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CONFERENCE PROCEEDINGS ON THE WEB 21

Pedestrian and Bicycle Safety

Summary of the 10th University Transportation Centers Spotlight Conference

December 1–2, 2016
Washington, D.C.

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Texas A&M Transportation Institute
Rapporteur

December 1–2, 2016
Keck Center
National Academies of Sciences, Engineering, and Medicine
Washington, D.C.

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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the National Academy of Medicine.

This conference was supported by the Office of the Assistant Secretary for Research and Technology, U.S. Department of Transportation.

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Preface

Walking and bicycling are important travel modes in urban, suburban, and rural areas. Ensuring the safety of pedestrians and bicyclists is critical to the ongoing use of these transportation modes. Although traffic crashes nationally declined from 2005 to 2015, the number of pedestrian and bicycle fatal crashes increased, even though improvements were made in pedestrian and bicycle facilities in many areas during that time.

The Transportation Research Board (TRB) hosted a conference entitled *Pedestrian and Bicycle Safety* at the Keck Center in Washington, D.C., in December 2016. This meeting was the 10th in a series of Spotlight Conferences funded by the U.S. Department of Transportation's Office of the Assistant Secretary for Research and Technology, University Transportation Centers (UTC) Program. The UTC Program awards grants to universities across the country to advance state-of-the-art transportation research, to conduct technology transfer activities, and to educate the next generation of transportation professionals.

TRB assembled a planning committee, appointed by the National Research Council (NRC), to organize and develop the conference program. The planning committee was chaired by Jennifer Dill of Portland State University. Committee members provided expertise in pedestrian and bicycle safety planning, public policy, operations, research, and evaluation.

The planning committee was responsible solely for organizing the conference, identifying speakers, reviewing submitted poster abstracts, and developing topics for the breakout group discussions. Katherine Turnbull of the Texas A&M Transportation Institute served as the conference rapporteur and prepared this document as a factual summary of what occurred at the conference. Responsibility for the published conference summary rests with the rapporteur and the institution.

The conference attracted approximately 150 participants. Agency personnel responsible for pedestrian, bicycle programs, and roadway safety joined faculty, researchers, and students from UTCs and other universities to explore issues and opportunities associated with pedestrian and bicyclist safety. Representatives from consulting firms, interest groups, and other organizations also participated in the conference. The conference, which was characterized by broad and active participation and discussion, considered potential research to address issues associated with pedestrian and bicyclist safety.

The conference included plenary sessions focused on the role of policy and guidance, emerging and future technologies, behavior change, and equity. Conference participants also had the opportunity to interact with poster authors and to discuss issues and areas for further research in six concurrent breakout sessions. Speakers in

the closing plenary session highlighted the topics and research needs discussed in the breakout groups.

These proceedings consist of presentation summaries from the plenary sessions and the six concurrent breakout sessions. A list of the posters is also provided. The views expressed in this summary are those of the individual speakers and discussants, as attributed to them, and do not necessarily represent the consensus views of the conference participants, the conference planning committee members, TRB, or the National Academies of Sciences, Engineering, and Medicine. The conference PowerPoint presentations used by speakers and video recordings can be accessed online through the links embedded in the final program at http://onlinepubs.trb.org/onlinepubs/conferences/2016/UTC/Program.pdf. Scroll to the presentation of interest and click on the title.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the NRC Report Review Committee. The purposes of this independent review are to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the project charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

TRB thanks the following individuals for their review of this report: Shaunna Burbidge, Active Planning, Kaysville, Utah; Mike Cynecki, Lee Engineering, Phoenix, Arizona; Jeffrey LaMondia, Auburn University, Alabama; and Meghan Winters, Simon Fraser University, Burnaby, British Columbia, Canada. Although the reviewers listed above provided many constructive comments and suggestions, they did not see the final draft of the summary before its release. The review of this summary was overseen by Susan Hanson of Clark University (emerita). Appointed by NRC, she was responsible for making certain that an independent examination of this summary was performed in accordance with established procedures and that all review comments were carefully considered. Karen Febey, TRB Senior Report Review Officer, managed the review process. Responsibility for the final content of this summary rests entirely with the authors and the institution.

The conference planning committee thanks Katherine Turnbull for her work in preparing this conference summary report and extends a special thanks to the U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology for providing the funding support that made the conference possible.

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ACB	American Council of the Blind
CAR	Crash Analysis Reporting
CMF	crash modification factor
DOT	Department of Transportation
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GIS	geographic information system
LPI	leading pedestrian interval
MPO	metropolitan planning organization
MSA	metropolitan statistical area
MUTCD	*Manual on Uniform Traffic Control Devices*
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
NYPD	New York City Police Department
ODU	Old Dominion University
RCI	Roadway Characteristics Inventory
RRFB	rectangular rapid flashing beacon
TRB	Transportation Research Board
UAB	University of Alabama at Birmingham
UTC	University Transportation Center
VMT	vehicle miles traveled

Contents

Opening Session

Kevin Womack, *Office of the Assistant Secretary for Research and Technology, U.S. Department of Transportation*
Jennifer Dill, *Portland State University*
T. Bella Dinh-Zarr, *National Transportation Safety Board*
Robert Schneider, *University of Wisconsin, Milwaukee*
Kari Watkins, *Georgia Institute of Technology*
Ellen Partridge, *Federal Transit Administration, U.S. Department of Transportation*

WELCOME FROM THE U.S. DEPARTMENT OF TRANSPORTATION

Kevin Womack

Kevin Womack provided a welcome from the Office of the Assistant Secretary for Research and Technology, U.S. Department of Transportation (DOT). He covered the following topics in his comments:

- Womack recognized the hard work of Jennifer Dill, Portland State University, and the conference planning committee in developing an outstanding program. He also thanked Robin Kline, of the U.S. DOT, Gabe Rousseau and Dan Goodman of the Federal Highway Administration (FHWA), and the Transportation Research Board (TRB) staff for their assistance in organizing the conference.
- Womack discussed the importance of the University Transportation Centers (UTCs) in advancing research, education, and technology transfer. He noted that this conference was the 10th in a series highlighting research conducted by the UTCs, as well as transportation agencies, consultants, and other groups. He stressed the benefit of these conferences in facilitating information sharing, promoting collaboration, and identifying additional research needs.
- Womack also stressed the importance of the conference topic—pedestrian and bicyclist safety. He noted that research in this area was helping to address key safety concerns. He encouraged participants to share their ideas and to actively engage in discussions in the breakout groups.

WELCOME FROM THE CONFERENCE PLANNING COMMITTEE

Jennifer Dill

Jennifer Dill welcomed participants to the 10th UTC Spotlight Conference. She recognized organizations and individuals responsible for planning and sponsoring the conference and reviewed the conference program. Dill covered the following topics in her presentation:

- The conference was sponsored by the UTC Program, the Office of the Assistant Secretary for Research and Technology, U.S. DOT, and was organized by TRB, National Academies of Sciences, Engineering, and Medicine. She recognized and thanked members of the conference planning committee for their hard work in developing informative sessions with excellent speakers. She also thanked Robin Kline and Tom Bolle of the U.S. DOT and Bernardo Kleiner and Freda Morgan of TRB for their assistance in organizing the conference.
- Dill stressed the importance of focusing on the safety of pedestrians and bicyclists. She noted that although traffic crashes declined overall nationally from 2005 to 2015, the number of pedestrian and bicyclist fatal crashes increased. At the same time, funding for pedestrian and bicycle improvements increased. Addressing safety concerns is key to ensuring the continued use of walking and bicycling. She noted that 130 abstracts were submitted for the conference, reflecting the interest in the topic.
- Dill noted that the conference focused on advancing practice-relevant research. Key conference objectives were to share research findings between university researchers, the U.S. DOT, and practitioners; to articulate knowledge gaps to help define specific research needs; and to foster ongoing collaboration among all groups.
- Dill reviewed the conference program. The plenary sessions would focus on the role of policy and guidance, emerging technologies, behavior change, and equity. The first day would conclude with an interactive poster session and reception. The second day would include six concurrent breakout groups featuring brief presentations followed by facilitated discussions of research needs and collaboration opportunities. The closing session would highlight summaries from the breakout sessions.

PEDESTRIAN AND BICYCLE SAFETY OVERVIEW

T. Bella Dinh-Zarr

T. Bella Dinh-Zarr described the responsibilities of the National Transportation Safety Board (NTSB), including those associated with pedestrian and bicyclist safety. She discussed the following topics in her presentation:

- Dinh-Zarr commented that bicycling and walking, along with public transit, were her major means of transportation. As a result, she noted that pedestrian and bicyclist safety is a personal priority, and also a relatively new priority for NTSB.
- Dinh-Zarr reported that NTSB is a unique federal agency as it is independent from all other government agencies. Congress established the NTSB mission to prevent accidents, reduce injuries, and save lives in all modes of transportation. To accomplish this mission, she noted that NTSB fiercely protects its core values of independence, credibility, and transparency. In addition to being an independent agency, NTSB is headed by five independent board members. None of the board members report to each other or to anyone else. By law, NTSB is bipartisan. Board members are appointed by the president and confirmed by the Senate. Board members serve specific terms regardless of changes in the presidency. Dinh-Zarr noted that her term ends December 31, 2018.
- Dinh-Zarr stressed the importance of scientific and investigative rigor at NTSB. She noted that all work and deliberations are conducted in public and that NTSB investigates every civil aviation accident and significant highway, rail, pipeline, marine, and hazardous materials accidents. On the basis of extensive analysis of the factual data associated with an accident, the Board comes to an independent conclusion on each incident and makes recommendations to prevent these types of accidents from occurring again.
- Over the previous year Dinh-Zarr reported that she had been to the site of a business jet accident that crashed into an apartment building in Ohio, the sinking of the El Faro cargo ship where 33 lives were lost at sea during Hurricane Joaquin, and a number of train crashes. She noted that focusing on fatalities on highways and the increase in pedestrians and bicyclist fatalities is important.
- Dinh-Zarr reported that although NTSB is not a regulatory agency, it can and it does make recommendations to federal, state, and local agencies, as well as industries and associations that are in a position to improve transportation safety. She noted that more than 80% of the NTSB recommendations are classified as "closed acceptable actions," which means the responsible group did what was asked. She suggested there may be areas where research can help inform NTSB work and areas where NTSB recommendations can help inform bicyclist and pedestrian safety research.
- Dinh-Zarr described her traditional research background in injury prevention. She noted that NTSB collects and analyzes a large amount of data from a single accident, which is similar to a very thorough case study. She further noted that NTSB has the ability to act quickly to make urgent recommendations that can affect public policy. She discussed the types of detailed data collected on all aspects of an accident, including human performance, crashworthiness, weather, highway and vehicle factors, medical issues, and data recorders. NTSB has experts in all the topics

needed to conduct a detailed, comprehensive accident investigation. She stressed the importance of high-quality data on the circumstances and risk factors, which are critical to effective programs and policies to prevent crashes. She noted that from the NTSB perspective, high-quality data can take different forms, from population-based data to crash investigation data.

