis-txdot.opendata.arcgis.com/
California Crash Data	Statewide Integrated Traffic Records System	Need an Account to Download Data	http://iswitrs.chp.ca.gov/Reports/jsp/userLogin.jsp
Pennsylvania Crash Data	Pennsylvania DOT	Pennsylvania Crash Data from 2000 to 2019	https://pennshare.maps.arcgis.com/apps/webappviewer/index.html?id=8fdbf046e36e41649bbfd9d7dd7c7e7e
Indiana Crash Data	Indiana DOT	Indiana Crash Data from 2007 to 2019	https://hub.mph.in.gov/dataset/aries-crash-data-2007-2017
South Dakota Crash Data	South Dakota Office of Highway Safety	South Dakota Crash Data from 2010 to 2019	https://safesd.gov/raw-data.html
HSIS Crash Data	HSIS[1]	HSIS Crash Data for Nine States (Need to Request Data)	https://www.hsisinfo.org/data.cfm
NPMRDS Speed Data	NPMRDS[2]	Need Account to Download Data	https://npmrds.ritis.org/analytics/
Open-Source GIS Data	Wilson, Robin	Open-Source GIS data	https://freegisdata.rtwilson.com/
Maryland Crash Data	Maryland DOT	Maryland Statewide Vehicle Crashes Data from January 2015 to June 2020	https://opendata.maryland.gov/browse?q=crash&sortBy=relevance
Massachusetts Crash Data	Massachusetts DOT	Massachusetts Crash Data	https://massdot-impact-crashes-vhb.opendata.arcgis.com/search?collection=Dataset
Vermont Crash Data	Vermont DOT	Vermont Crash Data from 2010 to present	http://apps.vtrans.vermont.gov/CrashPublicQueryTool/
Chicago Crash Data	City of Chicago	Chicago Traffic Crash Data from 2015 to Present	https://data.cityofchicago.org/Transportation/Traffic-Crashes-Crashes/85ca-t3if

Notes: [1]HSIS= Highway Safety Information System, [2]NPMRDS= National Performance Management Research Data Set

Table 6. Example Resources of Demographic Data in Traffic Safety Analysis

Data	Source	Description	Link
ACS Data	Census	American Community Survey Data	ftp://ftp2.census.gov/
Census Data	Census	Census Data	ftp://ftp2.census.gov/census_2010/
Census Decennial Data	Census	Census Decennial Data	ftp://ftp2.census.gov/decennial/
CTPP Data	Census	Census Transportation Planning Process Data	ftp://data5.ctpp.transportation.org/
LEHD Data	Census	Longitudinal Employer-Household Dynamics Data	https://lehd.ces.census.gov/data/#lodes
Airlines Origin-Destination Data	American Statistical Association	Airlines OD Data Covers from 1987 to 2008	http://stat-computing.org/dataexpo/2009/the-data.html

Notes: [1]CTPP= Census Transportation Planning Products, [2]LEHD= Longitudinal Employer-Household Dynamics

Table 7. Example Resources of Other Potential Data in Traffic Safety Analysis

Data	Source	Description	Link
New York Police Dept. Complaint Data	New York City OpenData	New York Police Department Complaint Data	https://data.cityofnewyork.us/Public-Safety/NYPD-Complaint-Data-Current-Year-To-Date-/5uac-w243/data
New York Police Dept. Arrest Data	New York City OpenData	New York Police Department Arrest Data	https://data.cityofnewyork.us/Public-Safety/NYPD-Arrest-Data-Year-to-Date-/uip8-fykc
New York Police Dept. Arrest Data (Historic)	New York City OpenData	New York Police Department Arrest Data (Historic) from 2006	https://data.cityofnewyork.us/Public-Safety/NYPD-Arrests-Data-Historic-/8h9b-rp9u
Vehicle Complaint Data	NHTSA	US Vehicle Complaint Data	https://www-odi.nhtsa.dot.gov/downloads/
Vehicle Fuel Economy Data	U.S. Department of Energy (USDE)	Vehicle Fuel Economy Data	https://www.fueleconomy.gov/feg/download.shtml
Chicago Crime Data	City of Chicago	Chicago Crime Data from 2011 to Present	https://data.cityofchicago.org/Public-Safety/Crimes-2001-to-present/ijzp-q8t2/data

Table 8. Example Resources of Mobility Data in Traffic Safety Analysis

Data	Source	Description	Link
Bike Share Data	BetaNYC	Listing of Bike Share Data Portals	https://github.com/BetaNYC/Bike-Share-Data-Best-Practices/wiki/Bike-Share-Data-Systems
TLC Trip Record Data	New York	Taxi and Limousine Commission Data Covers from 2009 to 2020	https://www1.nyc.gov/site/tlc/about/tlc-trip-record-data.page
Uber Trip Record Data	New York	Uber Trip Data from a Freedom of Information Request to NYC Taxi & Limousine Commission	https://github.com/fivethirtyeight/uber-tlc-foil-response
Uber Movement Data	Uber	Travel time, and Speed data	https://movement.uber.com/?lang=en-US
Austin Transportation Data	City of Austin	Repository of Austin transportation data	https://data.mobility.austin.gov/open-data/
Austin Dockless Mobility Travels Data	City of Austin	Shared Micromobility Vehicle Trip Data	https://data.austintexas.gov/Transportation-and-Mobility/Shared-Micromobility-Vehicle-Trips/7d8e-dm7r
Austin Radar Traffic Count	City of Austin	Traffic Count and Speed Data Collected from the Several Wavetronix Radar Sensors Deployed by Austin	https://data.austintexas.gov/Transportation-and-Mobility/Radar-Traffic-Counts/i626-g7ub
New York Real-Time Traffic Speed	New York City OpenData	New York Real-Time Traffic Speed	https://data.cityofnewyork.us/Transportation/Real-Time-Traffic-Speed-Data/qkm5-nuaq
NUSCENES AV data	NUSCENES by Motional	Need an Account to Download Data	https://www.nuscenes.org/
Ford AV data	Ford	Autonomous Vehicle Data	https://avdata.ford.com/
Waymo AV data	Waymo	Autonomous Vehicle Data	https://waymo.com/open
CARMA	USDOT	Connected Vehicle Data	https://its.dot.gov/data/

Over the evolution of highway safety analysis, researchers have developed different systems to automatically collect data with a goal of developing more accurate and reliable results. Similar crash data integration efforts are actively occurring internationally. The lack of uniformity across different jurisdictions has created several challenges for researchers and has hindered data integration. Montella et al. *(10)* developed a web-based software named ReGIS they used for solving this problem of data non-uniformity. The ReGIS software performed processing and analysis as well as data collection, assisting both on-site police officers and highway safety analysts.

Several such crash analysis studies have been performed over the last several decades. However, the results of these studies need to be implemented in order to identify and track crash trends and, subsequently, make changes to government policies, as well as highway and automobile design. Proper implementation of all the steps will potentially lead to a more efficient transportation system. Thus, the presence of robust crash injury or fatality data is necessary for government agencies to identify and initiate management action.

Core Competency 4: Contributing Crash Factors, Countermeasures, and Evaluation
Highway safety professionals need to identify candidate sites for safety improvement based on target crash information, assess the associated key contributing factors, determine suitable countermeasures to improve safety, and evaluate effectiveness after implementation. The key skills aligned with this core competency are summarized in Table 9.

Table 9. Crash Factors, Countermeasures, and Evaluation – Core Competency

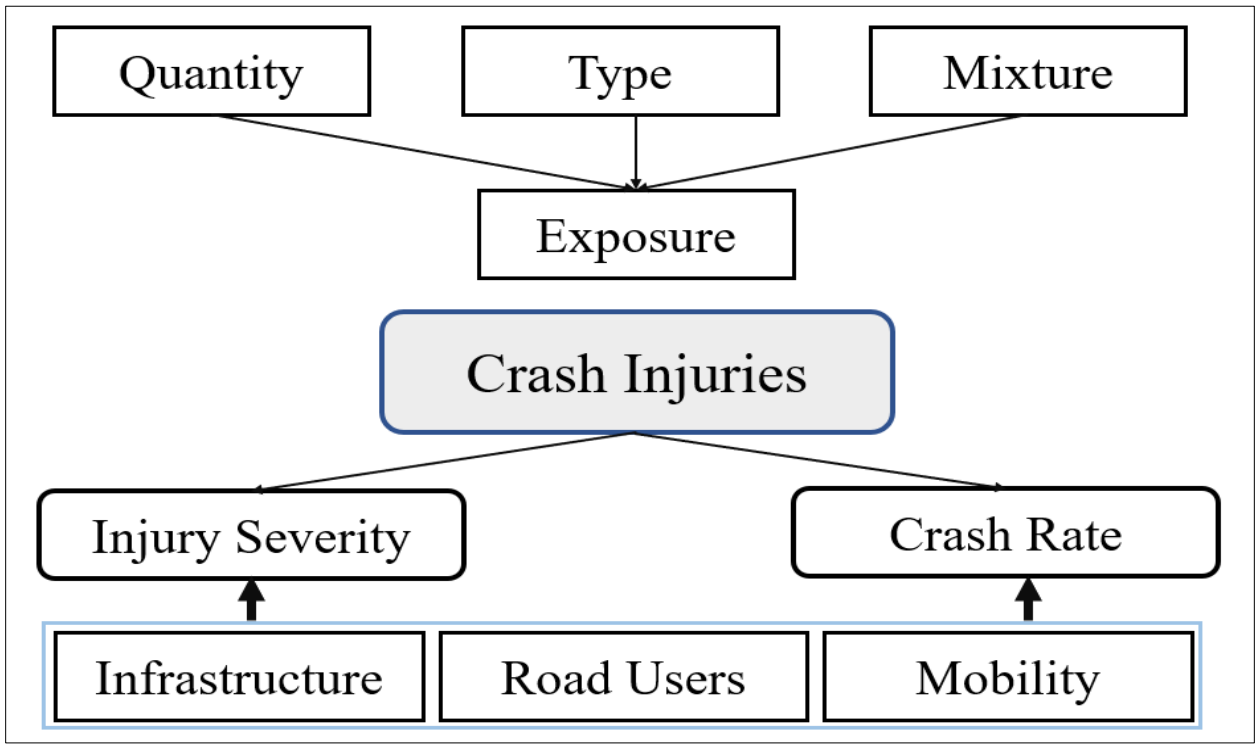
Identify	Establish	Evaluate
Identify current and potential **highway safety problems** using suitable **scientific methods**	Establish **priorities for alternative** interventions/ countermeasures based upon their expected cost and effectiveness and select countermeasures to implement	**Evaluate the effectiveness** of the implemented intervention/countermeasure using appropriate statistical techniques in safety management [e.g., use of Empirical Bayes (EB) and/or case-control designs]
Identify the association between human factors and behavior, roadway design, vehicle design, and other contributing factors **with respect to identified crash problems**		
Identify **effective countermeasures** that address specific crash factors		

In highway safety research, it is crucial to estimate the safety benefit/cost associated with implementing a countermeasure to improve safety.

Figure 3 illustrates a general taxonomy of crash-related key contributing factors. Elvik et al. *(11)* introduced four approaches to reducing traffic crashes and crash-related injury outcomes:

- Reduce exposure to crash events,
- Shift travel to means of transportation mode that have a lower level of risk,
- Reduce the crash rate for a given amount of travel, and
- Reduce crash severity with policy/guidelines and advanced vehicular design.

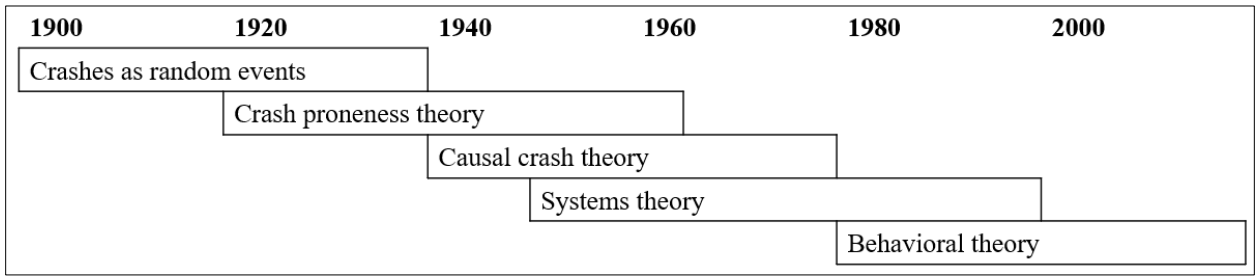
Exposure in the form of traffic volume or traffic density is closely associated with crash outcomes. Exposure can be measured based on the quantity (either traffic volume or traffic density), type (types of traffic, for example, large trucks), and mixture (e.g., traffic volume by vehicle type). As shown in Figure 3, the key contributing factors are typically associated with infrastructure, roadway users, and mobility/vehicles.



Source: Adapted from Elvik et al.,2009 (11)

Figure 3. General taxonomy of key contributing factors.