- Dinh-Zarr described the NTSB process for investigating pedestrian and bicyclist fatalities. She reported that the first NTSB pedestrian forum was held in May 2016. The forum, which included panels on different aspects of pedestrian safety, initiated a renewed focus at NTSB on pedestrian fatalities. She noted that a special investigative report is being developed on pedestrian fatalities. In describing the scene of a pedestrian fatality, Dinh-Zarr reported that one challenge is the lack of physical evidence. To address this challenge, NTSB investigators have developed a more nimble response, including a new method for documenting the crash scene using a Go-Pro camera, extension poles, and computer software. The system compiles hundreds of photos of the scene. This approach allows investigators to quickly reach and document the scene. She stressed the importance of quickly responding to pedestrian fatalities.
- Dinh-Zarr reported that NTSB is currently investigating 15 pedestrian fatalities that cover a range of events. She noted that although these fatalities do not constitute a representative sample, they could be used to answer broad research questions and should contribute insights into factors influencing pedestrian fatalities. The cases include different types of roads, travel speeds, times of day, weather conditions, ages of both the pedestrians and drivers, vehicle types, alcohol involvement, and cell phone use. She noted that the special investigative report, which should be available in mid to late 2017, will provide useful information for this area of research.
- Dinh-Zarr described the NTSB investigation of the June 2016 crash involving a pickup truck and nine bicyclists in the Kalamazoo, Michigan, area. Five of the bicyclists were killed in the crash and others suffered severe injuries. She noted that NTSB sent a full team of investigators to the site. She outlined some of the factual information about the crash, noting that the analysis has not been released. A 1996 pickup truck driven by a 50-year-old male was traveling northbound on an avenue in Cooper Township. The vehicle approached a group of nine bicyclists traveling in single file on the 4-foot shoulder. The bicyclists were part of a private bicycling group on a 28-mile ride. All the bicyclists were wearing helmets and brightly colored clothing. The vehicle departed the travel lane and struck all nine bicyclists, continued northbound, and came to rest in a drainage ditch. The driver fled the scene, but was later apprehended by law enforcement officials. Dinh-Zarr noted that the preliminary results have revealed that the driver of the pickup was impaired by one or more

drugs at the time of the crash. Emergency calls had been made as early as 22 minutes before the crash reporting a driver who was speeding and driving erratically and who had hit another vehicle. At least three calls were recorded before the accident actually happened. She noted that the investigation is still under way and that NTSB is carefully analyzing all available information in order to make a recommendation that will prevent similar situations from occurring in the future or at least prevent the deaths and injuries. Dinh-Zarr reported that this investigation was NTSB's first bicyclist investigation but would probably not be the last.

- Dinh-Zarr described the assistance NTSB provides to families of accident victims. She noted that NTSB has an advocacy office and is allowed to advocate for the changes and improvements contained in investigation recommendations to advance safety.
- Dinh-Zarr commented on the impressive list of activities under way at the federal, state, and local levels focused on keeping people safe and mobile. Examples of these efforts included FHWA's new safety performance measures, which go into effect in 2017, requiring states to set safety performance measures to reduce pedestrian and bicyclist fatalities and injuries, as well as roadway fatalities and injuries. She cited the FHWA Strategic Agenda on Pedestrian and Bicycle Safety, as well as the newly launched U.S. Road Assessment Program, which is part of the International Road Assessment Programme, which provides star ratings for vehicle, pedestrian, and bicyclist safety. The U.S. Road Assessment Program will examine crossings, foot paths, physical separations, bike lanes, shoulder widths, and other factors in determining star ratings for nonmotorized vehicles. She noted that a five-star road for vehicles might be rated a two-star road for pedestrians and bicyclists. The FiA Foundation and the National Center for Safe Routes to School partnered to sponsor Vision Zero for Kids, which was kicked off with Walk to School Day in 2016. Further, the Association of Pedestrian and Bicycle Professionals is hosting a seminar in June 2017 in Memphis, Tennessee, focusing on innovation, local business engagement, and equity in transportation.
- In closing, Dinh-Zarr suggested that the work of creating walkable, bikeable, livable, and safe communities is more important today than ever before. She noted that evidence continues to support the importance of people being outside and engaging in physical activities. She noted that people in all sizes of communities benefit from human encounters when they are outside walking or bicycling. She quoted a former NTSB chairman who paraphrased the words of Thomas Jefferson, "The care of human life and happiness . . . is the first and only legitimate object of good government."

COMPARISON OF METROPOLITAN REGION PEDESTRIAN AND BICYCLE FATALITY RISK

Robert Schneider

Robert Schneider discussed research examining pedestrian and bicycle fatality rates at the metropolitan level. He described the study process and highlighted some of the results and ideas for future research. He recognized the assistance of Jason Vargo, Aida Sanatizadeh, and Nancy McGuckin with the research. Schneider covered the following topics in his presentation:

- Schneider reported that data from the Fatality Analysis Reporting System (FARS) indicated that there was a 30% increase in both pedestrian and bicyclist fatalities from 2009 to 2015. He noted that if the 2009 level of fatalities had been maintained, 3,300 fewer pedestrians would have been killed and 590 fewer bicyclists would have lost their lives. A motivating factor for the research is to reduce the number of fatalities, which represent parents, children, and friends.
- Schneider discussed the focus of the research, which examined pedestrian and bicyclist fatality risk in different metropolitan areas to determine if there were lessons to be learned from areas with lower fatality rates. In addition to the FARS data, information from the National Household Travel Survey (NHTS) was used in the analysis.
- The following common risk measures in the traffic safety field were used in the analysis:

$$\text{risk} = \frac{\text{incidents}}{\text{exposure}}$$

$$\text{pedestrian or bicyclist fatality risk} = \frac{\text{fatalities (FARS)}}{\text{trips, distance, or time (NHTS)}}$$

- Schneider reported that two 5-year periods were examined, 1999 through 2003 and 2007 through 2011. He noted that the NHTS was conducted at the midpoint of each 5-year period. Forty-six metropolitan statistical areas (MSAs) were included in the analysis. He noted that MSAs in the New England region were not included because the MSA boundaries there do not always match with county boundaries, which is needed for the exposure analysis.
- Schneider described the initial qualitative analysis of possible differences in the MSAs that might affect the fatality rates. He noted that the MSAs with the lowest pedestrian fatality rates tended to be in more established cities in the Northeast, Midwest, and Northwest, and MSAs with the highest pedestrian fatality rates were

located in more recently developed, rapidly growing, and sprawling cities in Florida and the Southwest. He noted that the MSAs with the highest bicycle fatalities exhibited similar trends, although these trends were not as conclusive due to a lack of exposure data in some areas.

• The pedestrian fatality rates for all 46 MSAs were examined in the study. Schneider noted that the exposure rates obtained from the NHTS were based on relatively small samples. To address the uncertainty in the survey data, 90% confidence intervals were presented on the fatality rate estimates, and only regions with statistically significant differences were compared in the initial analysis. MSAs with low pedestrian fatality rates included Minneapolis–Saint Paul, Minnesota; Portland–Salem, Oregon; Seattle–Tacoma–Bremerton, Washington; Chicago–Gary–Kenosha (Illinois–Indiana–Wisconsin); and Pittsburgh, Pennsylvania. MSAs with high pedestrian fatality rates included Tampa–Saint Petersburgh–Clearwater, Florida; Miami–Fort Lauderdale, Florida; Orlando, Florida; Las Vegas, Nevada; and Jacksonville, Mississippi. Comparing the fatality rates between the two groups, Schneider noted that the highest fatality rates were five times higher than the lowest. On the basis of the median number of walking trips in a typical MSA, the highest fatality rates represent 49 more people killed each year in MSAs with higher crash risks.

• Schneider described the results of a similar analysis examining bicyclist fatalities from 2007 to 2011. MSAs with low bicyclist fatality rates included Minneapolis–Saint Paul; Chicago–Gary–Kenosha; and Washington, D.C.–Baltimore, Maryland. MSAs with high bicyclist fatality rates included Greensboro, North Carolina; New York–Northern New Jersey–Long Island; Jacksonville; and Tampa–Saint Petersburgh–Clearwater. He reported that rates in the MSAs with the five highest bicyclist fatality rates were seven times higher than those in the MSAs with the five lowest fatality rates, equaling 11 more people killed each year in MSAs with higher crash risks. He suggested that the New York–Northern New Jersey–Long Island MSA may be an outlier. He noted that the recent improvements in bicycle facilities in New York City were made after the years covered in this analysis and that the MSA covers an area much larger than just the city.

• A second qualitative measure examined in the study was investments in pedestrian and bicycle infrastructure in the regions, as well as the adoption of policies supporting bicyclist and pedestrian safety. Schneider noted that researchers examined the central cities of the regions participating in the Walk Friendly and Bicycle Friendly Community Programs and applied the program level—bronze, silver, gold, or platinum—for this measure. He reported that none of the central cities in regions with high pedestrian fatality rates had a Walk Friendly Community designation. In comparison, four central cities in the regions with low fatality rates (Minneapolis; San Francisco, California; Seattle; and Washington, D.C.) were gold or platinum Walk Friendly Communities. He noted that the results of the analysis of Bicycle Friendly

Communities were mixed. Three central cities in regions with low bicyclist fatality rates (Chicago, Minneapolis, and Washington, D.C.) were silver or gold Bicycle Friendly Communities. He noted that Portland was not included in this part of the analysis due to the lack of adequate exposure data. Two central cities in regions with high bicyclist fatality rates were Bicycle Friendly Communities: Greensboro at the bronze level and New York City at the silver level. He also noted a 2016 study by Pucher and Buehler that examined commute to work data that found 10 cities with reductions in bicyclist fatality rates.[1] All these cities had made major investments in their bicycle infrastructure and bicycle networks. He suggested that this study supports the notion that investing in bicycle infrastructure can help lower bicyclist fatality rates.

- Schneider described the quantitative analyses conducted in the study, which used models to examine different explanatory variables. Examples of these variables included pedestrian and bicyclist trip mode share, age of residents, and population density. He noted that the regions with higher proportions of foreign-born residents had higher pedestrian fatality rates in all the models. He suggested these higher pedestrian fatality rates could be due to foreign-born residents having different behaviors and traffic safety cultures, having to learn new traffic regulations, or living in areas that are less safe for walking. Schneider reported that the most significant variable in both the pedestrian and the bicyclist analyses was pedestrian and bicyclist trip mode share. He suggested that in both cases the results indicated that fatality risk is lower when more people are walking and biking.
- In closing, Schneider suggested an approach for considering possible influences on metropolitan region pedestrian and bicyclist fatality risks. He noted that the interaction of vehicles, bicyclists, and pedestrians occurs within an environmental and social context, including roadways and social norms related to how people walk and bike. Traditionally in the pedestrian and bicycle safety field, education, enforcement and engineering strategies, policies, and programs are used to address these concerns. He noted that encouraging mode shifts to more bicycling and walking may have a positive impact as well, which may be the result of education, enforcement, and engineering improvements. Thus, he noted the importance of thinking more broadly about the many factors influencing safer bicycling and walking and the interrelationships between these factors. Schneider identified as a topic for further research how best to educate immigrant populations to safely walk and bicycle as well as drive around nonmotorized travelers in new environments. Other suggested research topics were examining methods to enhance emergency responses to crashes involving bicyclists and pedestrians and examining age and personal factors that may affect individual risk levels.

[1] Pucher J., and R. Buehler. Safer Cycling Through Improved Infrastructure. *American Journal of Public Health*, Vol. 106, 2016, pp. 2089–2091.

LITERATURE REVIEW AND SURVEY RESULTS OF BICYCLE AND PEDESTRIAN TREATMENT SAFETY ASSESSMENT

Kari Watkins

Kari Watkins discussed a research project conducted for the Georgia Department of Transportation (DOT) examining factors state and local agencies could use to determine bicycle and pedestrian safety treatments and to prioritize the locations of those treatments. She commented on the results from the literature review, the survey of agencies conducted for the project, and the development of an analysis tool. Watkins covered the following topics in her presentation:

- Watkins reviewed the typical safety analysis process using the *Highway Safety Manual*. This process begins with defining a standard set of conditions and activity factors for use in assessing bicycle and pedestrian safety. The next step is assessing the risk of crashes, injuries or fatalities—called adverse events—to bicyclists and pedestrians under these standard conditions, which results in a safety performance function. The activity of bicyclists and pedestrians in different areas is measured. Understanding how departures from these "standard" conditions, including safety treatments, influence the risk of an adverse event is the next step, which results in a crash modification factor (CMF). She noted that the Georgia DOT was interested in CMFs for bicycle and pedestrian infrastructure, but that none currently exist. Further, the data needed to create these CMFs have not been collected.
- The literature review examined 22 bicycle treatments and 35 pedestrian projects. Watkins noted that the results revealed there was little research to date on the impact of bicycle and pedestrian treatments. Information on the number, type, and severity of crashes is lacking. Accurate crash data are often not available due to problems of underreporting and reporting bias. She noted there was a lack of standardized and transferable exposure data. Issues included very simple methodologies with few controls, too few sites in varying locations, and a lack of sufficiently robust data from which to draw broad conclusions.
- Watkins discussed available information on some bicycle and pedestrian treatments. For example, studies have documented reductions in crash rates from bicycle boulevards. Studies of other treatments either were not able to specify results or the changes were not significant. She stressed the lack of studies and data on most of the bicycle and pedestrian treatments, resulting in the inability to draw any conclusions about their impact.
- Watkins reviewed the results of the survey of staff at metropolitan planning organizations (MPOs), state DOTs, cities, and counties. A total of 133 responses were received from 699 distributed surveys, accounting for a response rate of 19%.

She noted that the responses indicated a wide range of data availability and planning techniques in use among the agencies. Further, although most agencies value safety as a key component of decisions, most do not collect enough exposure and crash data to adequately assess safety impacts on bicycle and pedestrian facilities. She noted that local agencies and state DOTs reported safety, coincidence with other projects, and connectivity as key factors in the project selection process.

- Watkins reported that 29% of the agencies responding to the survey have completed one or more before-and-after studies on bicycle and pedestrian treatments. The majority of the studies only measured once before and once after the treatment was implemented, however. She noted the importance of multiple measurements with these types of facilities, as use and effectiveness can change rapidly over the first few months of operation. Approximately one-third of the responding agencies stated they did not collect any type of permanent or temporary bicycle or pedestrian counts. Only four agencies counted more than 200 locations per year. She noted that count data are important, as exposure is a fundamental variable necessary to understand crash rates.
- Watkins summarized the study recommendations to the Georgia DOT. The first recommendation was to improve crash data collection for bicycle and pedestrian projects. A second related recommendation was to enhance bicycle and pedestrian counts. A third recommendation was to always conduct before-and-after studies of bicycle and pedestrian treatments. She noted that studies have documented that bicycle and pedestrian crashes are underreported. For example, bicyclists and pedestrians are less likely than other users to report crashes. Watkins stressed the importance of quantifiable exposure data and comprehensive data collection programs to obtain the data necessary for developing CMFs. She suggested obtaining information from bicyclists having their bikes repaired at bike shops to see if the repairs were needed as the result of a crash as one approach for enhancing data collection. This type of information could be combined with crash databases for more robust analyses. She also stressed the need for enhanced activity data. Exposure data and counts are key to developing crash rates. She stressed that comprehensive data collection programs and before-and-after analyses are key to providing the data needed to develop CMFs and improving the ability to make informed decisions on future bicycle and pedestrian projects.

UPDATE ON U.S. DEPARTMENT OF TRANSPORTATION BICYCLE AND PEDESTRIAN ACTIVITIES

Ellen Partridge

Ellen Partridge provided a welcome from the Federal Transit Administration (FTA) and the U.S. DOT. She described some of the activities under way at the U.S. DOT

related to improved bicycle and pedestrian safety. Partridge covered the following topics in her presentation:

- Partridge noted that the U.S. DOT believes pedestrians and bicyclists are first-class citizens on streets and sidewalks. She reported that under Secretary Foxx's leadership, the department has worked to make walking and bicycling safer. She noted that almost every trip on nearly every mode of travel begins on foot, in a wheelchair, or with some type of mobility device. In other words, almost every traveler begins as a pedestrian. Yet, she commented, there is no Federal Pedestrian Administration and there is no one single agency responsible for bicycling. Rather, the responsibility for infrastructure and safety for bicyclists and pedestrians crosses many of the modal agencies. She also stressed that partnerships among federal, state, and local governments and the private sector are required for good bicycle and pedestrian projects.
- Partridge noted that the U.S. DOT hosted the first UTC Workshop on Pedestrian and Bicycle Research in 2014. Approximately 35 participants from across the U.S. DOT and the UTCs participated in the intensive 3-hour session. Research being conducted at UTCs and within the department was discussed, and areas for further research were identified. She noted that the workshop discussion focused on four comprehensive areas: networks and connectivity, data needs, tools to address bicyclist and pedestrian safety, and equity considerations and ladders of opportunity. U.S. DOT modal representatives and UTC researchers discussed the critical needs for pedestrians and bicyclists with regard to connectivity, including how to define and measure networks, how to document nodes (the intersections between bicycle and pedestrian paths and a road), how to include networks and connectivity in planning, consistency issues with regard to research data, and how best to assess improvements.
- Partridge discussed some of the challenges associated with current data on bicyclists and pedestrians. Accurately measuring miles walked or bicycled in a way that is commensurate with vehicle miles traveled (VMT) represents one challenge. She suggested this type of measure would provide a context for crashes, injuries, and fatalities. It would also enable researchers and practitioners to better evaluate the safety impacts of engineering measures and infrastructure, and it would help estimate the need for bicycle and pedestrian lanes or paths, as well as other improvements. Partridge noted that the practical orientation of the researchers at the workshop in thinking about data needs was impressive. Rather than talking about data, it was suggested that the focus should be on decisions and the practical reasons for evidence-based decision making. It was also suggested that data needs depend on the question being addressed.
- Partridge discussed the Safer People, Safer Streets initiative launched by Secretary Foxx in 2014. The initiative included conducting a Safer Streets Assessment

in every state, as well as running the Mayors' Challenge. She noted that U.S. DOT personnel worked with local partners to evaluate pedestrian and bicyclist road safety in every state as part of the Safer People, Safer Streets assessment. The assessments included walking corridors with city and state transportation staff, local advocates, disabled residents, and many more stakeholders to identify gaps. Partridge reported that by June 2015, the U.S. DOT had completed 52 safety assessments (one for each state, the District of Columbia, and Puerto Rico).

- Partridge noted that the Mayors' Challenge, launched by Secretary Foxx in March 2015, called on mayors and other elected officials to take significant steps to improve safety for bicyclists and pedestrians of all ages and abilities. She reported that 246 communities took up the challenge and made public commitments to improve safety by forming local action teams to advance safety and accessibility goals.
- Partridge highlighted some of the results from the Mayors' Challenge. Twelve communities adopted new Complete Streets policies. Many cities conducted road safety assessments, inventoried existing pedestrian and bicycle facilities, and created safer street crossings. Cities installed 36 new systems to count pedestrians and cyclists, and 14 cities collected survey data from pedestrians and bicyclists. She noted that many cities developed new design standards and manuals, taking advantage of design flexibility. Street redesigns were initiated by using road diets and separated bike lanes to improve safety for pedestrians and bicyclists. Eleven cities reported constructing more than 370 miles of pedestrian and bicycle facilities. More than 40 cities undertook safety education activities, including several educational programs for school-aged children, which reached over 10,000 students.
- Partridge reported that a new Pedestrian and Bicycle Coordinating Committee has been approved within the U.S. DOT. A major purpose of the committee is to establish and monitor broad measures of progress in bicycle and pedestrian safety and use. The committee will also identify new cross-modal opportunities within the department to help advance safety, as well as partnerships with outside organizations. The committee will ensure coordination and information sharing among the modal administrations. She noted that bicyclist and pedestrian safety is a responsibility that cuts across modes. The committee will include the Secretary's Office, FTA, FHWA, the National Highway Traffic Safety Administration (NHTSA), the Federal Railroad Administration, and the Federal Motor Carrier Safety Administration.
- Partridge described the three main outcomes the department hopes to achieve through the Pedestrian and Bicycle Coordinating Committee and related activities. The first outcome is to achieve an 80% reduction in pedestrian and bicyclist fatalities and serious injuries by 2031 and zero pedestrian and bicyclist fatalities and serious injuries by 2046. The second outcome is to increase the percentage of short trips, defined as 5 miles or less for bicycling and 1 mile or less for walking, to 30% by 2025. The third outcome is to increase the number of states and MPOs that have adopted a Complete Streets policy to 35 states and 80 MPOs by 2018.

• Partridge noted that the U.S. DOT will use a variety of tools to share innovative design and safe network solutions with communities to achieve these outcomes. In addition, NHTSA will continue to provide grants and technical assistance to states, and all the modal administrations will focus on actions discussed in the new Strategic Agenda for Pedestrian and Bicycle Transportation. To obtain better data for planning and evaluating policies and programs, she outlined three efforts to improve bicycle and pedestrian data collection. The first area is improving the pedestrian and bicycle counts that are submitted to the Travel Monitoring Analysis System. The second area is developing better methods to track bicycle and pedestrian infrastructure improvements over time. The third area is enhancing coordination within the U.S. DOT to track its investments in bicycle and pedestrian infrastructure and programs. She commented that these activities represent the natural follow-up to the Safer People, Safer Streets initiative.

• Partridge described the FTA Bike and Pedestrian Catchment Policy. She noted that the FTA views safe and accessible services for both bicyclists and pedestrians as a key part of public transportation. As a result, grantees are allowed to use FTA funding for capital projects that improve access within the walk and bike catchment areas of transit stations. Examples of transit systems enhancing bicycle and pedestrian access include rebuilding crumbling sidewalks and broken curb cuts as part of improving bus services in Los Angeles, California; Memphis, Tennessee; and Cleveland, Ohio. She also noted that Columbus, Ohio, constructed a pedestrian overpass to eliminate dangerous street crossings as part of upgrading a transfer center. Further, as part of an extension of the Washington, D.C., Metro, new rail stations with secure parking for bicycles in an area that is accessible 24 hours a day are being provided. Partridge noted that grantees can use FTA funding to make improvements such as these that not only encourage people to walk and bike, but also make it safer and easier for them to do so, as long as the projects are within the catchment area for transit stations and stops.

• Partridge described the FTA's *Guidebook on Pedestrian and Bicycle Connections to Transit*, which will be released in early 2017. The guidebook includes a compendium of best practices to help transit and other transportation professionals evaluate, plan for, and implement improvements to pedestrian and bicycle access to transit. She noted that the guidebook covers key concepts, including access sheds, connected networks, station area comfort, safety, and legibility. It also addresses specific pedestrian needs, including complete sidewalks and safe, convenient crossings. Elements focused on bicyclists include bike parking and on-transit bicycle accommodations. Topics such as integrating bikeshare with transit and making bikeshare and transit more accessible to people who are not able to ride standard bicycles are covered. The guidebook also features a chapter on implementation that covers funding, marketing, interagency coordination, and data collection.

• Other elements of the guidebook highlighted by Partridge include references to existing guidance documents and information collected through a literature review, interviews with professionals, and case studies of three regions (Los Angeles; Minneapolis–Saint Paul; and Atlanta, Georgia) that are taking innovative approaches to integrating pedestrians and bicycles with transit. She noted that the case studies help to frame several key lessons, including the need for transit agencies to prioritize walking and bicycling for transit access, the value of strong plans and policies as pillars of future prioritization and investment in walking and biking connections, and the important role that transit agencies and MPOs play in assisting local jurisdictions to enhance their capacity to make improvements and to secure funding for projects.