Crash data analysis methodologies have a history of over a hundred years (see Figure 4). Although many transportation safety researchers alternatively use the term 'accident', the usage of the term 'crash' is preferable as crash solely indicates 'road traffic crash.' The term 'accident' can alternatively indicate any kind of accident such as an industrial accident. From 1910, the term 'crash' was first introduced to be used as an alternative of 'collision.' The first accident theory was evolved during the early 20th century. Five major theories have been evolved over the years: 1) accidents as random events, 2) accident proneness theory, 3) causal accident theory, 4) systems theory, and 5) behavioral theory.



Source: Adapted from Elvik et al., 2009 (11)

Figure 4. Theories associated with crash research.

The 'Vision Zero' concept acknowledges that even one traffic fatality is unacceptable. This calls for a Safe System approach, which was founded on the principles that roadway users are supposed to make mistakes and that human bodies have limited capacity to tolerate crash related wounds. In a Safe System, human errors should never lead to fatal crashes. The safe system will make the driving atmosphere less likely to cause any mistake and even if a mistake leads to a crash, the impact would be less severe. A safe system approach mandates six core principles: deaths and injuries are unacceptable, humans make mistakes, humans are vulnerable, responsibility is shared, safety is proactive, and redundancy is crucial.

Historical crash data analytics or predictive analysis is the most popular approach in conducting transportation safety research. The general approach is to develop crash prediction models using the historical crash data and other co-variates such as roadway, traffic, and environmental variables. A crash prediction model provides a simple interpretation of the complex structure of crash data. The overall crash data analysis is based on two basic categories: frequency analysis (crash counts), and classification analysis (crash injury types). Three extensive survey papers provide an overview of the latest crash modeling techniques *(12-14).* Mannering et al. *(15)* addressed the trade-offs associated with the methods applied in safety modeling regarding performance measures. He considered four modeling approaches: 1) traditional statistical model, 2) data-driven or machine learning model, 3) endogeneity/heterogeneity model, and 4) causal inference model. The three major performance measures are predictive capability, causal inference capability and big data suitability. Every modeling approach has unique advantages and disadvantages. For example, data-driven or machine learning models are good at prediction and big data analysis; however, these methods fall short in interpretation.

As crash data is sometimes difficult to attain, many agencies apply systemic analysis or system-based analysis to minimize risk to roadway users. This approach acknowledges crash data analysis is not always suitable for countermeasure selection, particularly on low volume local and rural roadways where crash frequencies are lower. Additionally, many minor or near-crash events are not even documented in the police reported crash data. The systemic approach

determines suitable countermeasures based on high-risk roadway features correlated with target crash types. The systemic safety project selection tool builds upon three core elements:

- Element 1: Identify priority crash types and key contributing factors; evaluate inexpensive and effective countermeasures; and prioritize alternative candidate locations for systemic safety investment
- Element 2: Provide a framework for setting funding goals between systemic and site analysis programs.
- Element 3: Provide a high-level direction for evaluating the effectiveness of systemic safety programs.

Although many research studies have developed improved tools and techniques for assessing countermeasure effectiveness, there is a growing need for assessing the effectiveness of a group or combination of countermeasures. Other areas that merit consideration include context-sensitive engineering design, safe design alternatives for non-motorists, and improvement in work zone safety.

After the contributing factors are identified, countermeasure should be selected to address each contributing factor. Crash Modification factors (CMFs) provide an indication of countermeasure effectiveness and can be useful to select potential countermeasures *(16).* Countermeasures with CMFs lower than 1.0 can potentially reduce crashes at a site. However, this does not mean that countermeasures with CMFs higher than 1.0 cannot be applied. Engineering judgement should also be considered when selecting the optimal countermeasures. After potential countermeasures are identified, treatments should be selected based on economic appraisal. The treatment with the highest benefit-to-cost ratio is sometimes preferred if the budgetary constraints exist. There are two major methods in analyzing the benefit of a project: benefit-cost analysis and cost-effectiveness analysis *(16).* Generally, when conducting an economic appraisal, the extent to which a countermeasure reduces crashes is compared directly with its economic cost. The goal is to reduce as many crashes as possible for a given investment of resources. In summary, the economic appraisal process has three steps: (1) assess expected project benefits; (2) estimate project cost; and (3) apply economic evaluation methods.

According to the HSM, the purpose of safety effectiveness evaluation is to quantitatively estimate the effect that a treatment, project, or group of projects has on the expected average crash frequency or severity. Safety professionals can use it to evaluate how well a group of projects has performed to alleviate crash number and severity. According to Gross et al. *(17),* an effectiveness study can be conducted in two ways: experimental studies and observational studies. Moreover, there are two common types of study designs for safety effectiveness evaluation: before-and-after design and cross-sectional design. Schultz et al. *(18)* introduced a framework for conducting a safety effectiveness evaluation. This framework includes five steps: 1) determine study focus area, 2) select the suitable analytic method, 3) collect and reduce input

data, 4) review and validate results, and 5) improve future decision making and policy development. The results of an effectiveness evaluation can be used to develop CMFs. The CMFs developed can be applied during decision-making processes. Moreover, the outcomes of the evaluation methods can also be used to assess how well safety improvement funds have been invested.

As both Core Competency 3 and Core Competency 4 are related to data analytics and engineering concepts, a majority of the safety-related courses incorporate the learning competencies described in these two core competencies.

Core Competency 5: Develop, Implement, and Administer a Highway Safety Management Program

The final core competency focuses on the capability to develop and manage a road safety management program. While most of the recommended skills associated with this core competency are broadly related to institutional level issues, there is a need for general understanding on this topic. For a technologically advancing society, agencies need to put emphasis on the importance of maintaining skilled staff and emerging technologies through professional development and technical upgrades. The necessary workforce skills for this core competency are depicted in Table 10.

Table 10. Establishing and Maintaining a Highway Safety Program – Core Competency

Promote	Identify	Explain	Recognize	Utilize
Establish and promote **multidisciplinary relationships** necessary to support effective highway safety initiatives	Identify opportunities for internal and external **coalition-building and strategic communications** for highway safety initiatives	Identify **strategies to integrate and amplify safety** in transportation planning processes	Recognize and understand the **value of leveraging resources** for highway safety program implementation	Utilize **scientific management techniques** in planning, implementing, and evaluating highway safety programs
Assess and promote **effective outreach**/public involvement program development and implementation	Identify **sources of current research** that support effective highway safety management	Explain the need to **provide leadership and funding** for ongoing service/support enhancements such as professional development, staff education and training, upgraded computer hardware and software		

Generally, a highway safety management system has three levels: institutional management functions, interventions, and results. Some of the key functions of highway safety management include: (1) focus, (2) coordination, (3) legislation, (4) funding and resource allocation, (5) promotion, (6) monitoring and evaluation, (7) research, development and knowledge transfer. Interventions are designed to comprise system-wide strategies and programs to address a safety target by focusing on: (1) planning, design, and operation of the road network, (2) the entry and exit of vehicles and users into and out of the road network, and (3) the recovery and rehabilitation of crash victims.

Results of a highway safety management system are expressed as long-term objectives and interim quantitative goals. In general, the results include social costs, financial outcomes, intermediate outcomes, and outputs. The result's target hierarchy of a safety management system can be outlined as:

- To reduce the socio-economic costs of traffic crashes,
- To maintain the required reductions in the numbers of fatalities and serious injuries,
- To determine intermediate outcomes that are consistent with the targeted safety improvement in final outcomes, and
- To provide institutional delivery outputs such as the enforcement outputs in determining intermediate outcomes.

Highway safety improvement is not achieved solely by one component but a series of evaluations, decision making, and coordination within a highway safety management program. Because developing and managing a highway safety program takes place at an institutional level, according to NCHRP Research Results Digest 302, its objectives should focus on the multidisciplinary viewpoint of safety and the increasing significance of partnerships and possible cost-sharing prospects *(3).* Agencies are required to focus on the importance of maintaining a skilled and knowledgeable workforce. Thus, it is also important for highway safety professionals to establish multidisciplinary relationships.

EMERGING TECHNOLOGIES

Emerging technologies can promote efficiency and safety in roadway operations by increasing the roadway capacity. There is a wide variety of emerging technologies in the transportation field, including internet of things (IoT), big data analytics, cloud computing, immersive technologies, and artificial intelligence. This wave of innovative technologies has the potential to become the primary mode of observing, comprehending, and analyzing transportation systems to evaluate them and make them safer and more sustainable. To build an adaptable and competent workforce, there is a need to continually train transportation workers for new technologies. The rapid advancement and rise in technologies along with the increased demand for technical personnel in data-related fields calls for an increasing emphasis on multi-disciplinary technical skills and core competencies related to emergency technology. The learning objectives of core

competencies are required to embrace the recent technological advancements. Specific courses and trainings are needed to help the workforce to get familiar to evolving technologies in the field.

Given the rapid advancement of emerging technologies in the transportation field, the required knowledge and skills for transportation safety professional now includes a wide range of subject areas. For this reason, highway agencies must constantly look for advanced workforce development opportunities to improve the skillsets of their workforce. Several key emerging technologies are explained below. Familiarity of these technologies are crucial for the future transportation workforce.

Connected and Autonomous Vehicles

Connected and autonomous vehicles (CAVs) aim to transform communities, and lives. CAV technology has the potential to increase a road's vehicle capacity and safety. Vehicles communicating with each other are expected to be able to travel closer together and more safely than the conventional human-driven vehicles (see Figure 5).

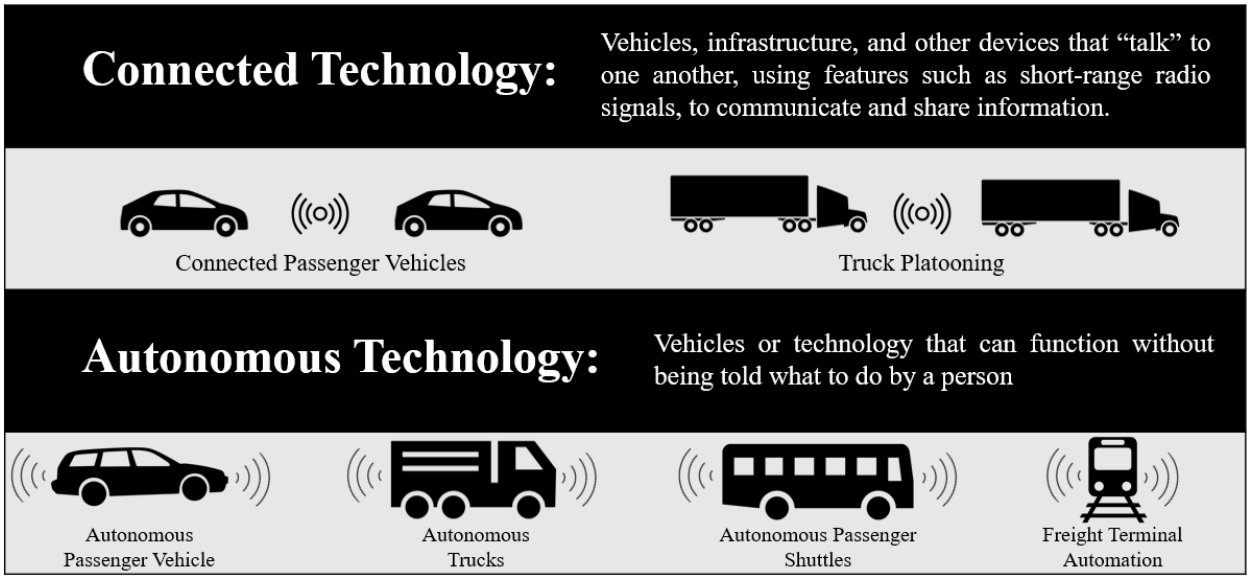


Figure 5. CAV technologies.

On the other hand, automated vehicles may ultimately make driving more convenient and less expensive, resulting in an overall increase in the number of vehicles on the roadways. The USDOT has been supporting the advancement of connected vehicle technology with a pilot deployment program. The USDOT recently published Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles (AV) 4.0. AV 4.0 expands the scope to 38 relevant United States Government components that have direct or tangential equities in the safe development and integration of AV technologies.

V2X Technology and Safety Band

Vehicle-to-Everything (V2X) technology is direct, device-to-device wireless messaging between vehicles, infrastructure and mobile devices—and uses 75 MHz of spectrum located at 5.9 GHz (termed as the Safety Band) to support safety communications. Interacting via the interference free Safety Band, these high-precision devices enable communications between vehicles and infrastructure, and transportation systems components can significantly improve safety and mobility. The Safety Band can be used for the following:

- Traffic monitoring and signal control
- Automatic toll collection
- Congestion detection
- Emergency vehicle signal preemption of traffic lights
- Red-light violation warnings
- Reduced speed zone warnings
- Curve speed warnings
- Spot weather-impact warnings and other safety-critical applications
- Travelers' alerts

Internet of Things

The IoT indicates networks of physical devices, including vehicles, home appliances and traffic-control systems, that are embedded with low-cost sensors and actuators for data collection, monitoring, decision-making and process optimization. In the transportation sector, the concept of Intelligent Transport Systems (ITS) has long been established. The rising number of IoT devices also increases security risks due to the abundance of less secure software in the connected devices. There is a need for skilled workforce with experience in IoT and cybersecurity for the safe and secure transportation system.