• Partridge stressed the importance of ensuring that efforts to increase bicyclist and pedestrian safety also build ladders of opportunity in communities across the country. She noted that building ladders of opportunity was championed by President Obama and that Secretary Foxx had made it integral to the U.S. DOT's activities. She suggested that FTA has been providing ladders of opportunity for over 50 years by providing vital connections to jobs, school, health care, and all the benefits a community has to offer. She noted that expanding access to safe, reliable public transportation makes it possible for more people to improve their lives and their families.

• Partridge commented that research is needed to improve policies and programs related to bicyclists and pedestrians. She noted that Secretary Foxx often speaks about growing up in a neighborhood in Charlotte, North Carolina, that was essentially trapped between two Interstate highways. The freeways limited access to the neighborhood and discouraged grocery stores, pharmacies, and other businesses from opening there. The freeways also had a psychological impact, giving people who lived there a sense they were second-class citizens. She noted that this problem was not limited to Charlotte, and that other modes—airports, railroads, and transit—have divided communities, damaged local businesses, and cut people off from opportunities. She suggested that even bikesharing programs, which have been such a successful model in a variety of urban areas, have trouble penetrating into every neighborhood and offering a way of travel that is affordable for everyone. According to Partridge, focusing on pedestrian and bicycle networks has a unifying effect because they create community and unite rather than divide residents.

• In looking to the future and making transportation decisions that will have long-lasting impact, Partridge reported that the Secretary is focusing on both the big picture and the small picture, both the macro and micro perspectives. The big picture is the Interstate's unquestioned role in supporting the national economy and in linking all parts of the country. The micro side focuses on the need to consider the historical, often harmful impact freeways have had on individual neighborhoods and communities and to explore options for reconnecting communities that will have long-term benefits. She noted that the bicycle and pedestrian community has long

championed community-based solutions because they work. Partridge suggested there is an opportunity to rebuild the transportation system so that it works for everyone in all communities, connecting people to opportunities without harming people in its path and building projects by, for, and with the input of the communities affected by them.

- Partridge discussed the disturbing trend that pedestrian fatalities and injuries happen twice as often in low-income communities as they do in high-income neighborhoods. She suggested that although one could debate causation and correlation, the simple fact is that low-income areas are twice as likely to lack things like sidewalks or marked crosswalks or street lights. She stressed that she believes cities and the public transit industry must do more for the people who rely on transit the most.
- In closing, Partridge noted that FTA was pleased to join the UTC program and TRB in this important conference. She noted that delivering safer travel options for people on foot, in wheelchairs, on bikes, and using other vulnerable modes takes creativity, commitment, and collaboration. She suggested that current efforts are helping to create safer, more efficient streets for everyone who uses them, and she challenged participants to continue to explore new and innovative approaches.

Jennifer Dill, Portland State University, presided at this session.

PLENARY SESSION 1

How Did We End Up Where We Are Today with Design? The Role of Policy and Guidance

Bill Schultheiss, *Toole Design*
Ryan Russo, *New York City Department of Transportation*
Sam Zimbabwe, *District Department of Transportation*

HOW DID WE END UP WHERE WE ARE TODAY WITH DESIGN?

Bill Schultheiss

Bill Schultheiss described the influence of transportation on the development of cities in the United States. He discussed issues with current bicycle and pedestrian design guidelines and his belief in the need for new approaches to improve safety. Schultheiss covered the following topics in his presentation:

- Schultheiss described the development of American cities, the invention of the automobile, and the evolution to a vehicle-centric culture. He highlighted the impact of Robert Moses on roadway building, the development of the suburbs and the Interstate system, and the use of highway and design guidelines. He noted that many of these guidelines still influence the design of streets and roads today. He talked about how it is his personal belief that new policies, guidelines, and strategies are needed to address safety and mobility concerns.
- Schultheiss highlighted the negative impacts of freeways, parking facilities, and funding policies on communities throughout the country. He questioned the premise of many roadway projects and suggested that with ever-increasing demand, freeway projects are not reducing congestion.
- Schultheiss suggested that suburban land use design, with the mix of high-speed arterials and residential neighborhoods, is dangerous. He believes that policies and design guidelines prioritize mobility over safety. He also suggested that the concept of vehicular cycling in the 1970s and 1980s had a negative impact on the development of safe bicycling facilities. Vehicular cycling or bicycle driving is riding a bicycle on a road in a manner in accordance with the principles of driving in traffic. He noted

that the 1974 American Association of State Highway and Transportation Officials (AASHTO) *Guide for Bicycle Routes* initially included many measures that would have enhanced bicycle safety, but they were eliminated from the final version. He reported that many of these elements are being added to the update he is working on, including continuing bike lanes at intersections, marking bike crossings, using two-stage turn boxes, and using protected intersection geometry.

- Schultheiss stressed the importance of challenging the premise that wider lanes are safer. He suggested there is no definitive research on the safety effect of lane width on suburban or urban arterials. He also disagreed with the norm, based on a 1972 study in San Diego, California, that marked pedestrian crosswalks confer a false sense of security.[2] He noted that in reviewing the 1972 study of the pedestrians who were struck, most were hit in the middle or end of the crossing, not the beginning. Citing the 2016 Omaha Crosswalk Policy, he noted that the 1972 study still wrongly influences policies and guidelines today.
- Schultheiss compared the pedestrian and bicyclist safety records in the United States and the Netherlands. He noted the much lower injury and fatality rates in the Netherlands and described the differences in bicycle and pedestrian facilities and design treatments in the two countries. He also talked about some of the treatments that provide safer environments for bicyclists, including separated bike lanes, bike priority lanes, and shared space.
- Schultheiss discussed the importance of considering ethics in Vision Zero programs and related safety projects. He said it was unethical to prioritize the mobility of one person over the safety of another person, which some policies and guides promote. He cited the warrants for traffic signals and optional use of pedestrian signals in FHWA's *Manual on Uniform Traffic Control Devices* (MUTCD) as examples of what he believes are unethical guidelines. He noted the importance of challenging these and other guidelines and the need for more research on these topics to make appropriate recommendations for changes.

VISION ZERO IN NEW YORK CITY

Ryan Russo

Ryan Russo discussed Vision Zero in New York City. He described the elements of the program, some of the results, and keys to success. He noted that New York City is able to leverage a history of land use density, pedestrian-oriented streets, and walkability in the program. Russo covered the following topics in his presentation:

[2] Herms, B. F. Pedestrian Crosswalk Study: Accidents in Painted and Unpainted Crosswalks. *Highway Research Record*, No. 406, 1972, pp. 1–13.

- Russo described the need for the Vision Zero program, citing the approximately 370,000 motor vehicle traffic deaths in the United States in the past 10 years. He compared that figure to the 120 deaths in commercial aviation, suggesting that the aviation industry has "designed death out of the system." He challenged conference participants and the transportation community to design death out of the roadway system as well, which is the focus of Vision Zero.
- Russo noted that New York City was aggressive with street redesign under former Mayor Michael Bloomberg and Transportation Commissioner Janette Sadik-Khan. Approaches included road diets, protected bicycle lanes, intersection redesigns, and neighborhood slow zones.
- Russo discussed the need for Vision Zero in New York City. He compared traffic fatality data for New York City and the country as a whole. Traffic fatalities per 100,000 residents for the United States are 10.7 compared with 3.3 for New York City. He noted that progress was made in lowering pedestrian fatalities from 453 and 72% of all fatalities to 167 and 51% in the 2000s. The number and percentage increased to 183 fatalities and 62% of total fatalities in 2013, however.
- Russo cited the aging of the baby boomer generation living in New York City as another reason for Vision Zero. He noted that older adults living in New York City are a population at risk. Although adults 65 years of age and older account for 12% of the population, they account for 36% of pedestrian fatalities. For the United States, pedestrian fatalities per 100,000 adults 65 years of age and older are 2.0, compared with 5.3 for older adults in New York City. Further, the number for New York City residents under the age of 65 is 1.4. The projected increase in the population 65 years of age and older makes addressing this issue even more important.
- Russo described the factors supporting the implementation of Vision Zero in New York City in 2013. Some of these factors included a reframing of the bicycle and pedestrian projects and activities as a result of a change in city leadership, the advocacy of individuals who had lost family members in bicyclist and pedestrian crashes, and the leadership of Mayor de Blasio.
- Russo described the five major focus areas of Vision Zero in New York City: legislation, planning, enforcement, engineering, and education. He noted the leadership of Mayor de Blasio and City Hall in maintaining the program, which increased its prominence. He also noted that the mayor successfully gained the participation of other agencies, including securing additional funding, which resulted in a comprehensive approach.
- Russo discussed some of the legislative accomplishments associated with Vision Zero in New York City. He cited legislation setting 25 miles per hour as the default speed limit on all New York City streets unless otherwise posted as the major accomplishment. The default speed limit had been raised from 25 to 30 miles per hour in 1964 against the recommendation of the then traffic commissioner.

- Russo described the planning activities for Vision Zero, which included developing Borough Pedestrian Safety Action Plans in the five boroughs. Development of the plans included a public consultation component with community conversations and an online dialogue to identify key issues and concerns. The plan development process also included a data analysis component. Russo reported that a major element of the Borough Pedestrian Safety Action Plans is maps identifying pedestrian fatalities and severe injuries per mile on roads. A measure of 50% of pedestrians killed or severely injured on a per mile basis was used for the analysis. As an example, in the Borough of Queens, 127 of 2,169 miles, or 6% of the street miles, host 50% of pedestrian fatalities or injuries. He noted that this information is being used to help target resources to the most critical locations.
- Russo described the enforcement component of Vision Zero in New York City. With competing concerns over terrorism, homicides, and public safety, he noted the challenge of promoting a focus on pedestrian safety among the enforcement community. He reported that the New York City Police Department (NYPD) supported the Vision Zero initiative under the new city administration. The NYPD effort focused on reducing speeding on city roads and ensuring that drivers were yielding to pedestrians. Speed enforcement was a major focus, with the purchase of additional speed radar guns and training for police officers. The annual average number of manual speeding summons issued by NYPD for 2009 through 2013 was 77,828 summons. After the initiation of Vision Zero, 117,768 speeding summons were issued in 2014, and 134,426 summons were issued in 2015. The 2015 figure represented a 73% increase from the pre–Vision Zero 5-year average.
- Russo described the legislatively approved speed camera program, which was initiated as part of Vision Zero in New York City. The legislation allows the use of speed cameras in 140 school zones in the city. The cameras must be located one-quarter mile from a school entrance and can be used only during school hours. Vehicles must be traveling 11 miles per hour over the speed limit for drivers to receive a citation. The citation fine is $50, but no points are assigned to the driver. In 2014, 445,065 school zone speed camera violations were issued. This number increased to approximately 1.2 million in 2015.
- Russo noted that although New York City has a good culture of drivers yielding to pedestrians in crosswalks when making turns on green lights at intersections, as required in the vehicle traffic code, the large volume of pedestrians results in conflicts, injuries, and fatalities. As part of Vision Zero, NYPD officers increased enforcement of failure to yield violations. As a result, the number of failure to yield summons increased from a pre–Vision Zero 5-year average of 10,808 summons to 33,577 summons in 2014 and 39,852 summons in 2015, a 269% increase.
- Russo discussed some of the New York City Vision Zero street engineering improvements. He reported that additional installations of speed bumps on streets

near schools and parks have been a major focus. He noted that a more proactive approach has been taken to adding the 7-second leading pedestrian interval at traffic signals with high volumes of pedestrians, using the maps developed in the Borough Pedestrian Safety Action Plans. He presented examples of roadway improvements including pedestrian safety improvements associated with a subway station at Broadway West 96th Street in Manhattan, a roundabout on Intervale Avenue in the Bronx, and enhancements at the Jackson and Westchester elevated train and bus stop in the Bronx. The Queens Boulevard project, which includes major safety improvements, is the mayor's signature Vision Zero project. The increased use of protected bike lanes and safety projects in priority locations has also occurred.

- Elements of education and outreach activities highlighted by Russo included cards distributed to motorists and pedestrians, advertising campaigns, and other activities. He noted that NYPD and New York DOT Street Teams working in high-crash neighborhoods interacted with 870,000 people. Outreach education activities were conducted in 1,200 schools, 185 senior centers, and many community groups. Further, the New York Taxi and Limousine Commission holds over 100 events for drivers and creates "Buckle Up" and "Drive Like Your Family Lives Here" videos. He noted that the Your Choices Behind the Wheel Matter campaign had a major focus on male drivers between 25 and 45 years of age. He also noted that an assessment of the Your Choices Matter campaign indicated that 72% of New York drivers recalled having seen the campaign, 75% of drivers reported that the advertisements compelled them to "expect more enforcement of traffic laws," and 86% of drivers reported that the advertisements convinced them to "pay more attention to pedestrians and cyclists while driving."
- Russo reported that overall traffic fatalities in New York City declined in 2014 and 2015. There were 233 traffic fatalities in 2015, compared with 297 in 2013. Further, pedestrian traffic fatalities declined from 183 fatalities in 2013 to 136 fatalities in 2015. He noted the ongoing difficulty in reducing pedestrian fatalities due to the aging population and the booming economy.
- Russo highlighted some of the keys to the success of Vision Zero New York City. These keys included the vision and commitment at the mayoral level, the partnership with the enforcement community, scalable and effective interventions, and using data to identify problems and act accordingly. He stressed the importance of maintaining a focus on culture change, which takes time, but is achievable.

THE ROLE OF POLICY AND GUIDANCE

Sam Zimbabwe

Sam Zimbabwe discussed transportation, land use, and mode choice in the District of Columbia. He described current trends, challenges with traditional transportation models, and topics for further research. Zimbabwe covered the following topics in his presentation:

- Zimbabwe described the development of cities, including Washington, D.C. He noted the role activism plays in transportation planning. As an example, he cited the freeway plans developed for the Washington, D.C., region in the 1960s that would have destroyed major sections of the city. He noted that the protests over these proposals changed plans in Washington, D.C., and in many metropolitan areas throughout the country.
- Zimbabwe discussed the role of land use in transportation. He noted the high nonautomobile mode share in the District, which can be attributed to land use and development patterns. The drive-alone mode share for the District is approximately 38%, compared with 69% for the region, and the mode share for transit in the District is approximately 39%, compared with 15% for the region.
- Zimbabwe pointed out the importance of looking beyond just mode share. He noted that the percentage of District residents commuting by automobile has declined over the past 25 years, while the bicycle mode share has increased. The population of the District increased by approximately 100,000 people during the same time frame. He reported that over 50,000 residents walk to work in the District, the number of people bicycling has increased, and the number of people driving has decreased.
- Zimbabwe suggested these trends highlight the challenges associated with traditional transportation planning, especially the four-step regional travel forecasting model. He noted that the Metropolitan Washington Council of Governments has been discussing the outcome measures for the constrained long-range transportation plan. The measures indicate that traffic congestion in the region will be worse in 25 years and that people will waste more time in congestion, even with the major investments being made. He further noted the public frustration with these forecasts. He voiced concern that the outcomes may be based on invalid assumptions and input data.
- Zimbabwe described some of the limitations with the current modeling processes. He noted that land use plans depend on local projections, trip generation depends on historic models that undercount nonautomobile trips, and trip distribution depends on logic models. Further, he suggested that mode choice discounts nonautomobile modes. Infrastructure decisions are then based on the outcomes of these models. He noted that overprojecting jobs in the suburbs and underprojecting

housing demand where people would actually like to live also tend to occur with the current modeling process.

- Citing the projected and actual growth in VMT from the annual *Conditions and Performance Report* to Congress developed by the Federal Highway Administration (FHWA), Zimbabwe suggested that flawed models have driven decision making at all levels. He noted that transit-oriented development also does not fit into the traditional modeling process. He reported that research in the District and other areas indicates that the total number of trips from transit-oriented development is understated and the total number of vehicle trips is overestimated. Further, vehicle ownership and parking demand are overestimated. These over- and underestimates result in mitigating issues at intersections, rather than focusing on connecting networks to better address travel needs. They also undervalue the role of design in transportation planning.
- Zimbabwe described the MoveDC 2040 Vision and compared it to existing conditions. He cautioned that one challenge is that equal access does not always mean equal use. He noted that having travel choices does not mean that people will use them. He suggested that education and outreach on available transportation options are important.
- Zimbabwe discussed the importance of Vision Zero. He presented the 10 leading causes of injury death in the United States by age group in 2013. Unintentional motor vehicle traffic fatalities were the number one or number two cause of injury death for all age groups, except for infants under 1 year of age. He noted that the District has made steady progress in lowering traffic fatalities over the past 25 years through a series of investments. He also noted that homicides are still a major problem in the District, with five times as many homicides as traffic fatalities. He noted the important link in the District between personal safety and transportation choices.
- Zimbabwe concluded by highlighting areas for further research. Examining the important role of land use policy in shaping transportation was one topic. A second topic was exploring how to develop performance measures that focus on key objectives rather than using performance measures based on available data. Although it is not necessarily a research topic, he noted the difficulty in obtaining adequate operating funding. Finally, he suggested research to identify methods to better integrate affordability and equity into the land use and transportation dialogue.

Shaunna K. Burbidge, Active Planning, presided at this session.

PLENARY SESSION 2

Impact of Emerging and Future Technologies on Pedestrian and Bicycle Safety

Heidi Coleman, *National Highway Traffic Safety Administration*
Robert Scopatz, *VHB*
Alex Rixey, *Fehr & Peers*
Michael Clamann, *Duke University*

PEDESTRIAN AND DRIVER DISTRACTION: OVERVIEW AND NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION PREVALENCE AND RISK STUDY

Heidi Coleman and Robert Scopatz

Heidi Coleman and Bob Scopatz discussed a NHTSA study examining pedestrian and driver distractions. They summarized the key elements of the study, including the literature review, the pedestrian and driver observation methodology, and high-level preliminary results. Coleman and Scopatz covered the following topics in their presentation:

- Coleman defined a distraction as any activity that can divert a person's attention away from the primary task. The three basic types of distractions are visual, manual, and cognitive. Examples of possible distractions for drivers and pedestrians include texting, talking on a cell phone, using a navigation system, eating and drinking, and personal grooming.
- Coleman presented information from the National Occupant Protection Use Survey, an annual observational survey sponsored by NHTSA. She noted that drivers observed text messaging or manipulating handheld devices increased from 1.7% in 2013 to 2.2% in 2014 and in 2015. A 2009 study by the Virginia Tech Transportation Institute found that drivers who are texting take their eyes off the road for 5 seconds, which is equivalent to the length of a football field, when traveling at 55 miles per hour. A 2012 study by the Pew Research Center found that 53% of all adult cell phone owners have been on the giving or receiving end of a distracted walking encounter.

• Coleman noted that according to 2014 crash data, distraction was reported in 10% of fatal crashes and 18% of injury crashes. Further, of the 3,179 distraction-affected fatalities, 420 (13%) were pedestrians. She noted that these figures may be low, as distracted driving often goes unreported, especially in crashes involving pedestrians.

• Coleman discussed the total number of fatalities from motor vehicle crashes from 2006 to 2015, including pedestrian fatalities. Of the 35,092 total traffic fatalities in 2015, 5,376 (15%) were pedestrian fatalities. There were approximately 2.4 million total injuries from crashes in 2015, with approximately 70,000 pedestrian injuries, accounting for 3% of the total injuries. She noted that total annual fatalities have declined over the past 10 years, but pedestrian fatalities have increased. As a result, the rate of pedestrian fatalities has been steadily on the rise. Distraction-affected fatalities held relatively constant at approximately 3,000 per year over the 5-year period from 2010 to 2015, representing around 10% of all fatalities.

• Coleman reported that NHTSA commissioned the pedestrian and driver distraction study to examine these trends and to better understand the impact of distracted drivers on pedestrian safety. She noted that Kristie Johnson of the NHTSA Office of Behavioral Safety Research served as the lead on the study, which was conducted by VHB. Bob Scopatz of VHB served as the principal investigator.

• Coleman reviewed the study's research goals, which included quantifying distraction among pedestrians and drivers at intersections and identifying the most prevalent electronic and nonelectronic distractions. The other research goals were to quantify the safety-related behaviors of pedestrians at intersections and to quantify the risks associated with pedestrian and driver distraction. She noted that the three key study components were a review of relevant literature, conducting naturalistic observations of pedestrians and drivers, and analyzing crash data.

• Coleman discussed the literature review process and results. She noted that available literature on pedestrian distraction, driver distraction, and interactions between pedestrians and vehicles was reviewed. The types of studies examined included naturalistic observations, simulator studies, and laboratory experiments. Studies analyzing crash and injury data were also reviewed, as were engineering studies.

• Coleman described some of the findings from the literature review, including the ways that distraction influences how pedestrians walk, react, and behave. She noted that inattentional blindness occurs when a pedestrian fails to notice something that is in their line of sight. Path keeping, crossing times, gait, and stride may also change when pedestrians are distracted. She reported, however, that no studies showed a direct link between the behavioral effects of distraction and pedestrian crash risk.

• According to Coleman, driver distraction has been studied much more extensively than pedestrian distraction. Impacts of distracted driving identified from the literature review included delays in response times, errors in driving performance, and reductions in field of vision. She noted that studies have identified mixed risks

associated with talking with other people and other possible distractions. There were strong findings that texting influences driver performance, with some drivers compensating by adjusting speed and following distance, but that these adjustments are incomplete or not entirely effective.

- The literature review did not identify many studies on distraction and the interaction of pedestrians and vehicles. Coleman noted that a few studies focus on traffic conflicts as a predictor of crashes. These studies may examine the interaction of two road users with at least one user changing course or changing speed to avoid an imminent collision. The literature review findings were used as a foundation for the other elements of the study.
- Scopatz discussed the list of electronic and nonelectronic distractors used in the study. Electronic distractors included cell phones, audio devices, tablets, GPS, and other devices. Nonelectronic distractors included other people, reading, eating and drinking, and other activities.
- Scopatz described traffic conflicts as pedestrians and vehicles coming within a few seconds or feet of each other, with one having to slow down, stop, or change direction to avoid a collision. He noted that the severity of a conflict can be quantified. Elements of a serious conflict might include a pedestrian leaping, running, or making other quick movements and a driver hard braking, accelerating, swerving, or making other emergency maneuvers. He noted the observations in the study did not include any actual crashes.
- Scopatz described the research methodology, which was developed on the basis of the literature review. The field data collection included four simultaneous observation types that involved one observer and one supervisor positioned at each site. In the first type of situation, observers counted the number of pedestrians crossing at a certain point on a sidewalk and the prevalence of distractors. Observers recorded the gender and age of the pedestrians. In the second situation, highly trained observers recorded pedestrian crossing behavior, distractions, and traffic conflicts. The age and gender of the pedestrians were recorded, as well as any behavior taken by the pedestrian to avoid a conflict with a vehicle. The third type focused on counting vehicles and driver distractions and behavior to avoid a conflict with a pedestrian.
- Scopatz reported that in the final type of observation, vehicle conflict and driver distraction were paired with pedestrian observations. He noted that this situation required the pedestrian observer and the vehicle observer to work in concert. The study software program was set to alert the pedestrian observer to select the next pedestrian who was distracted or not distracted, male or female. The pedestrian observer told the vehicle observer whom they were watching, and the vehicle observer had to select the vehicle most likely to come in conflict with that pedestrian. Scopatz reported that the observers became very proficient at working together and

selecting the appropriate vehicle to follow. He noted that special features of the methodology included training to 95% agreement and promoting the best observers to more difficult tasks. The supervisors also conducted some tandem observations as a quality control check.