Artificial Intelligence

Artificial intelligence (AI) is a set of related technologies that make machines do things that would require intelligence if done by humans. AI systems are mainly designed for precision improvement. As the safety engineers aim to develop precise models with high prediction accuracies, AI models can be instrumental in achieving this goal. The AI-driven results can help the agencies in targeting roadways and associated safety treatments more accurately. The common concern of the AI concept is the lack of interpretation due to the black box algorithms in the trained models. However, there is significant advancement in explainable and trustworthy AI algorithms which can provide adequate interpretation of the developed models.

Micromobility and Ride-sharing Services

Micromobility options such as bike sharing and e-scooter sharing have been rapidly growing in the recent years, while other "disruptive" companies like Uber and Lyft are also altering the

mobility patterns. Future safety engineering should incorporate these disruptive technologies while performing safety analysis.

Immersive Technologies

Immersive technologies, also known as virtual reality (VR) and augmented reality (AR), distort the border between the physical and simulated environment to create a sense of immersion. The advancement of VR can transform the transportation sector by creating real-time VR to provide safety critical information to the roadway users.

INFORMATION REVIEW ON AVAILABLE COURSES

The 2011 report, prepared for NCHRP 20-07 (Task 290), provides a comprehensive list of course materials for highway safety professionals *(4).* This report documents 184 courses. Approximately 55 percent of the courses were developed by Local Technical Assistance Program (LTAP), National Highway Institute (NHI), and Institute of Transportation Engineers (ITE) for professional development. Only 13 of these courses were graduate/undergraduate level full semester courses, and 14 of these courses were part of the continued educational program of universities. As this report was prepared in 2011, many of these courses and relevant metadata were unavailable in 2021.

The research team conducted an extensive search to generate a list of available training opportunities for transportation safety professionals in the United States. At first, the team assembled a comprehensive list of courses. After careful observation, some of the courses were removed from the list because the content of the courses did not appear to cover many of the core competency topics or contained material restricted to a particular subject area. Table 11 lists 36 identified courses that were developed for semester-long courses by universities.

Table 11. List of Semester Long University Courses

No.	Course name	Institute
1	CVEN 626: Highway Safety	Texas A&M University
2	CE 552: Traffic Safety, Operations, and Maintenance	Iowa State University
3	Accident Investigation & Reconstruction	Michigan State University
4	CE 576: Traffic Safety	University of Idaho
5	CE 509: Highway Safety	North Carolina State University
6	CIV ENGR 574: Traffic Control	University of Wisconsin-Madison
7	CEE 763: Traffic Safety	University of Nevada-Reno
8	CE 556: Transportation Safety Analysis	Oregon State University
9	CE 528: Transportation Safety Analysis	Penn State University
10	Roadway Safety 101	University of Toronto

Table 11. List of Semester Long University Courses (continued)

No.	Course name	Institute
11	CE 635: Highway Safety.	University of Kentucky
12	TBA 4320: Traffic Safety and Risk Evaluation	Norwegian University of Science and Technology
13	Accident Analysis and Prevention	University of Leeds
14	CE 5803: Explicit Consideration of Safety in The Transportation Planning Process	University of Colorado
15	CE 579: Transportation Safety Systems	Southern Illinois University Edwardsville
16	Road Traffic Injury Prevention and Control in Low- and Middle-Income Countries (RTIP)	Johns Hopkins International Injury Research unit
17	Global Road Safety Leadership Course	Johns Hopkins International Injury Research unit
18	MTSA 8000: Introduction to Road Safety	Clemson University
19	MTSA 8420: Road Safety Culture	Clemson University
20	MTSA 8300: Road Safety Management	Clemson University
21	MTSA 8150: Transportation Safety Engineering	Clemson University
22	CRP 8130: Fundamentals of Transportation Safety Planning	Clemson University
23	TR-GY 7033: Multimodal Transportation Safety	New York University Tandon School of Engineering
24	CEE 6255: Transportation Safety	Utah State University
25	CE 872: Transportation Safety	Kansas State University
26	OESH 226 Transportation Safety	University of North Dakota
27	Highway Safety Fundamental Course	University of Louisiana at Lafayette
28	TTE 6315: Traffic Safety Analysis	University of Central Florida
29	CEE 4684: Transportation Safety	Virginia Polytechnic Institute and State University
30	Traffic Safety and Human Behavior	University of the Negev, Beersheba, Israel
31	CE 614: Statistical and Econometric Methods I	University of South Florida
32	CIVL 440: Transportation Engineering II	The University of British Columbia
33	CVEN9421: Transport Logistics Engineering	The University of New South Wales
34	ENG 30010: Traffic and Road Safety Engineering	Southern Cross University, Australia
35	CEG 8410: Road Safety	Newcastle University

Table 12 lists the most relevant short courses (23 courses) developed by different institutes. Additional details of these courses are provided in Table 17 through Table 19 in the appendix. The general findings from the identified courses, based on the five core competencies, are described below:

- Core Competency 1: A majority of the courses include some of the key learning objectives of this competency. However, some learning objectives such as combining countermeasures, multidisciplinary collaboration, and potential barriers are not incorporated in many of these courses.
- Core Competency 2: Road safety history and legislation are generally briefly discussed in the identified courses.
- Core Competency 3: A majority of the courses include the key learning objectives of Core Competency 3.
- Core Competency 4: A majority of the courses include the key learning objectives of Core Competency 4. Courses that are focused on statistical and machine learning methodologies, however, provide training on the development of predictive models in a way to identify the contribution of the key factors. Many of these courses also cover observational before-after studies to determine the effectiveness of the countermeasures.
- Core Competency 5: A good highway safety management program is essential to prevent traffic injuries, effectively invest public money in improving safety, and generate valuable results for long-term objectives. Highway safety professionals should have the ability to properly develop and manage a safety management program. Many of the learning objectives in this core competency do not appear consistently in the available courses.

Table 12. List of Short Courses

No.	Course name	Institute
1	CEG 8410: Road Safety	Newcastle University
2	Incorporating Safety into the Highway Design Process - Introduction	Texas Transportation Institute
3	Incorporating Safety into the Highway Design Process: Urban / Suburban Arterials	Texas Transportation Institute
4	Incorporating Safety into the Highway Design Process: Multilane and Freeways	Texas Transportation Institute
5	Fundamentals of the Highway Safety Manual Predictive Method	Institute of Transportation Engineers
6	Predicting Crash Frequency on Rural Highway	Institute of Transportation Engineers
7	Predicting Crash Frequency on Urban and Suburban Arterials	Institute of Transportation Engineers
8	Highway Safety Improvement Program Manual	National Highway Institute
9	Fundamentals of Highway Safety Series	National Highway Institute
10	Interactive Highway Safety Design Model (IHSDM); NHI course FHWANHI-380071	National Highway Institute
11	HSM Applications for Two-Lane Rural Highway Intersections	FHWA Resource Center
12	HSM Applications to Project Identification	FHWA Resource Center
13	Intersection Safety	Florida Transportation Technology Transfer Center
14	A Short Course on Safety Performance Functions (SPFs) and Safety Analysis Techniques	Illinois Center for Transportation
15	Highway Safety Manual Workshop – Predictive Method Training	Kittelson & Associates, Inc.
16	Highway Safety Fundamentals: Countermeasure Selection	Virginia Local Technical Assistance Program (LTAP)
17	Highway Safety Fundamentals: Evaluating Countermeasures	Virginia Local Technical Assistance Program (LTAP)
18	Highway Safety Fundamentals: Identifying Hazardous Sites	Clemson University
19	Safety Analyst Software Tools	Clemson University
20	HSM Applications to HSIP	FHWA Resource Center
21	New Approaches to Highway Safety Analysis	National Highway Institute
22	Data & Analysis Technical Assistance Program Technical Webinar: Systemic Safety Approaches	Clemson University

EXAMPLE COURSES

Roadway Safety 101 Course

The NCHRP Report 667 presents 'Road Safety 101' course materials, including the instructor's guide and student workbook *(19).* The course presents the required core competencies for transportation safety professionals.

Road Safety 101 is an introductory curriculum that involves a range of teaching techniques including instructor-led webinars, self-paced online learning, and face-to-face seminars in the classroom. It teaches the key core competencies connected with road safety as described by a large group of multidisciplinary experts, including experts in engineering, road safety, public health, public policy, research, information, and analysis.

The instruction of the course begins with a two-hour teleconference introduction. It includes the following exercises and topics:

- Introductions,
- Course purpose and background,
- Syllabus overview,
- Pre-test instructions, and
- Homework assignments and drills for the pre-seminar.

The pre-test can be administered online or during the seminar's first session. The course includes a three-day seminar in a classroom setting. Methods of instruction include lectures, facilitated discussion, guest lectures, group activities, and group exercises. A course final exam can be administered in the classroom or online after the face-to-face seminar.

The course consists of five modules and includes multiple areas of study such as traditional science, engineering, public health science, quality information and data systems, data-driven road safety approaches, and the significance of professional assistance for science-based approaches. The first module provides insights into the nature of road safety and does the following:

- Defines road safety as a complex, multidisciplinary, multi-modal area dedicated to preventing and/or mitigating casualties, crashes, and fatalities.
- Addresses various perspectives for defining crash dynamics and models for understanding and explaining crashes.
- Describes the demographic trends that underlie the need for extensive and integrated management of road safety.
- Recognizes the influence of road design and activities, the local environment and vehicle design on road user decisions.
- Describes and values scientific research on road safety and its implementation as vital to further advancement in the field of road safety.

- Demonstrates the use of instruments, such as statistical modeling, the Australian model, the Haddon Matrix, engineering research, and road safety audits or evaluations to identify the efficient measures for road safety.

The second module offers insights into the history of road safety management and organizational structures, as well as the following:

- Identifies regulatory measures, program and distribution structures, research projects and other variables that have influenced the methods of road safety management.
- Describes the organizational roles and obligations of federal / state / local governments, private/non-profit organizations, professional associations, and research agencies that are responsible for managing safety.
- Describes the opportunities available in the United States for road safety education and training, as well as identifying, accessing and sharing funding to support road safety initiatives.

The third module offers insights into the origin, traits, and uses of crash data. It also describes the state, local, and national data, information systems used in road safety management, as well as the process of collecting and using crash data in road safety management.

The fourth module addresses contributing crash factors and the assessment and choice of countermeasures. Furthermore, it does the following:

- Identifies significant motor-vehicle crash factors (such as human crash factors, road crash factors, vehicle crash factors, and environmental crash factors) and explains how they interact.
- Applies scientific concepts to the identification of road safety issues, the selection and assessment of countermeasures, and the exposure to the safety performance function (SPF).
- Identifies present and potential road safety issues (such as high-risk sites, comparable sites, promised sites, crash types and action motives) using appropriate research approaches.
- Uses research and suitable techniques (such as Site / Road Segment Review Methods, Countermeasure Selection Resources, Comparison Tools, and Market Research) to select efficient countermeasures and target varied cultural and geographical populations.
- Prioritizes procedures and countermeasures based on performance measures (e.g., benefit-cost ratio, CMFs, pre-analysis, regression-to-mean).

The final module provides the articulated management of the road safety program and multiple program-related elements. In addition, the module:

- Provides a wide background on transportation planning by defining policies to integrate and enhance safety in transportation planning.
- Describes basic organizational leadership and support requirements for effective and efficient management of road safety.

- Identifies strategies to establish and maintain efficient cooperative multidisciplinary relationships and coalitions.
- Develops possibilities to encourage change through efficient methods of communication and outreach. It also identifies the sources of present studies that promote efficient management of road safety.

Development of a Highway Safety Fundamental Course

In Sun's 'Development of a Highway Safety Fundamental Course' project, she developed a comprehensive training module package (with PowerPoint slides and quizzes and questions) for undergraduate and graduate students in civil engineering *(20).* The course covers seven topics: introduction to highway safety, basic safety concepts, safety data, fundamental statistics, development of predictive models, discussion of HSM models, and safety evaluation (see Table 13).

Table 13. Outline of Key Topics

Topic	Objectives	Content
Introduction to Road Safety		
Traffic Crash—a global underemphasized problem	Be familiar with the gravity of the problem	Crash statistics (global, U.S. and the state) Comparing traffic crashes with other types of fatalities
Impact of crashes on a society	Recognize the multidimensional aspects of safety	Public health problem Economic problem Liability problem Social problem
Dissecting a crash	Identify influential and contributing factors to a crash and its severity	Basic crash mechanism Haddon matrix How roadway, vehicle, and environmental conditions contribute to a crash occurrence and its severity
Introduction to 4E approach	Understand the significance of 4E approach	Roadway users' characteristics Vehicles characteristics Roadways characteristics Environment Emergency service
Basic Safety Concepts		
Defining Safety	Understand the scientific definition of safety	How do customers define safety Objective safety and subjective safety Safety definition
Safety Data		
Safety Related Data	Understand how the crash data can be used to measure safety and the issues related to crash counts	• Regression to the mean • Issues with the data quality • Direct measurement • Surrogate measurement

Table 13. Outline of Key Topics (continued)

Topic	Objectives	Content
Fundamental Statistics		
Fundamental Statistics	Refresh fundamental statistics related to safety analysis	• Mean and variance estimation • Accuracy and standard error • Related probability distribution faction • Introduction to Empirical Bayes method
Development of Predictive Models		
Introduction	Understand the purpose, development history and issues in safety models	• The need for safety predictive models in project decision making process • Introduction to parametric and non-parametric modeling techniques • Conceptual safety predictive model
Development of Safety Models	Understand the basic steps in safety modeling process and be able to develop models with local crash data	• Data cleaning process • Exploratory data analysis • Formulating model structure • Parameter estimation • Model fitness evaluation
Safety Predictive Models from HSM		
Safety Predictive Models from HSM	Be familiar with the safety models for three types of highways for potential safety management applications.	
Safety Evaluations		
Introduction to safety evaluation	Understand the purpose and requirements for safety evaluation	Safety evaluation objectives and definitions
Methodology	Understand the correct way to do safety evaluation and apply the fundamental concept in roadway safety to estimate safety of a project or crash countermeasure	• The logical basis for safety evaluation • General evaluation types • Observational nature of roadway safety evaluation • Before-and-after study • Cross-sectional study
Case studies	Be able to perform safety evaluation analysis	• Atchafalaya I-10 Speed study • Lane conversion (4U to 5T) study

Source: Sun, 2015 (20)

SAFETY FUNDAMENTALS TEXTBOOK

The FHWA sponsored development of a "Road Safety Fundamentals" textbook that can be used to complement the safety courses (*21*). This resource is available for free download (see https://rspcb.safety.fhwa.dot.gov/RSF/default.aspx). This textbook synthesizes content by compiling information into five units. Collectively this information focuses on two target audiences: 1) professionals with jobs that include some aspect of transportation safety, and 2) university professors and students who can focus on the entire document or reduce information to one or more of the available units. Table 14

Unit 1 introduces foundations for road safety. This content includes

Table 14. Format of the Road Safety Fundamentals Textbook

Unit 1: Foundations of Road Safety
Chapter 1: Context of Road Safety
Chapter 2: Road Safety Through the Years
Chapter 3: Multidisciplinary Approaches
Chapter 4: Road Users
Unit 2: Human Behavior and Road Safety
Chapter 5: Understanding Human Behavior
Chapter 6: Changing Human Behavior
Unit 3: Measuring Safety
Chapter 7: Importance of Safety Data
Chapter 8: Types of Safety Data
Chapter 9: Improving Safety Data Quality
Unit 4: Solving Safety Problems
Chapter 10: Road Safety Management Process
Chapter 11: Site-Level Safety Management
Chapter 12: System-Level Safety Management
Unit 5: Implementing Road Safety Efforts
Chapter 13: Who Does What
Chapter 14: Road Safety Research
Chapter 15: Strategic Communications
Chapter 16: Advancing Road Safety

Source: https://rspcb.safety.fhwa.dot.gov/RSF/default.aspx

CERTIFICATIONS

The Transportation Professional Certification Board (TPCB) developed two Road Safety Professional (RSP) Certifications known as the RSP1 and RSP2. The goals of these two RSP certifications are to establish a recognized level of practice and knowledge and to incentivize roadway safety education.

Road Safety Professional Level 1

The Level 1 RSP certification demonstrates proficiency in the foundations of road safety principles. Table 14 lists the examination format and content of RSP1.

Table 15. Exam Format and Content of RSP1

Define	Identify	Explain / Describe
Domain 1: Foundations of Road Safety		
Define road safety by using an approved reference source	• Road safety partners including disciplines and agency types. • Road safety-relevant characteristics for varying road users.	• Evidence-based road safety including the distinction of nominal vs. substantive safety. • Complexity of road safety including elements that are involved in crash causation and influence the outcome severity. • Different approaches to road safety management. • Ways to balance safety with other transportation goals. • Elements and techniques to foster a road safety culture. • Developments in policy and technology that will influence road safety.
Domain 2: Measuring Safety		
	• Types, applications, and users of safety data including use of nontraditional safety data. • Primary components of quantitative safety analysis.	• How safety data quality leads to more effective programs, projects, initiatives, and investments. • How key factors may impact the frequency and severity of crashes.
Domain 3: Human Behavior and Road Safety		
	• Key characteristics and limitations of human behavior that influence how road users interact with the roadway environment.	**<u>Statements refer to modifying human behavior:</u>** • Multidisciplinary safety strategies. • Effective educational strategies and their benefits and limitations. • Key characteristics of effective enforcement campaigns and their benefits and limitations. • How influence of roadway infrastructure features and elements. • Why human factors should be explicitly considered in the safety assessment process. • How applying positive guidance principles to road elements can be used to improve safety performance.

Table 15. Exam Format and Content of RSP1 (continued)

Define	Identify	Explain / Describe
Domain 4: Solving Safety Problems		
Understand collision patterns and crash contributing factors.	• Steps in a safety management process that apply effective data driven. • A systemwide approach. • Reliable multidisciplinary countermeasures to reduce fatalities and serious injuries. • Advantages and disadvantages of tools used to diagnose safety problems. • Impacts of using data to evaluate countermeasure performance. • Techniques for estimating and comparing the safety performance of alternatives.	• How multidisciplinary approaches can be used to deploy the most effective solutions. • Opportunities for user-focused interventions targeted at different populations. • How countermeasure costs and benefits can be used to evaluate the effectiveness of program and project investments.
Domain 5: Implementing Road Safety Programs		
	• Elements of successful communication and outreach strategies that build consensus among decision-makers and lead to increased public acceptance /awareness about road safety initiatives. • Important elements of successful road safety policies and programs.	• How strategic safety plans are prepared and used. • The role and value of champions in influencing road safety policies and programs. • How multidisciplinary teams and partnerships can achieve road safety goals. • The value of safety program evaluation and how results influence future program delivery.

Source: https://www.tpcb.org/certification/rsp1/exam-format-and-content/

Road Safety Professional Level 2

The TPCB Level 2 RSP certification expands on the RSP1 certification by demonstrating more comprehensive safety expertise for behavioral and infrastructure specialties. The RSP2 is targeted towards transportation professionals with roadway safety as their primary job function. Table 15 lists the examination format and content for the behavioral specialty exam. Table 16 similarly summarizes the infrastructure specialty and associated exam format.

Table 16. Format and Content for RSP2 Behavioral Specialty Exam

Define	Identify	Explain / Describe
Behavior Domain 1: Fundamentals		
Define the safety and risk of a unit and explain how they differ.		• Crash injury severity scales and levels. • What makes a crash reportable. • Application of crash frequency and crash rates. • Behavioral adaptation and impacts. • How to estimate crash costs. • Elements of cost-effectiveness versus cost-benefit analysis.
Behavior Domain 2: Road Safety Program Management		
	• Compare motor vehicle crashes to other major causes of death. • Identify and diagnose crash contributing factors using qualitative and quantitative safety data analysis. • Identify traditional and non-traditional stakeholders related to countermeasure selection. • Identify continuous monitoring and oversight of behavioral safety project components. • Identify programmatic and financial criteria related to behavioral safety programs.	• Implement road safety management process. • Apply Haddon Matrix. • Describe proactive versus reactive approach to problem identification. • Select and apply promising evidence-based countermeasures. • Describe post implementation program or project evaluation. • Describe how strategic safety plan and project plan differ. • Explain differences between impact, outcome, and process evaluation. • Describe how safety education programs and social marketing campaigns differ. • How human limitations associated with information processing lead to expectations and can contribute to varying crash types.
Behavior Domain 3: Safety Data and Analysis		
	• Alternative data sources and their associated analysis methods. • Public knowledge, attitudes, and behavior related to safety concerns and respective countermeasures.	• Transportation safety data and their respective sources and significance. • How to integrate data to improve decision making. • Ways to analyze crash datasets. • Communication and outreach efforts associated with behavioral safety. • Crash data development process. • Constraints and challenges using safety data and understanding any data limitations. • Crash trend analysis techniques. • Interventions used to improve safety based on quantitative and qualitative analysis. • Impacts gaps in data have on decision making and countermeasure selection.

Table 16. Format and Content for RSP2 Behavioral Specialty Exam (continued)

Define	Identify	Explain / Describe
Behavior Domain 4: Target Crashes and Countermeasures		
	• Type, features, and selection strategies for evidence-based countermeasures.	• Countermeasure selection rationale. • Other factors that may influence countermeasure effectiveness and outcome.
Behavior Domain 5: Human Health and Transportation Modes		
Crash avoidance versus crash worthiness.	• Measures that can help to reduce crash forces and improve survivability. • Health risks other than crashes and mitigation strategies. • Most common crash contributing factors. • Most common high-risk behaviors.	• Physics associated with a crash including how these forces differ per user type. • How design influences operating speed. • How operating speed influences road user. • Impairments and their influence on driver performance. • Diminished or limited cognitive or physical capacities and appropriate accommodations.
Behavior Domain 6: Public Health and Transportation Safety		
	• Conditions where multiple countermeasures are used together to influence highway safety. • Candidate education and outreach methods to improve safety for varying users.	• Strategies for successful public health campaigns. • Effects of public outreach or education campaign. • Emergency response strategies to improve occupant survival. • Use of health data for safety analysis. • Limitations of education and public outreach related to influencing behavior change. • Role of crash severity in prioritization and identification of safety strategies. • Role of injury prevention professionals at all levels. • Application of mortality and morbidity data for injury prevention. • Use of injury surveillance data to determine ways to prevent traffic crash injuries. • How public health campaigns can influence safety culture.

Table 16. Format and Content for RSP2 Behavioral Specialty Exam (continued)

Define	Identify	Explain / Describe
Behavior Domain 7: Addressing Safety Problems with Public Policy (Law, Regulation, Policies, and Standards)		
	• Public policy measures that can help address target crashes.	• Major transportation safety policy in North America. • How public policy influences behavior and safety of road users. • Process to develop a public policy based on identified safety problem. • Varying costs associated with policy countermeasures. • Influence of zero-based initiatives on policy development. • How funding policy can impact transportation safety project implementation. • Relationship between policy, education, and behavior change. • Methods where data, research, and other information types can help advance safety policy initiatives.
Behavior Domain 8: Strategic Safety Planning		
Essential components of a strategic safety plan.		• Roles of stakeholders in development and application of strategic safety plan. • Alignment of transportation plans with strategic safety plans. • Multidisciplinary, multi-agency approach to strategic safety plan development.
Behavior Domain 9: Safe System Approach		
Guiding principles of a Safe System approach.	• Role of system owners, users, and other stakeholders in creating Safe System approach. • Key elements required to implement a Safe System approach.	• Safe impact speeds as applied to a Safe System approach. • Interactions between stakeholders to successfully manage a Safe System approach.

Source: https://www.tpcb.org/certification/road-safety-professional-2/behavior-domains/

Table 17. Format and Content for RSP2 Infrastructure Specialty Exam

Define	Identify	Explain / Describe
Infrastructure Domain 1: Fundamentals		
Risk and associated uses.	• Limitations of crash rate. • Strengths and limitations of crash reporting.	• Crash frequency, crash rate, predicted crashes, expected crashes, and excess crashes. • Apply predictive analysis techniques. • Differences between road safety metrics and risk. • Crash injury severity scales and levels. • What makes a crash reportable. • Physics of a crash. • Influence of speed on crash frequency and severity. • Posted speed effects compared to operating speed. • How human limitations influence driver performance and driver expectations. • Positive guidance for roadway design. • Human factors and how they contribute to crash types. • Nominal versus substantive safety. • Crash cost estimation. • Elements of economic analysis in policy and project development.
Infrastructure Domain 2: Road Safety Management		
	• Network screening options. • Identify candidate treatments for sites selected during diagnosis.	• Strengths and weaknesses of spot speed analysis. • Roadway safety and systemic analyses. • Application of network screening at select locations. • Strengths and weaknesses for safety diagnosis methods. • Diagnose safety performance for selected locations. • Conduct economic appraisal for location-specific and systemic perspective. • Rank prioritized safety projects based on different methods. • How to integrate safety considerations into projects. • Pitfalls of single project evaluation. • Strengths and weaknesses of various safety effectiveness treatments.

Table 17. Format and Content for RSP2 Infrastructure Specialty Exam **(continued)**

Define	Identify	Explain / Describe
Infrastructure Domain 3: Acquiring and Using Safety Data		
	• Key characteristics of various crash types. • Level of detail acquired from crash reports to support safety management process. • Potential errors in safety data analysis process.	• Relevant safety data and sources. • Data needs for roadway safety management. • Linkage of safety data to other data sources. • Analyze data sets for safety evaluation. • Crash data processing (initial to final). • Constraints and challenges or using safety data.
Infrastructure Domain 4: Crash Prediction and Trend Interpretation		
	• Suitable statistical methods for safety analysis. • How and where to consider potential points of treatment.	• Random nature of crashes and interpretations of data trends and regression to the mean. • Attributes of statistical methods and how to interpret findings. • Temporal effects of safety trends. • Development of safety performance functions and related calibration efforts. • When to use predicted versus expected crash frequency.
Infrastructure Domain 5: Target Crashes and Countermeasures		
	• Countermeasure sources (online, research studies, guidelines). • Process for applying crash modification factors (CMF).	• Types and characteristics of evidence-based countermeasures. • Selecting suitable target crash type and severity level. • Data requirements for evaluating countermeasures. • Research-based countermeasure effectiveness. • Selection of countermeasure and CMF for specific application. • Considerations other than safety effectiveness that influence countermeasure selection. • Factors for applying more than one treatment at the same location. • Issues selecting or developing CMFs.
Infrastructure Domain 6: Multimodal Transportation Safety		
Speed management strategies affecting safety.	• Mobility and safety tradeoffs for multimodal systems.	• Safety effects of operating speed for all users. • Relationship between design characteristics and safety performance. • Operational parameters and related safety effects for all users. • Crash contributing factors for all users. • Human factors at multimodal facilities.