- Scopatz reported that the study is complete and that the results are under final review by NHTSA and are not yet publicly available. The report should be available by early 2017. A journal article is also planned for 2017. He noted that the results will include information on the proportion of distracted pedestrians and drivers, the most common types of distractors, the gender and age of the most commonly distracted pedestrians and drivers, and any trends in location type and time of day. He noted that 3,964 pedestrians were counted at 10 sites. Approximately 69% were distracted by a variety of electronic and nonelectronic sources, with women more distracted than men. Cell phones and MP3 players were the most common forms of electronic distractors. Other people and eating and drinking were the most common types of nonelectronic distractors. A total of 4,184 drivers were counted, with 54% distracted. Men and women drivers appeared to be equally distracted. The types of distractors were in the same order of prevalence as those recorded for pedestrians, although the prevalence was slightly different. The analysis is examining if distracted pedestrians have an increased risk of traffic conflicts and if they behave differently than nondistracted pedestrians at crossings. Other factors being examined include if distracted drivers have an increased risk of traffic conflicts, risks associated with the combination of distracted pedestrians and distracted drivers, if electronic devices pose a greater threat than other distractors, the most distracting devices or behaviors, and if pedestrians are doing anything to mitigate risk.

CROWDSOURCING PEDESTRIAN AND CYCLIST ACTIVITY DATA

Alex Rixey

Alex Rixey discussed crowdsourcing pedestrian and bicycle activity data and suggested possible approaches for use of the data. He credited the January 2015 FHWA report, *Crowdsourcing Pedestrian and Cyclist Activity Data*, by Amy Smith of Fehr & Peers for much of the information. Crowdsourcing refers to data provided by individuals to the Internet and used by individuals and organizations for different purposes. Rixey covered the following points in his presentation:

- Rixey described the four main categories of crowdsourced data: in situ, thematic, thumbtack, and spatial inventory. In situ data track people and their trips.

Thematic data are compiled information, such as demographic data, on large groups of people. Thumbtack data can be as low tech as having people put Post-it notes on a board at a community meeting to using sophisticated web-based tools to highlight specific problems or ideas. Spatial inventory data are obtained from a wide group of users to better describe the built environment.

- Rixey discussed other distinctions associated with crowdsourced data. He noted the difference between explicit and implicit data. Reponses to a specific question on a survey that a participant knows is being collected is an example of explicit data. With implicit data, participants may not know that data are being collected or how the data are being used. Crowdsourced data can also be characterized as general purpose data or domain-specific data. General purpose data do not require specialized knowledge from the participant. Domain-specific data are collected from participants with specific expertise. Another characteristic described by Rixey was the scope of the data. Global data, which do not have any restrictions, have the largest scope. Audience-centric data are collected at a specific place and during a specific period of time. Geocentric data pertain to a specific location but are not necessarily constrained in time. Event-centric data concern a specific event but not necessarily a specific place.
- Rixey highlighted examples of these different data attributes. Individuals using STRAVA, an activity-tracking smart phone app, can explicitly opt in to participate and track their running or bicycle trips. Those data can be aggregated with activity trips from other users with STRAVA|METRO to provide an overall picture of where activity is occurring in an area. He noted that Capital Bikeshare installed GPS receivers on some bicycles as part of a pilot program for tracking trips without explicitly notifying users, which provides an example of implicit data. The results illustrate the different types of bicycle trips made by tourists and regular users. Trip data collected by INRIX, AirSage, and other companies from mobile devices provide other examples of implicit data. StreetLight Data and other companies package such trip data into more user-friendly formats tailored to specific uses. He noted that U.S. Census data provide a good example of thematic data. The District (Washington, D.C.) DOT Vision Zero interface, which allows individuals to report safety concerns, is an example of thumbtack data. He cited ConnectSF, which allows individuals to identify preferences for new subway lines, as another example of thumbtack data. Rixey noted that OpenStreetMap is used by many people for spatial inventory data and that it continues to be updated. He also highlighted the Montgomery County, Maryland, online Bicycle Stress Map as another example of spatial inventory data. He noted that this site was developed by the county, but that it could also have been created by using crowdsourced data.
- Rixey reviewed some of the potential issues associated with crowdsourced data. He noted that privacy concerns and proprietary versus open data are frequently voiced issues. Concerns with biases related to the underreporting of collision data,

self-selection, limited demographic groups, and honesty and validity are also possible issues with crowdsourced data. The interpretation of crowdsourced data, especially from data-tracking mobile devices, may also be an issue.

- Rixey described examples of combining various types of crowdsourced data for different uses. In one example, in situ data on the origins and destinations of Capital Bikeshare trips in Montgomery County were combined with thematic data from the Census and other sources. These data were analyzed along with data from the Montgomery County Bicycle Stress Map to predict the number of trips between bikeshare stations on the basis of demographic characteristics, built environment variables, and the bicycle stress level. Another example he cited was the Walk First project in San Francisco, which estimated pedestrian crossing risk at intersections by using synthetic data modeled using thumbtack counts, population data, and information on the built environment. He noted that none of the top 20 intersections by absolute pedestrian crashes were in the top 20 by pedestrian crossing risk, which helped identify where to focus safety improvements.
- Rixey discussed opportunities to obtain new and improved data through crowdsourcing. One example was the use of better traffic collision and near-miss data through smartphone reporting apps. The Bike Accident Toolkit developed at Boston University represents one way for people to report information about a bicycle collision. Bicyclists and individuals involved in other activities can turn on the CRASH app on a smartphone. The app detects unusual movement and alerts the user. If the user does not respond within a specific amount of time, the app automatically alerts the emergency contact and calls for emergency services to come to the GPS location provided by the phone. Rixey noted that data from this app could be used to help identify high-risk areas. He also suggested that obtaining more accurate data from emergency dispatchers and first responders would be beneficial.
- BikeMaps.org was another example cited by Rixey, who noted it is used in Vancouver in British Columbia, Canada, and in Germany to allow bicyclists to report and track collisions, near misses, and risk areas. Data can be aggregated and displayed for multiple uses. He noted that autonomous vehicles and self-driving cars provide another source of infrastructure data. Possible uses of these data include identifying poor roadway pavement, missing curbs and curb cuts, and other infrastructure needs. He suggested that data on the use of different modes could also be collected from the Apple Maps or Google Maps apps on smartphones by examining the characteristics of different trips. He noted that these data could help obtain larger samples of exposure data than household surveys and other methods. He also noted that StreetLight Data recently acquired Cuebiq, which produces additional mobile device movement data and is refining a “tripifying” algorithm. The initial focus is on automobile movements, but other modes, including active transportation modes, are anticipated to be included in the future.

- Rixey discussed possible uses for crowdsourced data from numerous sources. He suggested that better collision and near-miss data, better trip data, and better spatial data could be used to improve reactive safety analysis capabilities and apply more proactive analysis techniques. He also suggested a new approach that would use the improved data to enhance the current reactive practice of counting the number of collisions, injuries, and fatalities and obtaining a rate by dividing the total by the exposure. This information is typically focused on an individual spatial point, such as an intersection or roadway segment. Developing a profile and identifying countermeasures are the typical next steps. He noted that having better data on each of these elements would improve the overall safety analyses. He suggested that the improvements would also allow for proactive safety analysis. For example, it might be possible to identify where bicycle and pedestrian activity is suppressed due to unsafe conditions, to conduct better predictive analyses on the basis of characteristics of known unsafe locations, and to address design concerns to prevent an area from becoming a safety hot spot.
- Rixey noted that the trend in transportation metrics is to examine the system as a whole rather than as a series of isolated components. He suggested this same approach in safety by flipping the script to focus on safe conditions for travelers and people in general, rather than safety conditions at specific locations. For example, crashes, injuries, and fatalities are now examined per 100 million VMT. He suggested that examining crashes, injuries, and fatalities per resident, per employee, per grocery trip, per dollar of goods delivered, or other measures would be beneficial. These measures could be used to provide a full accounting of the safety costs, or risks, of travel. He explained how this method could be applied by using a trip to the grocery store in two neighborhoods in Washington, D.C., as an example of analyzing the internal safety cost and the external safety cost for an individual. He also noted other ways to improve safety and still help people accomplish their trip purposes. These methods include designing safer land use and transportation systems and reducing VMT and speeds on local roads.

AUTONOMOUS VEHICLE DISPLAYS AND PEDESTRIAN SAFETY

Michael Clamann

Michael Clamann discussed autonomous vehicles and pedestrian safety. He described some of the technology associated with autonomous vehicle pedestrian detection, potential issues with pedestrian safety, and current research at the Duke University

Human Autonomy Laboratory. Clamann covered the following topics in his presentation:

- Clamann suggested it was not an overstatement to say that autonomous vehicles will revolutionize transportation in many ways, including providing transportation access for people with disabilities and mobility impairments. Further, autonomous vehicles may change the paradigm for automobile ownership, with shared vehicles becoming the norm. He noted that by eliminating human error and preventing crashes, the safety benefits from autonomous vehicles are a key factor in their promotion.
- Clamann reviewed the different autonomous vehicle development and testing efforts under way, including the Tesla Motors Autopilot, the Google Car, and Volvo Intellisafe. Mercedes Benz, BMW, Honda, Ford, and Volkswagen are also developing and deploying different automated and connected vehicle technology. He noted that although many tests are under way, full-scale deployment of autonomous vehicles was well in the future. As a comparison, he said the 2 million miles driven by Google Cars is approximately 2 days of taxicabs driving in Manhattan.
- Clamann described the technology used by autonomous vehicles to detect pedestrians and other objects. He noted that the exact process varies by the technologies being used by automotive companies. In general, when an autonomous vehicle encounters a pedestrian, algorithms in the vehicle's visual perception system and computer search for a match with a similar-looking object in its database. He noted that pedestrians may move in groups, and they have different postures and walking speeds. He suggested that these factors may make pedestrians difficult to match in a vehicle's database. Further, he noted that the computers must be taught to deal with many different situations.
- Clamann described the potential pedestrian point of view with autonomous vehicles. He highlighted different behaviors pedestrians exhibit when crossing streets in trying to determine the intention of a driver. He suggested that pedestrian behavior will change with autonomous vehicles, as pedestrians may be uncertain if it is safe to cross in front of an oncoming autonomous vehicle. He noted that Google and automotive companies are working on vehicle-to-pedestrian communication, and that Google is programming its cars to make tighter turns at corners to better mimic human drivers.
- Clamann described the research at Duke's Human Autonomy Laboratory focusing on pedestrians and autonomous vehicles. Currently, a driver communicates with a pedestrian and a pedestrian communicates with a driver. In an autonomous vehicle, the driver and the pedestrians may never have contact, as the vehicle computer is in charge.
- He explained an experiment conducted to compare the effectiveness of different methods of presenting vehicle-to-pedestrian information as well as collecting data on the behaviors of pedestrians crossing the street. He noted that the results will be used

as the basis for developing models of pedestrian behavior in different street-crossing applications.