Table 17. Format and Content for RSP2 Infrastructure Specialty Exam (continued)

Define	Identify	Explain / Describe
Infrastructure Domain 7: Addressing Safety Problems with Policy		
	• Public policy measures that can help address target crashes.	• Major transportation safety policy in North America. • How public policy influences behavior and safety of road users. • Process to develop a public policy based on identified safety problem. • Policies outside of North America that have improved road safety. • How funding policy can impact transportation safety project funding. • Relationship between policy and behavior change.
Infrastructure Domain 8: Safe System and Vision Zero Approaches		
	• Key principles and strategies of Safe System and Vision Zero. • Key steps and challenges to implement Safe System and Vision Zero approaches.	• Role of responsible parties in Safe System and Vision Zero initiatives. • Impact of Safe System and Vision Zero on engineers, behavioral safety professionals, and planners. • Development of a strategic road safety plan within the Safe System and Vision Zero approaches.

Source: https://www.tpcb.org/certification/road-safety-professional-2/infrastructure-domains1/

CHAPTER SUMMARY REMARKS

Core competencies in transportation safety represent critical skills and capabilities necessary for transportation professionals to make key safety decisions. While the core competencies do not represent *all* of the knowledge and skills necessary for a safety professional to be successful, there are five core competencies that have been identified as necessary for transportation safety professionals. These include:

- Core Competency 1: Multidisciplinary Nature of Safety
- Core Competency 2: History and Institutional Setting for Safety Management
- Core Competency 3: Multidisciplinary Nature of Safety
- Core Competency 4: History and Institutional Setting for Safety Management
- Core Competency 5: Multidisciplinary Nature of Safety

Emerging technologies can promote roadway safety and efficiency by removing some of the driver error and increasing roadway capacity. Examples of emerging technologies in the transportation field include connected and autonomous vehicles, V2X technology and Safety Band, IoT, artificial intelligence, and immersive technologies. Core competencies need to embrace recent technological advancements, and specific courses and training opportunities are

needed to provide the transportation safety professional workforce with relevant new skillsets and knowledge.

Various training opportunities, including short courses and semester-long university courses, are available for transportation safety professionals (see Tables 11 and 12). Examples include:

- *Road Safety 101*—An introductory curriculum that teaches key core competencies connected with road safety.
- *Highway Safety Fundamental Course*—A comprehensive course for undergraduate and graduate civil engineering students that includes:
    - Introduction to highway safety,
    - Basic safety concepts,
    - Safety data,
    - Fundamental statistics,
    - Development of predictive models,
    - Discussion of HSM models, and
    - Safety evaluation.
- FHWA's Road Safety Fundamentals textbook (see Table 14).
- TPCB's RSP Certification Program—establishes a recognized level of practice and knowledge and incentivizes roadway safety education (see Tables 15, 16, and 17).

CHAPTER 3. FRAMEWORK AND TOOL

INTRODUCTION

Roadway safety is a major focus of the FAST Act. Transportation safety professionals must have 'critical knowledge in the form of core competencies' to perform their work efficiently. The current workforce faces two critical issues: 1) the rise of emerging technologies requires new skillsets and knowledge, and 2) the loss due to trained and experienced professionals leaving the workforce with their wealth of knowledge and expertise.

In one of his earlier works, Ezra Hauer *(22)* identified two different workforces in the transportation safety engineering field: 1) the research related workforce, and 2) the non-research related workforce. This chapter provides a broad overview of the occupational descriptors of transportation-related jobs. It also includes the prototype framework and a tool to help highway agencies identify effective and efficient training and educational opportunities.

OCCUPATIONAL DESCRIPTORS

To understand the transportation engineering related job descriptions, this study examined job specifications and job postings within the transportation workforce at various levels through a well-validated dictionary of occupational descriptors (*23*). After an extensive search of transportation engineering jobs, the team identified the following four relevant titles and associated job descriptions:

- Traffic Technicians,
- Transportation Engineers,
- Transportation Managers, and
- Transportation Planners.

Table 18 through Table 21 lists the tasks associated with each job description. The task indicators explain the common job duties at various levels, and safety engineering is one of the critical components of these tasks.

Table 18. Transportation Engineering Job Descriptor – Traffic Technician

Traffic Technician Responsibilities
• Interact with the public to answer traffic-related questions, respond to complaints or requests, or discuss traffic control ordinances, plans, policies, or procedures. • Prepare graphs, charts, diagrams, or other aids to illustrate observations or conclusions. • Analyze data related to traffic flow, crash rates, or proposed development to determine the most efficient methods to expedite traffic flow. • Prepare work orders for repair, maintenance, or changes in traffic systems. • Plan, design, and improve components of traffic control systems to accommodate current or projected traffic and to increase usability and efficiency. • Study factors affecting traffic conditions, such as lighting or sign and marking visibility, to assess their effectiveness. • Gather and compile data from hand count sheets, machine count tapes, or radar speed checks and code data for computer input. • Measure and record the speed of vehicular traffic, using electrical timing devices or radar equipment. • Lay out pavement markings for striping crews. • Provide technical supervision regarding traffic control devices to other traffic technicians or laborers. • Operate counters and record data to assess the volume, type, and movement of vehicular or pedestrian traffic at specified times. • Place and secure automatic counters, using power tools, and retrieve counters after counting periods end. • Maintain or make minor adjustments or field repairs to equipment used in surveys, including the replacement of parts on traffic data gathering devices. • Visit development or work sites to determine projects' effect on traffic and the adequacy of traffic control and safety plans or to suggest traffic control measures. • Establish procedures for street closures or for repair or construction projects. • Provide traffic information, such as road conditions, to the public. • Monitor street or utility projects for compliance to traffic control permit conditions. • Develop plans or long-range strategies for providing adequate parking space. • Interview motorists about specific intersections or highways to gather road-condition information for use in planning.

Source: Occupational Information Network (23).

Table 19. Transportation Engineering Job Descriptor – Transportation Engineer

Transportation Engineer Responsibilities
• Check construction plans, design calculations, or cost estimations to ensure completeness, accuracy, or conformity to engineering standards or practices. • Design or prepare plans for new transportation systems or parts of systems, such as airports, commuter trains, highways, streets, bridges, drainage structures, or roadway lighting. • Confer with contractors, utility companies, or government agencies to discuss plans, specifications, or work schedules. • Design or engineer drainage, erosion, or sedimentation control systems for transportation projects. • Prepare project budgets, schedules, or specifications for labor or materials. • Plan alteration or modification of existing transportation structures to improve safety or function. • Investigate traffic problems and recommend methods to improve traffic flow or safety. • Estimate transportation project costs. • Present data, maps, or other information at construction-related public hearings or meetings. • Prepare administrative, technical, or statistical reports on traffic-operation matters, such as traffic crashes, safety measures, or pedestrian volume or practices. • Evaluate transportation systems or traffic control devices or lighting systems to determine need for modification or expansion. • Review development plans to determine potential traffic impact. • Inspect completed transportation projects to ensure safety or compliance with applicable standards or regulations. • Evaluate traffic control devices or lighting systems to determine need for modification or expansion. • Direct the surveying, staking, or laying out of construction projects. • Participate in contract bidding, negotiation, or administration. • Model transportation scenarios to evaluate the impacts of activities such as new development or to identify possible solutions to transportation problems. • Investigate or test specific construction project materials to determine compliance to specifications or standards. • Supervise the maintenance or repair of transportation systems or system components. • Inspect completed transportation projects to ensure compliance with environmental regulations. • Evaluate construction project materials for compliance with environmental standards. • Develop plans to deconstruct damaged or obsolete roadways or other transportation structures in a manner that is environmentally sound or prepares the land for sustainable development. • Analyze environmental impact statements for transportation projects. • Design transportation systems or structures, using sustainable materials or products, such as porous pavement or bioretention structures. • Develop or assist in the development of transportation-related computer software or computer processes.

Source: Occupational Information Network (23).

Table 20. Transportation Engineering Job Descriptor – Transportation Manager

Transportation Manager Responsibilities
• Plan, organize, or manage the work of subordinate staff to ensure that the work is accomplished in a manner consistent with organizational requirements. • Direct activities related to dispatching, routing, or tracking transportation vehicles, such as aircraft or railroad cars. • Monitor operations to ensure that staff members comply with administrative policies and procedures, safety rules, union contracts, environmental policies, or government regulations. • Serve as contact persons for all workers within assigned territories. • Implement schedule or policy changes for transportation services. • Monitor spending to ensure that expenses are consistent with approved budgets. • Promote safe work activities by conducting safety audits, attending company safety meetings, or meeting with individual staff members. • Prepare management recommendations, such as proposed fee and tariff increases or schedule changes. • Direct investigations to verify and resolve customer or shipper complaints. • Direct or coordinate the activities necessary to obtain use of equipment, facilities, or human resources. • Analyze expenditures and other financial information to develop plans, policies, or budgets for increasing profits or improving services. • Collaborate with other managers or staff members to formulate and implement policies, procedures, goals, or objectives. • Plan or implement energy saving changes to transportation services, such as reducing routes, optimizing capacities, employing alternate modes of transportation, or minimizing idling. • Direct staff performing repairs and maintenance to equipment, vehicles, or facilities. • Conduct employee training sessions on subjects such as hazardous material handling, employee orientation, quality improvement, or computer use. • Recommend or authorize capital expenditures for acquisition of new equipment or property to increase efficiency and services of operations department. • Conduct investigations in cooperation with government agencies to determine causes of transportation crashes, coordinate cleanup activities, or improve safety procedures. • Set operations policies and standards, including determining safety procedures for the handling of dangerous goods. • Develop criteria, application instructions, procedural manuals, or contracts for federal or state public transportation programs. • Develop or implement plans to improve transportation services control from regional to national or global load control center operations. • Direct central load control centers to maximize efficiency and effectiveness of transportation services. • Supervise clerks assigning tariff classifications or preparing billing. • Negotiate, authorize, or monitor fulfillment of contracts with equipment or materials suppliers. • Evaluate transportation vehicles or auxiliary equipment for purchase by considering factors, such as fuel economy or aerodynamics. • Identify or select transportation and communications system technologies to reduce costs or environmental impacts. • Provide administrative or technical assistance to those receiving transportation-related grants. • Direct procurement processes including equipment research and testing, vendor contracts, or requisitions approval. • Participate in union contract negotiations or grievance settlements.

Source: Occupational Information Network (23).

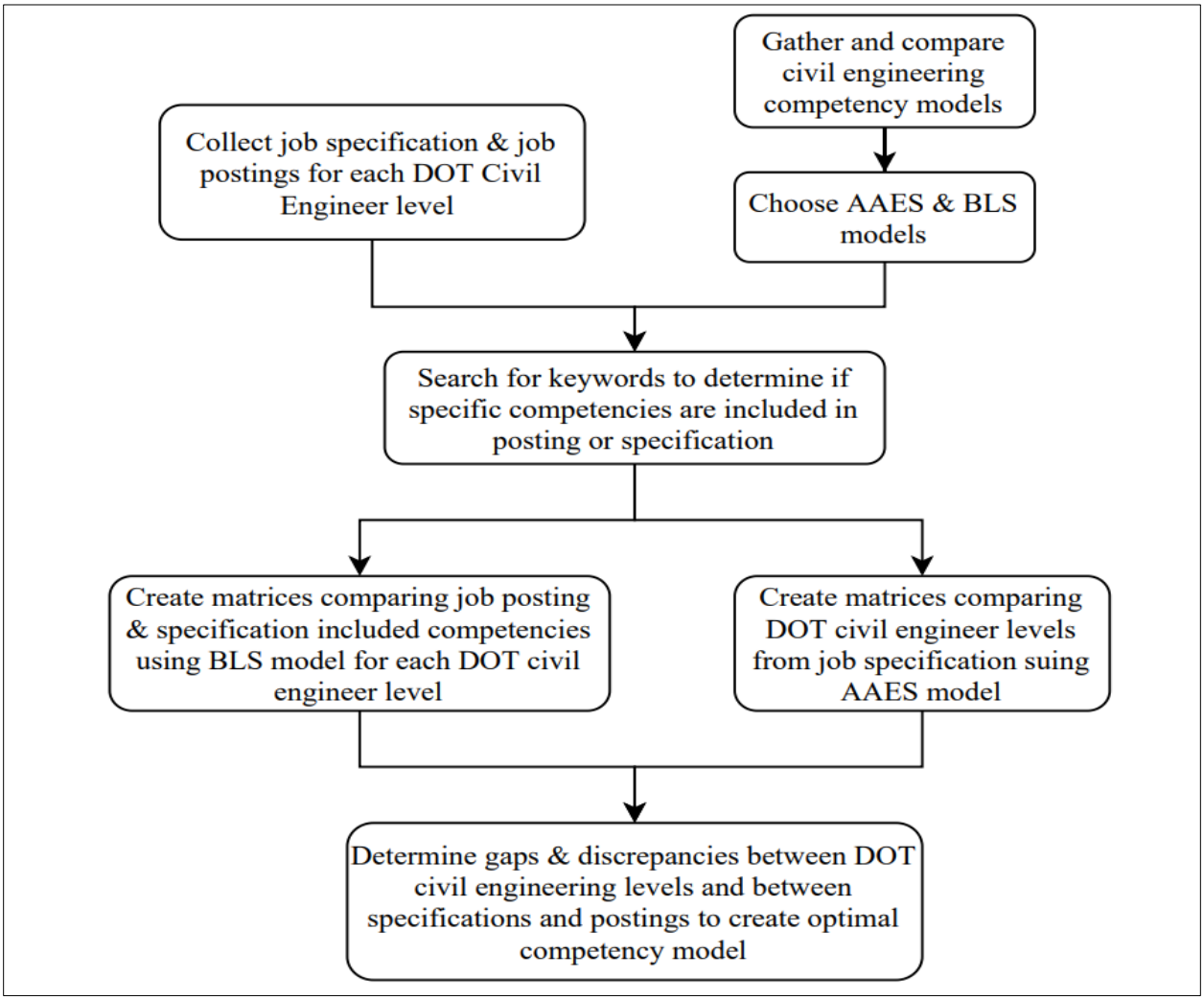
Table 21. Transportation Engineering Job Descriptor – Transportation Planner

Transportation Planner Responsibilities
• Recommend transportation system improvements or projects, based on economic, population, land-use, or traffic projections. • Define regional or local transportation planning problems or priorities. • Participate in public meetings or hearings to explain planning proposals, to gather feedback from those affected by projects, or to achieve consensus on project designs. • Design transportation surveys to identify areas of public concern. • Interpret data from traffic modeling software, geographic information systems, or associated databases. • Prepare reports or recommendations on transportation planning. • Design new or improved transport infrastructure, such as junction improvements, pedestrian projects, bus facilities, or car parking areas. • Analyze information related to transportation, such as land use policies, environmental impact of projects, or long-range planning needs. • Collaborate with engineers to research, analyze, or resolve complex transportation design issues. • Evaluate transportation project needs or costs. • Collaborate with other professionals to develop sustainable transportation strategies at the local, regional, or national level. • Prepare necessary documents to obtain planned project approvals or permits. • Develop computer models to address transportation planning issues. • Develop or test new methods or models of transportation analysis. • Prepare or review engineering studies or specifications. • Review development plans for transportation system effects, infrastructure requirements, or compliance with applicable transportation regulations. • Evaluate transportation-related consequences of federal or state legislative proposals. • Produce environmental documents, such as environmental assessments or environmental impact statements. • Represent jurisdictions in the legislative or administrative approval of land development projects. • Define or update information such as urban boundaries or classification of roadways.

Source: Occupational Information Network (23).

FRAMEWORK

To develop a framework for 'core competencies of highway safety professionals,' it is important to find critical gaps in the profession and develop mandatory training to overcome these gaps. Ryan et al. *(24)* explored civil engineering job positions to determine the critical gaps and formulate methods to overcome these gaps. Figure 6 illustrates the general framework of the study by Ryan et al.



Source: Ryan et al., 2009 (24)

Figure 6. Framework for Core Competencies in Civil Engineering.

Based on the job descriptors in Table 15 through Table 18, the research team created three major levels based on experience: 1) junior, 2) mid-level, and 3) senior. Note that the junior level includes mostly technical jobs, while the mid-level and senior level jobs can be broadly divided into two groups: management and technical. Table 19 shows a matrix that represents different job levels and associated learning objectives for the five core competencies.

Table 22. Levels of Job Categories and Key Core Competency Learning Objectives

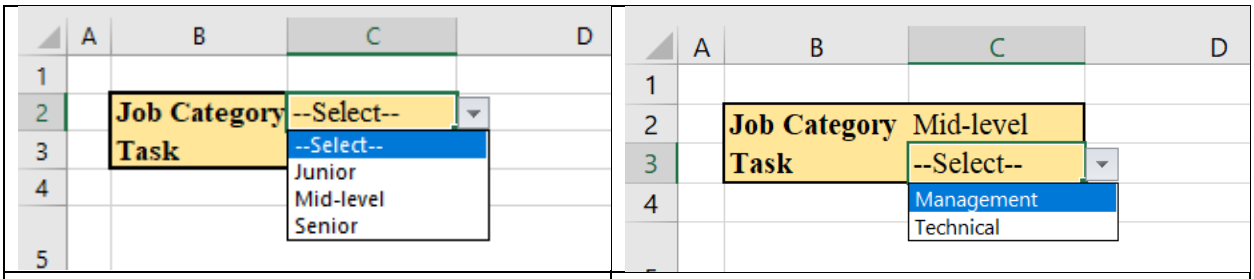
Levels	Focus	Core Competency 1	Core Competency 2	Core Competency 3	Core Competency 4	Core Competency 5
Junior	Technical	Highway Safety Definition Highway Safety Basics Highway Safety Management Basics Contributing Factors	History of Highway Safety	Key Data Elements Public Databases Data Collection Process	Key Highway Safety Problems Determination of Key Contributing Factors Selection of Effective Countermeasures	Professional Development Strategic Communication Conduct Research
Mid-level	Management	*Core Competency 1 (Junior)* *plus* Countermeasures Four E	*Core Competency 2 (Junior)* *plus* Legislations Institutional Roles	*Core Competency 3 (Junior)*	*Core Competency 4 (Junior)* *plus* Project Prioritization	*Core Competency 5 (Junior)* *plus* Highway Safety Planning Multidisciplinary Relationships
	Technical	*Core Competency 1 (Junior)* *plus* Countermeasures Four E	*Core Competency 2 (Junior)* *plus* Institutional Roles	*Core Competency 3 (Junior)* *plus* Information Systems Basic Crash Data Analysis	*Core Competency 4 (Junior)* *plus* Project Prioritization	*Core Competency 5 (Junior)* *plus* Highway Safety Planning
Senior	Management	*Core Competency 1 (Mid-level)* *plus* Highway User Decision Making Collaborative Efforts	*Core Competency 2 (Mid-level: Management)* *plus* Policy and Investment Decisions	*Core Competency 3 (Mid-level: Technical)*	*Core Competency 4 (Mid-level)*	*Core Competency 5 (Mid-level: Management)* *plus* Value of Leveraging Resources Outreach
	Technical	*Core Competency 1 (Mid-level)* *plus* Science-based Highway Safety	*Core Competency 2 (Mid-level: Management)*	*Core Competency 3 (Mid-level: Technical)* *plus* Advanced Crash Data Analysis	*Core Competency 4 (Mid-level)* *plus* Statistical Analysis and Advanced Modeling	*Core Competency 5 (Mid-level: Management)* *plus* Scientific Highway Management

SPREADSHEET TOOL

The research team developed a spreadsheet tool 'Safe Analysis Core competency Tool.xlsx,' which can be used in selecting learning objectives, courses, and key topics associated with each core competency. A step-by-step user manual is described below:

- Download and open the 'Safe Analysis Core competency Tool.xlsx' tool
- The excel file contains three tabs: a) Core Competency Matrices, b) Tool, and c) Topics and Courses. The tool can be accessed by clicking on the 'Tool' tab.
- As shown in Figure 7, the "Tool" sheet contains two drop-down options– "Job Category" and "Task." Figure 7a shows that "Job Category" has three options: 'Junior,' 'Mid-level,' and 'Senior.' Once an option is selected from the "Job Category" menu, options in the "Task"

drop down menu become available for selection (see Figure 7b). For example, after selecting 'Mid-level' from ''Job category'', two drop-down menu items (Management and Technical) will be visible in the drop-down menu. However, if a user selects 'Junior' from ''Job category'', only one Task ('Technical') will be visible in the drop-down menu.



(a) Drop-down menus in Job Category (b) Drop-down menus in Task

Figure 7. Drop-down Menus in the Spreadsheet Tool.

- Once both options from "Job category" and "Task" drop down menus are selected, the core competencies, courses, key learning objectives and major topics associated with them will be displayed in the spreadsheet. For example, if a user selects 'Mid-level' and 'Technical,' from "Job Category" and "Task" respectively, the display will be like the screenshot shown in Figure 8. If a user selects 'Mid-level' and 'Management' and wants to select another option such as 'Technical' from ''Job Category'' options, an alert will be displayed (in red text) as 'Technical' does not have a role for 'Management' Task (see Figure 9).

Job Category	Mid-level					
Task	Technical					
			Core Competencies			
			Core Competency 1	**Core Competency 2**	**Core Competency 3**	**Core Competency 4**	**Core Competency 5**
			Highway Safety Definition	History of Highway Safety	Key Data Elements	Key Highway Safety Problems	Professional Development
			Highway Safety Basics	Institutional Roles	Public Databases	Determination of Key Contributing Factors	Strategic Communication
			Highway Safety Management Basics		Data Collection Process	Selection of Effective Countermeasures	Conduct Research
			Contributing Factors		Information Systems	Project Prioritization	Highway Safety Planning
			Countermeasures		Basic Crash Data Analysis		
			Four E				
			Courses, Key Learning Objectives and Topics				
			Core Competency 1	**Core Competency 2**	**Core Competency 3**	**Core Competency 4**	**Core Competency 5**
		Course	Highway Safety Engineering	Highway Safety Engineering	Highway Safety Engineering	Highway Safety Engineering	Highway Safety Engineering
		Key Learning Objectives	Highway safety basics; Science based safety concepts	Highway safety history; Roles of institutions	Introduction to data and collection process; Basic data analysis	Highway safety problems and their solutions; Project prioritization	Professional opportunities and ongoing research in highway safety; Planning of highway safety projects
		Topics	Describe the fundamentals of the HSM Part C: Predictive method; Safety Performance Functions, Crash causation, countermeasures, and Crash Modification Functions; Overview of safety evaluation	Highway safety history	Elements of statistics and crash count distributions; Exploratory analysis of crash data; Regression analysis of count data and development of statistical models	Before-after studies; Network screening and diagnosis (identification of hazardous sites); HSM and CMFs; Methods to reduce collisions and injuries on highways	Introduce to scientific literature relevant to the transportation safety discipline and enable their use of the HSM

Figure 8. Final Display Items after Selecting Both Options.

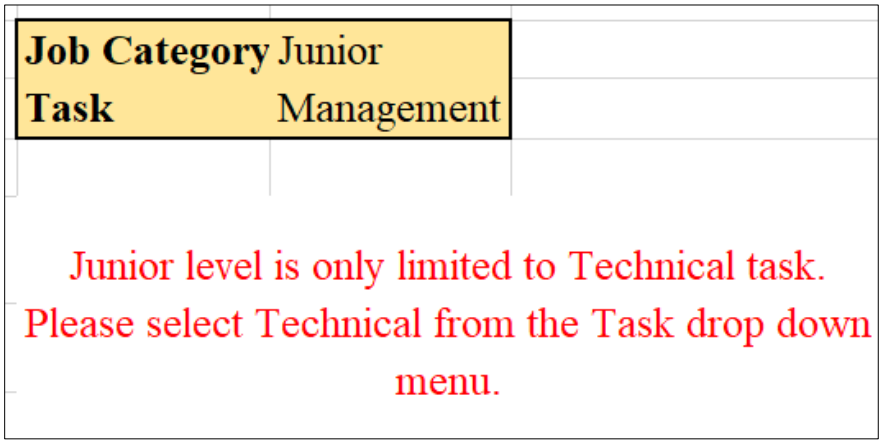


Figure 9. Alert Notice for Wrong Selection.

GitHub Resources

The research team developed a GitHub resource page (https://github.com/subasish/NCHRP-20-07-384-CC-Courses) for interested readers. This page provides a list of the courses in three levels: 1) basic, 2) mid-level, and 3) advanced. Course materials and other information can be accessed via the links on the page.

Chapter Summary Remarks

Chapter 3 provided a framework for identifying key roadway safety professional levels of expertise. This chapter first defined four occupational descriptors and then packaged this information into a user-friendly excel file that any agency can use to customize their job categories based on level of expertise, focus, and key competencies.

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CHAPTER 4. CONCLUSIONS

In recent years, the transportation safety work force has experienced rapid transitions in analytical methods as well as evolving design, maintenance, and safety treatment techniques. At the same time, the associated work force has also transitioned. In many cases, experienced safety experts have retired from the work force and with their exit is a substantial loss of professional expertise. There is a need, therefore, to identify core competencies that are essential for safety analysis so that transportation agencies can use this information to either identify qualified safety professional candidates or establish training initiatives that will enable prospective safety professionals to gain the knowledge needed for them to establish this expertise.