- Clamann described the vehicle displays developed for the study. One was an advice display, which used the "Walk–Don't Walk" symbols. The second was an information display with the vehicle's speed. The displays were mounted on the front of the test vehicle used in the experiment. The subjects were asked to cross a street at a crosswalk and midblock with the test vehicle approaching. The subjects started with their back to the test vehicle and were asked to cross to a destination on the other side of the street pointed out by the researchers. Clamann noted that the subject made the decision to cross when the test vehicle was approximately 7 seconds away. He also noted that the research protocol included using a leash on the participants to ensure their safety.
- Clamann reported that 50 people participated in the experiment, accounting for approximately 850 street crossings. The average age of the participants was 26, with 33 female participants and 17 male participants.
- Clamann highlighted some of the results from the experiment. He noted that participants' decisions to cross the street at the crosswalk were made more quickly than their decisions to cross at midblock locations. He suggested this result makes sense, because pedestrians should feel safer in a crosswalk, with drivers required to stop. Clamann reported there was no effect due to the vehicle display type. In the follow-up interviews, 12% of the participants reported using the displays, although 76% reported seeing the display. Only two people (4%) reported using the displays as primary information in making their decision to cross the street, but 56% reported they used vehicle distance, 46% used vehicle speed, and 24% used traffic density. He noted that 46% of the participants stated that having a display made the crossing decision easier even though few participants actually reported using the display.
- Clamann noted that children are taught to make eye contact with the driver of a vehicle when crossing the street. He suggested that new training and public education will be needed with autonomous vehicles. He noted the potential confusion for pedestrians if the makers of autonomous vehicles use different messages and warnings. He also commented that pedestrians could game the system and cause problems for autonomous vehicles. He concluded by suggesting additional research is needed on the topic.

Nancy Lefler, VHB, presided at this session.

PLENARY SESSION 3

Behavior Change Mechanisms

Tara Goddard, *Portland State University*
Jennifer Dill, *Portland State University*
David Schwebel, *University of Alabama at Birmingham*
Laura Sandt, *University of North Carolina Highway Safety Research Center*

THE PSYCHOLOGY OF ROADWAY INTERACTIONS: IMPLICATIONS OF ROAD SAFETY

Tara Goddard and Jennifer Dill

Jennifer Dill discussed a project examining the psychology of roadway interaction and possible implications for bicyclist and pedestrian safety being conducted by Tara Goddard, who was not able to attend the conference. Dill reviewed literature on the topic, discussed the potential influence of attitudes on traffic safety, and described a conceptual model of roadway interaction. Dill covered the following topics in her presentation:

- Dill restressed the issue of bicycle and pedestrian safety noted by other speakers. According to NHTSA, 4,884 pedestrians were killed in traffic crashes in 2014, and 65,000 were injured. Additionally in 2014, 726 bicyclists were killed and 50,000 were injured in traffic crashes. She noted that in addition to being a moral and public health issue, these crashes represent a significant economic burden.
- Dill noted that part of the overrepresentation of pedestrians and bicyclists in serious injuries and deaths is due to the vulnerability of people not protected by an automobile's "bodywork of metal." Dill discussed information from the United Kingdom that indicates a majority of these crashes are attributed to problems of perception or attention on the part of drivers. When just unimpaired drivers during the daytime are considered, these issues of (mis)perception and (lack of) attention are a serious problem. She noted that the similarity of infrastructure and issues of vulnerable road user safety in the United Kingdom and the United States suggests that this pattern holds true here.
- Dill noted that hazard perceptions tests in laboratories have demonstrated that drivers do not recall or react to everything in their visual environment, even critical events, despite the opportunity to see the hazards. She discussed some of the mechanisms behind these "looked but failed to see" errors that make up such

a large percentage of crashes between drivers and bicyclists and pedestrians. She noted that despite what we might like to think, we do not perceive everything in our visual environment, which would be too much to process. The human brain makes decisions, often unconscious ones, about what information to process and how to process it. Dill also noted that although we like to think we at least process the important things, some studies have shown that, unfortunately, that is not always true.

- Dill reviewed the two main ways the human brain processes information: controlled processes and automatic processes. She noted that controlled processes are intentional, involve awareness, require effort, interfere with other processes, and tend to be linguistic or reportable in words. Automatic processes are basically the opposite of controlled processes. Automatic processes do not require intention, awareness, or effort. Automatic processes can be executed simultaneously; they tend to be perceptual and are hard to capture in words.
- Dill presented a video highlighting the interplay between attention and controlled processes. In the video two teams of players are passing a basketball in a circle. She asked the conference participants to count the number of passes completed by the players in the white shirts. After showing the video, Dill asked how many people saw the gorilla walk through the players. She reported that in multiple laboratory studies, approximately half of the study participants did not see the gorilla. She pointed out that this example illustrates how tasks that take a lot of directed attention can "blind" people to strange or otherwise obvious things in plain sight.
- Dill discussed the concept of inattentional blindness, which was noted by earlier speakers. Inattentional blindness is caused by a physiological lack of attention. The outcome is failing to perceive an unexpected stimulus in plain sight. She suggested that in places with lower bicycle or pedestrian traffic, or places where few drivers walk or bicycle themselves, vulnerable road users may not be part of a driver's mental model. The idea of "safety in numbers" might turn pedestrians and bicyclists from unexpected to expected "stimuli."
- Dill discussed the psychology of attention and inattention. Examining how attention works is important to understanding the "looked but failed to see" or other perception errors. She noted that psychologists have known for a long time that attention does not arise in a vacuum. When issues of driver attention are considered, she suggested, it is useful to think of intention as an effect, not a cause. This consideration raises a question: If attention relies on having an idea about something, are some ideas more important than others?
- Dill noted that examining attitudes, which is performed in assessing travel behavior, is also important in examining traffic safety. An attitude is an evaluation of a person, object, group, or concept that has multiple components. Attitude has conscious and unconscious aspects. Attitude can affect mental models and processing, and it can direct attention.

- Dill noted that psychologists describe the three major components of attitude as the "ABCs." The A is affective, which includes moods and emotions. The B is behavioral, which includes intended and enacted behaviors. The C is cognitive, which includes thoughts and beliefs. Dill presented an example of attitude toward bicyclists. In the example the affective is "Bicyclists annoy me." The behavioral is "I do not want to bicycle." The cognitive is "Bicyclists should not block cars."
- Dill noted it is also important to understand that attitudes have two related but distinct forms: explicit and implicit. These aspects relate to the controlled and automatic processes discussed earlier. Explicit attitudes are deliberate, conscious, and controlled. They are voluntarily accessible and can be acknowledged. Implicit attitudes are automatic, below conscious awareness, and involuntarily activated.
- Dill noted that explicit and implicit attitudes are not always consistent. Studies in multiple domains have shown it is possible to hold inconsistent explicit and implicit attitudes about a single concept. She outlined an example of inconsistent explicit and implicit attitudes regarding bicyclists. The explicit attitude is that "Bicyclists are doing good things for the environment." The implicit attitude is that "Bicyclists are annoying." She noted that examining these types of responses is important because it has been shown that implicit attitudes are a better predictor than explicit attitudes in complex, high-stress, or high-speed environments. The roadway environment is one of the most complex, cognitive load–heavy environments, especially in high-speed situations. Implicit attitudes are better predictors than explicit attitudes when automatic processing conditions such as time pressure and cognitive load exist, sensitive topics like prejudice are being discussed, and with nonverbal or subtle behaviors.
- Dill described implicit bias, which can be thought of as preferences for or against something on the basis of an individual's implicit attitudes about that thing. Implicit biases have been shown to affect people's behaviors in a variety of domains, from policy making to health care to workforce to policing. Dill questioned if implicit bias might affect how people behave in the roadway environment.
- Dill reported that previous studies have shown that drivers do not respond equally to all pedestrians. Examples cited in the literature include drivers yielding more frequently to visibly disabled pedestrians, drivers more likely to yield to pedestrians in the same age group, drivers in high-status cars being less likely to yield to a pedestrian, and drivers displaying racially biased yielding behaviors to pedestrians at crosswalks. Dill noted that none of these studies intercepted and studied the drivers, however, so it is not possible to say if these behaviors were based on explicit or implicit decision making. Evidence from the extensive literature on bias, however, suggests many people act on implicit biases, not explicit ones.
- Dill noted that the literature also suggests that drivers do not respond equally to all bicyclists. For example, studies have indicated that drivers passed more closely to male, Lycra-wearing bicyclists. Dill commented that some evidence suggests that the

bias drivers may exhibit could be compounded by how they evaluate the motivation of people outside the car. Further, an individual's implicit views of motivations and the perceived status of different modes can also affect their mode choice.

- In concluding, Dill described a conceptual model of roadway interactions developed by Goddard. Roadway interactions are influenced by a complex interplay of individual, sociocultural, and physical components. Roadway interactions cover all three of the components. Attitudes are caused by, and contribute to, multiple aspects of this interplay as theorized in the conceptual model. The potential importance of attitudes and biases in the overlapping areas of the model and their relationship with behavior were noted as an important but understudied area of research. Beyond the serious safety implications of driver–pedestrian and driver–bicyclist interactions, negative interactions can affect the quality of the pedestrian and bicycling experience and the likelihood of individuals choosing healthier, more environmentally friendly modes. The following questions were presented by Dill as possible implications of these psychological aspects of roadway behavior for further discussion. Can design "overrule" these implicit biases? Can education or enforcement be better informed by theory? How do we normalize or legitimize all roadway users?

AN INTERVENTION TO REDUCE DISTRACTED WALKING

David Schwebel

David Schwebel discussed a behavioral intervention to reduce distracted walking on an urban college campus. He described the project background, the behavioral interventions, and the results. Schwebel covered the following topics in his presentation:

- Schwebel described possible factors for the continued increase in crashes involving pedestrians. Some factors include more driving due to lower gasoline costs and more walking due to health promotions. He noted that more distracted drivers and pedestrians may also be contributing to the increase in crashes.
- Schwebel described the goal of the project, which was to reduce distracted pedestrian behavior on urban college campuses. He noted that the theory-driven behavioral intervention was among the first to focus on reducing distracted pedestrian behavior. He noted that young adults have a high rate of smartphone and technology use and that urban college campuses have high rates of pedestrian activity.
- Schwebel noted that the interventions were conducted on the campuses of Old Dominion University (ODU) in Norfolk, Virginia, and the University of Alabama at Birmingham (UAB). He noted that both campuses are in urban areas, with high

minority enrollments and large undergraduate populations. An intersection was targeted on each campus. In both cases, the intersection was on a major boulevard with a median and a somewhat minor cross street with traffic signals. Hampton Boulevard and 45th Street in Norfolk and University Boulevard and 14th Street in Birmingham were the two test locations. Both intersections have student housing on one side and classrooms on the other side, with heavy pedestrian traffic.

- Baseline data were collected at each site by using observational data collection methods. Behavior data were collected continuously on weekdays from 7:45 a.m. to 5:45 p.m.; 30-minute coding blocks were used, and coders rotated every 30 minutes. There were three sets of observations with one rest period:
  - 5 minutes of traffic count;
  - 5 minutes of random selection of an approaching pedestrian with observation for full crossing and detailed coding on individual differences, crossing behavior, and distraction;
  - 15 minutes of coding of all approaching pedestrians as distracted or not distracted; and
  - 5 minutes for coders to rest and rotate to a different corner of the intersection.
- Schwebel described the collected data, which included traffic counts and the 5-minute individualized coding. Data recorded during the individualized observation included apparent gender, estimated age, if the individual entered with the walk signal, if the individual looked left before entering the street, if the individual entered within the crosswalk, if the individual looked right while leaving median, and if the individual exited within the crosswalk. Whether the individuals were distracted was also recorded, and if they were, the type of distraction (e.g., phone, texting, headphones) was noted.
- Schwebel reported that 9,523 individuals were recorded crossing the two streets. The baseline results showed that 33% of all pedestrians crossing the streets were distracted. There were slight differences between the campuses, with higher use of headphones at ODU and higher levels of texting at UAB.
- Schwebel described the results focusing on the safety of the distracted pedestrians. As an example, he noted that 65% of nondistracted pedestrians crossed with the walk signal, but 70% of the pedestrians who were texting crossed with the walk signal. He suggested these individuals may know they are distracted by texting and are making sure they cross with the walk sign as a compensatory mechanism. He noted that women were more likely to be distracted by talking on the phone, texting, and other multiple distractions, while men were more likely to be distracted by headphones.
- Schwebel concluded that the data show there is a problem with pedestrians distracted on urban college campuses. The question then becomes: How do we create change? He noted that health behavior theory indicates that change is difficult. He noted that the literature indicates that distracted driving interventions have

shown mixed results, and distracted pedestrian interventions are few in number. He further noted that distracted driving policy change has some efficacy, and distracted pedestrian policy is sparse.