This report has provided updated content on core competencies essential for key safety analysis. This report includes a review of five core competencies as well as a discussion regarding the role of emerging technologies and how they will play a role in future safety analysis expertise. The report further identifies example courses and certifications that an agency can consider as a means of establishing a base set of requirements for safety professional expertise. Chapter 3 of the report further reviews this general framework and outlines a simple excel tool that agencies can use to customize their process for establishing staff safety expertise thresholds.

Though this report is largely intended as a guidance document, it does highlight the fact that transportation agencies place a high priority on safety assessment for the roadways they manage and that there is a need to establish ways to maintain core safety knowledge with the ever-changing transportation safety work force.

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APPENDICES

Table 23. Levels of University Courses and Additional Information

No.	Instructor	Level	Credit Hours	Times Offered
1	Dr. Dominique Lord	Graduate	3	Annually
2	Dr. Peter Savolainen	Graduate	3	Annually
3	Dr. Daniel G. Lee, Tim Howery, Ted Foster	Undergraduate / Graduate	3	
4	Dr. Mike Lowry	Graduate	3	Annually
5	Dr. Billy M. Williams	Graduate	3	Annually
6	Faculty Member	Graduate	3	Every Semester
7	Dr. Zong Z. Tian	Graduate	3	Annually
8	Dr. Salvador Hernandez	Graduate	3	Annually
9	Dr. Rajesh Paleti	Graduate	3	Annually
10	Dr. Ezra Hauer	Undergraduate / Graduate	3	--
11	Dr. Reginald R. Souleyrette	Graduate	3	Annually
12	Dr. Bo Thomas Jonsson, Dr. Eirin Olaussen Ryeng, and Dr. Erlend Hoksrud Aakre	Second degree level	7.5	Annually
13	A.J. Nicholson and M. R. Tight	Graduate	3	Online/Classroom
14	Kononov, J., Richard, G. S., Elliot, S., and Kelly, L.	Undergraduate / Graduate	3	Online/Classroom
15	Dr. Huaguo Zhou	Graduate	3	Annually
16	Faculty Member	Training	Certificate Program	Online
17	Faculty Member	Training	Certificate Program	Training
18	Dr. Kim Alexander	Graduate	3	Annually
19	Dr. Kim Alexander	Graduate	3	Annually
20	Dr. Kim Alexander	Graduate	3	Annually
21	Dr. Kim Alexander	Graduate	3	Annually
22	Dr. Kim Alexander	Graduate	3	Annually
23	Faculty Member	Graduate	3	Annually

No.	Instructor	Level	Credit Hours	Times Offered
24	Dr. Patrick Singleton	Graduate	3	Annually
25	Dr. Sunanda Dissanayake	Undergraduate / Graduate	3	Every spring
26	Faculty Member	Undergraduate	3	Online/Classroom
27	Dr. Xiaoduan Sun	Safety Professionals/Graduate	3	Online/Classroom
28	Dr. Mohamed A. Abdel-Aty	Graduate	3	Spring
29	Dr. Fred Mannering	Graduate	3	Annually
30	Dr. Bryan Katz	Undergraduate	3	Annually
31	Dr. Ben Gurion	Undergraduate / Graduate	3	Annually
32	Dr. Tarek Sayed	Undergraduate / Graduate	3	Annually
33	Dr. David Rey	Graduate	6	Annually
34	Faculty Member	Undergraduate	12	Annually
35	Dr. Neil Thorpe	Graduate	10	Annually

Table 24. Details of University Courses

Course Names	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
1. CVEN 626: Highway Safety	Classroom	Fundamental concepts for performing traffic safety analyses, crash data collection and database management, safety improvement programs, crash data analysis, development of statistical models, before-after studies, economic analyses, crash risk.	Introduction: what is traffic safety; human factors in traffic safety; economic costs of crashes and value of life; crash data collection and database management; elements of statistics and crash count distributions; exploratory analysis of crash data; regression analysis of count data and development of statistical models; before-after studies; network screening and diagnosis (identification of hazardous sites); HSM and CMFs.	1, 3, 4	42
2. CE: 552 Traffic Safety, Operations, and Maintenance	Classroom	Highway traffic safety, reduction of crash incidence and severity through highway design and traffic control, crash analysis, and safety in highway design, maintenance, and operation.	--	1, 3, 4	42
3. Accident Investigation and Reconstruction	Classroom	--	--	3, 4	--
4. CE 576: Traffic Safety	Classroom	Describe the importance of road safety, identify key points in the history of road safety, including key legislation, distinguish between nominal and substantive safety, compare and contrast various approaches to improving road safety, explain the two systems that drive human behavior and give examples of each, and explain why how human	Analysis of highway design alternatives and control strategies with respect to crash probabilities, statistical models for safety analysis, crash countermeasure selection and evaluation methodology, and risk management.	2, 3, 4	42

Course Names	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
		behavior impacts design and implementation.			
5. CE 509: Highway Safety	Classroom	Discuss the historical, legal, and political framework of highway safety in the U.S., major problems with current collision data systems and new technologies for alleviating those problems, identified high hazard highway locations, chooses appropriate countermeasures or programs, evaluates the safety effectiveness of countermeasures or programs, and establishes appropriate design and redesign standards for highways.	Methods to reduce collisions and injuries on highways. Identifying promising locations, choosing appropriate countermeasures, and evaluating past projects. Understanding the institutional context and establishing appropriate highway design standards.	3, 4, 5	42
6. CIV ENGR 574: Traffic Control	Classroom	Description traffic data collection studies, measures of effectiveness and evaluation of traffic system performance, design and application of traffic control devices, design of traffic signal systems, operational controls and traffic management strategies.	--	3, 4	--
7. CEE 763: Traffic Safety	Classroom	Focuses on applying engineering research and theory to advance the art, science, and practice of the discipline, designing and conducting experiments as well as to analyze, interpret, and apply.	--	1, 3, 4	42
8. CE 556: Transportation Safety Analysis	Classroom	Major transportation safety issues and general background in the application of various statistical and econometric safety analysis techniques. In	--	3, 4, 5	42

Course Names	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
		addition, this course will present a number of model-estimation methods that are used in transportation safety data analysis, and other subject areas that deal with safety analysis.			
9. CE 528: Transportation Safety Analysis	Classroom	Issues and methods in transportation safety analysis; factors contributing to crashes; methods of analysis for determining crash causation, modeling crash occurrence, identifying crash sites for treatment. Students will be evaluated using periodic homework assignments, a mid-term exam, and a class project. Students are expected to learn fundamental aspects of highway crash occurrence and modeling.	--	1, 3, 4, 5	42
10. Roadway Safety 101	Classroom/ Online/ Seminar		6 sessions. Session 1: Safety Performance Functions, Crash Causation, Countermeasures, and Crash Modification Functions Session 2: An Overview of Safety Evaluation Session 3: Can Multivariate Regression Modeling Lead to Cause-Effect Inferences Session 4: A Review of Speed and Safety Session 5: Evidence-based safety: The other side of the coin Session 6: The Road Ahead.	1, 3, 4	--
11. CE 635: Highway Safety	Classroom	Understanding of the various aspects of transportation safety by seeking answers to general questions and issues and exploring the methods used to quantify safety. Safety issues	--	1, 2, 3, 5	42

Course Names	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
		regarding all modes of transportation are also discussed.			
12. TBA 4320: Traffic Safety and Risk Evaluation	Classroom	Knowledge of traffic safety (TS) and risks of road transport, TS-work in Norway and elements of such work in other countries, data sources and empirical knowledge of crash, how different types of measures influence on risks and behavior of road users, TS-audits and risk analysis applied in TS planning; understanding of how traffic management measures and road design influence on road user behavior, to carry out TS analyses in team work, and to present results and professional judgements in a clear and understandable way.	The basis for evaluation and analysis of traffic safety and risk related to design and regulation of the road and street network, and how this network is applied by different user groups. Main course elements are: Traffic safety, crashes, crash cost, road user behavior and risk. Effects of TS measures. Before-and-after studies. TS audits and inspections. Black spot analysis. Challenges related to road and street design for pedestrians and cyclists. In-depth crash studies and risk analysis. Methods for risk evaluation in principal and detailed planning of the road system. Risk management in Public Roads Administrations and other transport agencies.	1, 3, 4, 5	
13 Accident Analysis and Prevention	Classroom		Transport planning and engineering. The course consisted of 18 lectures.	3, 4, 5	1 year M.S. program
14, CE5803: Explicit Consideration of Safety in the Transportation Planning Process	--	--	--	1, 2, 3, 4	--
15. CE 579: Transportation Safety Systems		Understand the knowledge about human factors and the fundamentals of highway safety; apply the roadway safety management process at a small roadway network, use predictive	Introduce the graduate students in transportation engineering the growing body of scientific literature relevant to the transportation safety discipline and enable their use of the HSM. Safety is maturing as a science with more promising scientific methods and	3, 4, 5	42

Course Names	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
	Classroom	methods to estimate the number of crashes for different facility types; and use Crash Modification Factors (CMFs) for safety benefit analysis.	tools that can be applied to reduce the deaths and injuries occurring on our roads.		
16. Road Traffic Injury Prevention and Control in Low- and Middle-Income Countries (RTIP)	Online training	Consists of 6 multimedia educational modules, which cover a wide range of topics in the fields of road safety and road traffic injury prevention. All modules were designed with the general public in mind but are especially useful for	--	1, 3, 4	--
17. Global Road Safety Leadership Course (GRSLC)	Online training	The GRSLC includes, among others, modules on the following topics: road safety management, safer roads and mobility, safer vehicles, safer road users, post-crash response, and advocating for road safety policy passage and implementation.	--	1, 2, 3	--
18. MTSA 8000: Introduction to Road Safety	Classroom	Complex, interdisciplinary, and multimodal nature of the road safety profession. The course will include a group project pertinent to road safety management.	Specific topics include examining road safety from a science-based perspective and strategies to achieve cooperation among the disciplines in the profession	1, 5	42
19. MTSA 8420: Road Safety Culture	Classroom	Theories, strategy formation, implementation, and evaluation for road safety programs using a culture-based approach. Origin of risk behaviors and culture-based interventions in order to support best practices in road safety management. Techniques for measuring the road safety culture in their geographic	--	1	42

Course Names	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
		region and strategies for changing the culture to be more supportive of safety.			
20. MTSA 8300: Road Safety Management	Classroom	Theories, strategy formation, implementation, evaluation for road safety programs, risk behaviors and interventions to support road safety management. Techniques for measuring the road safety culture, strategies supportive of safety.	--	3, 4, 5	42
21 MTSA 8150: Transportation Safety Engineering	Classroom	Fundamental organizational leadership strategies and support needs for effective and efficient road safety management. Using complexity theory, students learn how to establish and sustain effective multidisciplinary collaborative relationships, develop opportunities to stimulate change and identify current research to support best practices in road safety management.	--	4, 5	42
22. CRP 8130: Fundamentals of Transportation Safety Planning	Classroom		--	1, 3, 4, 5	42
23. TR-GY 7033: Multimodal Transportation Safety	Classroom		--	1, 3, 4, 5	42
24. CEE 6255: Transportation Safety	Classroom	Technology, legislation and market forces have contributed to improved transportation safety for decades, The	--	2, 3, 4, 5	42

Course Names	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
		role of demographics and traffic levels and other factors in analyzing and predicting safety trends. The course pays attention to a system view, to metrics by mode and to both standard field and statistical analyses.			
25. CE 872: Transportation Safety	Classroom	Statistical analysis of transportation data, including safety, risk assessment; regression and discriminant analysis, canonical correlation, and factor analysis; and in-depth study of selected methodologies for analyzing transportation safety and designing countermeasures. Additional coursework is required for those enrolled in the graduate level course.	--	3, 4	42
26. OESH 226: Transportation Safety	Classroom	Importance of transportation safety, crash data collection, common crash databases, traffic safety studies, crash data analysis, identification of high crash locations, traffic control devices as related to safety, special population group safety, traffic conflict studies, crash reconstruction, statistical methods in crash data analysis and traffic calming.	--	1, 3, 4	42
27. Highway Safety Fundamental Course	Online	Background in the application of various statistical and econometric analysis techniques, model-estimation methods used in the analysis of engineering and scientific data.	--	4, 5	--

Course Names	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
28. TTE 6315: Traffic Safety Analysis	Classroom	Assessment of simultaneous, equations models, generalized extreme value models, nested, logit models mixed logit models. latent-class models, models with fixed and random effects, and zero-inflated count data models.	--	1, 3, 4	4
29. CEE 4684: Transportation Safety	Classroom	Statistical and econometric analysis techniques. The course will present a number of model-estimation methods that are used in the analysis of engineering and scientific data. It is important to note that the methods presented can be used in a wide variety of data-analysis applications and go well beyond the techniques typically covered in statistics courses.	--	3, 4	42
30. CE 614: Statistical and Econometric Methods I	Classroom	To provide students with background in application of statistical and econometric data. Present model estimation methods for transportation data analysis. Discuss the underlying theory and limitations to ensure proper application of the models.	Review of least squares regression; maximum likelihood estimation. Specification errors; simultaneous equation models. Count-data models; Poisson regression; negative binomial; zero-inflated models count-data models. Discrete outcome models and analysis and economic theory and discrete choice model. Multinomial logit model, Data sampling, Nested logit value model, Hypothetical Data, Probability model with random and fixed effects, Duration model, parametric and non-parametric estimation, Random para meter model	3, 4	42
31. Traffic Safety and	Classroom	Basic principles associated with transportation safety related to		1, 3, 4	

Course Names	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
Human Behavior		humans, vehicles and infrastructure as well as principles of design for safety and practices of empirical evaluation of safety. Principles and practices of crash investigation and injury epidemiology as well as safeguards and control practices.			
32. CIVL 440: Transport. Engineering II	Classroom	--	Traffic operations and network analysis: traffic studies and data design; traffic stream flow and roadway analysis; weaving and interchange ramp analysis; intersection traffic control measures and control design; progressive signal system design; flows prediction; road network simulation and assignment algorithms; motor vehicle crash analysis; field exercises	1, 3, 4	42
33. CVEN 9421: Transport Logistics Engineering	Classroom	Develop an integrative holistic approach to problem solving through systems modelling. Ability to select optimal designs from a set of alternatives as a fundamental of engineering problem solving. Abstract a complex technical system into quantitative models and/or qualitative frameworks that represent that system. Use abstracted models and frameworks to evaluate and compare effective design decisions. Implement optimization methods to improve the performance of various infrastructure systems. Create a strategy for implementing design decisions. Understand the	Transport logistics engineering, mathematical optimization concepts and approaches used in solving large-scale logistical problems encountered in transportation, such as shortest path, network flow and vehicle routing, mathematical modelling and linear and discrete optimization theory, algorithms to solve large-scale transport logistics problems	1, 3, 4, 5	84

Course Names	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
		fundamental concepts and principles applied by engineers in advanced systems modelling. Explore the interdisciplinary nature of integrated real-world systems. Apply methods learned to emerging real world engineering problems.			
34. ENG 30010: Traffic and Road Safety Engineering	Classroom	In depth understanding of traffic engineering and contextual factors the influence the decision making. Analyze traffic and transport systems including traffic variables. Use traffic analysis software to analyze a traffic engineering problem. Identify, formulate and solve traffic problems using established traffic engineering methods. Critical elements in road safety and identify practical preventative measures to address road safety issues. Explain traffic related professional and ethical responsibilities	The concepts of traffic engineering. The fundamental principles of traffic flow theory and analysis. Traffic capacity analysis for various types of roads and intersections. Road safety	1, 4, 5	168
35. CEG 8410: Road Safety	Classroom	To provide the techniques to analyze data and prepare programs to reduce crashes by providing a better human/vehicle/road environment. Also develops understanding of policy and practice in the key areas of road safety management, crash analysis and prevention and road safety audit techniques.	Part A: Road safety Policy, Part B: Crash Investigation and Prevention, and Part C: Road Safety Audits	3, 4	140

Table 25. Details of Short Courses

No.	Course	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
1	CEG 8410: Road Safety	Classroom	To provide the techniques to analyze data and prepare programs to reduce crashes by providing a better human/vehicle/road environment. This module also develops understanding of policy and practice in the key areas of road safety management, crash analysis and prevention and road safety audit techniques.	Part A: Road safety Policy, Part B: Crash Investigation and Prevention, and Part C: Road Safety Audits	3, 4	Semester
2	Incorporating Safety into the Highway Design Process - Introduction	Classroom	• To inform participants about safety impacts of design alternatives; and availability of tools for evaluating safety impact • To demonstrate how to apply these tools	• Highway safety and geometric design • Working with crash data • Overview of safety evaluation • Procedure for rural two-lane highway segments and rural intersections	3, 4, 5	6.5 hrs.
3	Incorporating Safety into the Highway Design Process: Urban / Suburban Arterials	Classroom	• To inform participants about safety impacts of design alternatives; and availability of tools for evaluating safety impact • To demonstrate how to apply these tools	• Roadway safety and geometric design • Working with crash data • Overview of safety evaluation • Procedure for urban street segments; urban signalized and unsignalized intersections	3, 4	6.5 hrs.
4	Incorporating Safety into the Highway Design Process: Multilane and Freeways	Classroom	• To inform participants about safety impacts of design alternatives; and availability of tools for evaluating safety impact • To demonstrate how to apply these tools	• Review of highway safety issues • Overview of safety evaluation • Procedure for multilane highway segments; freeway segments; and interchange ramps	3, 4	6.5 hrs.

No.	Course	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
5	Fundamentals of the Highway Safety Manual Predictive Method	Online	• Fundamental concepts in applying the predictive method • The HiSafe software for the predictive method	Describe the fundamentals of the HSM Part C: Predictive Method. Use of safety performance functions, crash modification factors, calibration factors, and EB method	1, 3, 4	1.5 hrs.
6	Predicting Crash Frequency on Rural Highway	Online	• Case study examples on applying the HSM predictive method • The HiSafe software to demonstrate applications	Describe applications of the HSM predictive method on rural two-lane highways and multi-lane highways	3, 4, 5	1.5 hrs.
7	Predicting Crash Frequency on Urban and Suburban Arterials	Online	• Case study examples on applying the HSM predictive method • The HiSafe software to demonstrate applications.	Describe applications of the HSM Predictive Methods on Urban and Suburban Arterials	3, 4, 5	1.5 hrs.
8	Highway Safety Improvement Program Manual	Classroom/Online	• Recognize HSIP Manual purpose, structure, and benefits • Describe the importance of current legislation and agency guidelines • List opportunities to integrate safety into the transportation process •Be knowledgeable about state of art safety methods and their use in the HSIP process	• Identify performance measures for safety goals and objectives • Differentiate between nominal and substantive roadway safety; define regression to the mean • Describe the statewide crash data collection process and other road safety data sources • Define safety performance functions • Explain the purpose and the steps in the network screening process to identify systemic improvements and sites with potential for safety improvement • Demonstrate how to use data to develop collision	1, 2, 3, 4, 5	13 hrs.

No.	Course	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
				diagrams and to identify crash patterns • Identify roadway, human, vehicle and environmental contributing crash factors • Define countermeasures and selection resources • Define crash modification factors and how they are used in countermeasure selection • Relate how to convert safety benefits to a monetary value to use in a benefit/cost analysis • Recognize the different methods of countermeasure prioritization • Identify potential allocation issues and mitigation methods • Recognize the importance of including HSIP projects in the STIP • Describe what to include in the evaluation plan and why		
9	Fundamentals of Highway Safety Series	Classroom/Online	• Recall the definition of basic descriptive and predictive statistics • Interpret descriptive, inferential and predictive statistical analysis in commonly used road safety resources • Apply descriptive and predictive statistical analysis and problem-solving skills to evaluate and solve highway safety situations • Demonstrate several methods for calculating the costs and benefits of highway safety projects • Calculate the monetary values of crashes by type and severity • Prioritize highway	• Introduction to Statistics in Road Safety • Evaluation and Application of Statistical Analysis Techniques • Economic Evaluations of Highway Safety Projects • Defining and Assessing Intersection and Roadway Segment Attributes for Safety • Selecting A Safer Intersection Type Based on Crash Histories • Modern Roundabouts and Intersection Safety • Technology-Oriented Safety Solutions: Red	1, 3, 4, 5	13.5 hrs.

No.	Course	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
			safety improvements based on an economic evaluation • Describe components of the MMUCC and MMIRE • Compare the safety benefits of modern roundabouts with traditional intersections • Describe crash patterns at roundabouts • Describe the countermeasures to reduce the most frequent types of crash at roundabouts • Explain the regulatory issues related to deployment of red light cameras	Light Camera Deployment • Roadway Departure Crashes • Measures to Reduce Roadway Departure Crashes		
10	Interactive Highway Safety Design Model (IHSDM); NHI course FHWANHI-380071	Classroom/Online	• Describe key capabilities and limitations of IHSDM • Evaluate a two-lane rural highway using IHSDM • Recognize when and how IHSDM can be used in the project development process	• Safety Considerations in the Project Development Process • IHSDM Data Organization and Workflow • Use of each of the 6 Modules • Putting It All Together – Solving Safety and Operational Problems on Two-Lane Rural Highways (Synthesizing IHSDM Output to Make Design Decisions)	3, 4, 5	12 hrs.
11	HSM Applications for Two-Lane Rural Highway Intersections	Online	• Review Safety Performance of Two-Lane Rural Highway Intersections • Define Substantive and Nominal Safety • Describe the SPF Base Models • Calculate Predicted Crash Frequency for Rural Two-lane Highway Intersections • Describe and apply CMF's for rural two-lane highway intersections	•Safety performance functions • Predictive models • Safety Fundamentals • CMFs	4, 5	2 hrs.

No.	Course	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
12	HSM Applications to Project Identification	Online	• Locations Review Safety Performance of US Highways and Streets • Define Substantive and Nominal Safety • Apply the EB methods to a specific Site • Compare the Predicted Crash to Observed/Expected Crash Frequency • Identify "higher" than expected crash locations	• Use of EB methods for project identification	4, 5	2 hrs.
13	Intersection Safety	Classroom/Online	• Describe the latest information on readily available and low-cost practices that are proven to reduce the incidence of intersection crashes • Recognized applications for low cost treatments	• Low cost countermeasures • Safety issues and potential measures for rural and urban intersections • Case studies of proven practices and crash reduction measures for both rural and urban intersections	3, 4	7 hrs.
14	A Short Course on Safety Performance Functions (SPFs) and Safety Analysis Techniques	Classroom/Online	• Develop knowledge and hands-on experience on SPFs and other science-based safety analysis techniques • Apply the new methods for Illinois' system-wide screening for roadway locations for safety improvements	• Basic Statistics: A Recap • SPF Development and Data Needs • Empirical Bayesian Method: A Recap • Potential for Safety Improvements and Level of Safety Service • Roadway Network Screening • SPF Applications and Local Tools	3, 4, 5	6 hrs.
15	Highway Safety Manual Workshop – Predictive Method Training	Classroom/Online	• Apply the predictive method on a typical transportation planning, traffic engineering project	• Safety performance functions • Predictive models • CMFs in conjunction with base models	4, 5	8 hrs.

No.	Course	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
16	Highway Safety Fundamentals: Countermeasure Selection	Classroom/Online	• Identify and select countermeasures to prevent the most fatalities and injuries possible • Collect the needed data and how to identify countermeasure solutions, and how to compare countermeasure to make the best selection for a given site • Present Highway Safety Manual CMFs	Field reviews and engineering studies • Traffic conflict studies • Generating countermeasure solutions • Finding and using collision modification factors • Finding and using collision models • Predicting countermeasure cost-effectiveness	4, 5	6.5 hrs.
17	Highway Safety Fundamentals: Evaluating Countermeasures	Classroom/Online	• Apply the latest techniques to measure the effectiveness of highway safety countermeasures. • Apply traditional "before and after" studies • Apply newer statistical-based techniques, EB techniques to remove regression to the mean and other biases	• Conventional approaches • Comparison groups • Empirical Bayes approaches • Control groups and experiments • The future of highway safety	4, 5	6.5 hrs.
18	Highway Safety Fundamentals: Identifying Hazardous Sites	Classroom/Online	• Apply latest techniques to identify sites with promise and other sites for further analysis	• Historical, political, and legal context of safety • The case for quantitative methods • Collision data and collision-based methods • Identifying sites with promise • Bayesian methods • Exposure data sources	1, 3, 4	6.5 hrs.
19	Safety Analyst Software Tools	Classroom	• Apply Safety Analyst • Describe Safety Analyst's features • Conduct analyses with Safety Analyst and interpret the output • Describe how to use Safety Analyst effectively • Identify the types of data and specific variable	• The tools of Safety Analyst Software	3, 4, 5	16 hrs.
20	HSM Applications to HSIP	Online	• Apply roadway management process methods and procedures presented in Part B of the HSM	• HSIP examples utilizing the Network Screening, Project Prioritization, and Program Evaluation tools in the HSM	3, 4, 5	2 hrs.

No.	Course	Delivery Method	Learning Objectives	Summary of Main Topics	Core Comp.	Dura. (hrs.)
21	New Approaches to Highway Safety Analysis	Classroom	• Describe the components of the Highway Safety Improvement Program (HSIP) • Explain safety engineering principles relevant to planning for highway safety improvement measures • Describe the relevance and impact of human factors in the planning of highway safety improvement measures • Determine strategies for the selection of cost-effective highway safety improvement measures	• HSIP and the state-of-the-art (HSM) methods and procedures • In-depth investigations for three types of crashes: roadway departures, intersection related, and pedestrian	1, 3, 4	24 hrs.
22	Data & Analysis Technical Assistance Program Technical Webinar: Systemic Safety Approaches	Online		Provides overview of three approaches to safety analysis: U.S. Road Assessment Program (us RAP), Systemic Safety Project Selection Tool (SSPST), and Roadway Safety Audits (RSA).	3, 4	1.5 hrs.