- Schwebel commented that the broader health literature indicates that people must feel vulnerable or susceptible to a health risk in order to make a behavior change. If an individual feels he or she may be harmed personally by a behavior, then there is motivation and reason to change. He reported that walking while texting in a simulated environment was tested to evoke this idea of perceived vulnerability to an individual.
- Second, Schwebel described the approach to change the perceived and actual norms in the community to make it normal to behave in the safe way. He used the example of changing the norm in seat belt use as a successful approach. In this case, the focus was on accomplishing a change in the norms at a university campus by creating social contagion, also called diffusion, through the spreading of ideas, behaviors, and practices via established social networks of known individuals. Both traditional face-to-face interaction and social media were used to make this change.
- Schwebel reviewed the intervention approach, which included a quasi-experimental, pre- and postdesign with a control group. ODU was the control group and UAB was the test group. Baseline data were collected at both campuses. The intervention at UAB offered individuals the opportunity of being a distracted pedestrian in a virtual reality environment through the use of a simulator. Extensive media were also used to change norms. Survey data were collected at UAB at baseline, postintervention, and at 5 months. Postintervention and 2- and 6-month follow-up observations were conducted at both campuses.
- Schwebel described the intervention, which focused on increasing the perceived vulnerability among individuals. This goal was accomplished by having individuals text while crossing a street in a virtual pedestrian environment in the simulator. A second goal was to change norms in the community. A Distracted Pedestrian Week was organized on campus with significant media and advertising. The media included local television coverage, posters, and signs around campus. He noted that a high level of visibility was created. Further, the single simulator with the virtual pedestrian environments was open to the public in two different classroom buildings at different times. He presented a short film to illustrate the use of the simulator. He also presented examples of the "Pocket & Walk It" logo that was used on t-shirts, yard signs, and other media.
- Schwebel summarized some of the self-reported survey results from the students using the simulator. A total of 78% reported receiving a flyer or brochure on pedestrian safety, 83% said the simulator experience made them think more carefully about distracted pedestrian behavior, and 61% self-reported they had changed behavior since using the simulator. Further, 84% felt the experience was worthwhile

to improve their health and safety, and 95% would recommend that others try the simulator experience.

- In summary, Schwebel reported that the goal to change perceived vulnerability among college students was accomplished with individuals reporting a greater intent to walk undistracted. He suggested that the exposure to the experience of walking while distracted in the simulator may have influenced a behavior change. The observational results of the proportion of individuals walking while texting on both campuses were used to assess changes in actual behavior and community norms. He noted that although the number of individuals walking while texting declined slightly at UAB from the pre- to postintervention periods, the change over time was not significant. Interaction was significant, but not behaviorally meaningful. There was also no change at UAB in the safety elements of crossing with the walk signal, looking left when entering the cross walk, and looking right at the median.
- In concluding, Schwebel noted that distracted pedestrian behavior is common on urban college campuses. The intervention of providing information through highly visible methods on campus and allowing individuals to try crossing a virtual street in a simulator while distracted resulted in a self-reported decrease in risky pedestrian behavior but only a small and nonsignificant change in observed distracted pedestrian behavior.

DEVELOPING AND EVALUATING POPULATION-LEVEL INTERVENTIONS AIMED AT BEHAVIOR CHANGE TO REDUCE PEDESTRIAN AND BICYCLIST CRASHES

Laura Sandt

Laura Sandt discussed the Watch for Me NC program. She described the behavioral change concepts and applications within the context of designing and evaluating a population-level intervention aimed at improving pedestrian and bicycle safety in North Carolina. She provided a brief overview of the Watch for Me NC program, focusing on the elements addressing drivers yielding to pedestrians, and described some of the challenges and lessons experienced in developing, delivering, and evaluating the program. Sandt covered the following topics in her presentation:

- The Watch for Me NC program was initiated as a pilot in four communities in 2009 with funding from a NHTSA demonstration grant. The initial effort focused on educational, enforcement, and behavioral strategies to address pedestrian and bicycle crashes in the state. It was intended to complement Complete Streets and infrastructure projects under way in different areas. Sandt noted that Watch for Me NC evolved over time with support from the North Carolina DOT and the Governor's

Highway Safety Program. There are 25 coalitions participating in 2016. She noted that the initial pilots included analyzing crash data to better understand behaviors that may be contributing to crashes.

- Sandt reported that the first challenge in the early stages of the program was developing a conceptually sound, evidence-based intervention that could be delivered at the community level across the state. She noted there are few examples or evaluations to draw from within the pedestrian and bicycle literature. As a result, literature from public health, psychology, and social science was used to examine behavior change theories and to help determine what behaviors could be addressed through the Watch for Me NC program.
- Sandt reinforced the comments of other speakers related to the complexity of human behavior. There are many aspects of behavior to consider including conscious, unconscious, spontaneous, involuntary, rational, and irrational. She stressed that this complexity needs to be considered in developing interventions. She suggested that one analogy is considering travel behavior similar to learning to play a sport. There is movement across a space involving many people, there are rules to the game, and there is some planned and conscious thinking, but there are also a lot of muscle memory and spontaneous reactions happening and communication and interaction with other people on the field. In developing interventions aimed at improving transportation behaviors and safety skills, she noted it is important to acknowledge the complexity and to consider the mechanics of those behaviors to understand what can be influenced through interventions.
- Sandt noted that the public health and behavioral science fields are useful to transportation practitioners and researchers in identifying target populations and behaviors and developing and applying conceptual models. This information can help focus on different levers to use to help change behavior. She also noted that it relates to the conceptual model of roadway interactions shared by Dill and her comments related to the need for interventions to be more informed by these relationships.
- Sandt noted that the Watch for Me NC intervention was influenced by several theoretical models of behavior change, primarily the socioecological framework, which suggests that to effectively change behaviors and ultimately prevent crashes, work at several different levels is needed. These levels include the individual, organizational, and environmental.
- Sandt reviewed the Watch for Me NC intervention elements at these different levels. Interventions at the individual and social levels included paid, earned, and social media as well as public outreach and engagement. High-visibility enforcement was also a major element. At the organizational level, interventions included training for officers to ensure they understood the laws, intra-agency capacity building, and technology support and templates. The environmental interventions focused on low-cost engineering measures at key locations.

- Sandt reviewed some of the challenges in evaluating the delivery of these intervention elements. She noted that although behavioral intervention delivery evaluations are rarely reported in the literature, they are an important first step for understanding potential program impacts. For example, if a program was not delivered as intended, measuring possible change is difficult.
- Sandt discussed an issue associated with large, populationwide interventions of measuring how the program was delivered by the local agencies, understanding how intensively it was being delivered, and determining what intensity may be needed to change behaviors. Another challenge was obtaining needed data from local agencies. A related issue was underreporting, which may lead to misclassification of exposure to the intervention.
- Sandt described the different methods and data sources used to monitor program delivery at the different levels. Data collected at the organization level included the number of officers trained and safety operations and outreach events reported by each community. Media impressions and individuals receiving a citation were used at the individual or population level. More recently, she noted a focus on developing measures to track how the Watch for Me NC messaging is shared through social media. She commented that this information provides a picture of the level to which communities are participating in the Watch for Me NC program and helps explain differences in outcomes across communities, but it does not explain how these metrics translate to outcomes.
- Sandt described a final challenge of measuring the outcomes and evaluating the impacts of the behavioral intervention outcomes. Issues include deciding what to measure, when to measure it, and how to isolate the effect of interest and measure or control for other covariates. Although researchers need to address these issues in most studies, she noted there is a particular lack of research to guide behavioral intervention study design. Ideally, she reported that monitoring crashes involving drivers failing to yield to pedestrians in crosswalks would be the best measure, but that data are not currently available to assess this measure.
- Sandt described the data collection and evaluation activities that were conducted. Knowledge of traffic laws was measured through pre- and postsurveys of officer training each year and a telephone survey of the general public in 2015. Surveys were also used to gauge attitudes and perceptions of social norms and self-reported behaviors. Observed behaviors were examined through pre- and postdesigns with comparison groups and field data collection. Capacity and organizational changes were monitored through surveys and interviews. Examining crashes involving bicycles and pedestrians is slated for 2017. Sandt reported that the conceptual model was used to develop the evaluation program, focusing on the behaviors targeted by the intervention, the data needed to evaluate the intervention, and the elements to control for in the study design.

• Sandt highlighted some of the findings to date. On the organizational level, agencies participating in the Watch for Me NC program have reported an increase in knowledge of pedestrians and bicycling laws, capacity to perform enforcement and outreach, and different policy changes that may help increase safety for vulnerable road users. The statewide telephone survey indicated that a large majority of respondents appeared to be aware of the law requiring drivers to yield to pedestrians in crossings. Most perceived that yielding was not the normative behavior in their community, however. Evidence also indicated that driver compliance with yielding laws was improving at locations where enforcement is occurring, though the magnitude differs depending on the time period of the follow-up and the level of sustained enforcement efforts. She noted that how features of the built environment, including roadway speed, crosswalk markings, and number of lanes, affect yielding continues to be explored.

• Sandt concluded with suggestions for future research. Continuing to cultivate a better understanding of the transportation-related behaviors that affect pedestrians and bicyclists and how those behaviors can be influenced by the social, policy, and built environment was one topic for additional research. Sandt also noted it would be helpful to have more enhanced, consistent, and valid metrics to measure behavioral intervention delivery and outcomes, as well as more research to help understand how changes in behaviors can predict changes in actual crashes. She further suggested that crash-based evaluations of long-term comprehensive interventions would be beneficial.

Susan Handy, National Center for Sustainable Transportation, presided at this session.

PLENARY SESSION 4

Cycling and Pedestrian Equity

Charles Brown, *Alan M. Voorhees Transportation Center, Rutgers University*
Carniesha Kwashie, *The Mayor's Fund for Philadelphia*
Anthony Stephens, *American Council of the Blind*

ACCESS DENIED: BIKING WHILE BLACK AND HISPANIC–LATINO IN NEW YORK AND NEW JERSEY

Charles Brown

Charles Brown discussed research examining black and Hispanic bicyclists in New Jersey and New York. He described the results of focus groups and a survey of bicyclists and nonbicyclists conducted in New Jersey and a focus group of cyclists in New York City. Brown covered the following topics in his presentation:

- Brown quoted from the American Planning Association that planners are "professionals that work to improve the welfare of people and their communities by creating more convenient, equitable, healthful, efficient, and attractive places for present and future generations." He noted the bicycle research focused on equity concerns. Brown noted that the purpose of the research in New Jersey was to ascertain barriers to bicycle use among blacks and Hispanics and identify solutions to those barriers. Brown said the research asked the following questions:
    1. Why do blacks and Hispanics choose not to bicycle?
    2. What prevents blacks and Hispanics from choosing to bicycle more?
    3. What can be done to encourage blacks and Hispanics to bicycle more often?
- Brown reported that the research included a literature review, two focus groups, and intercept surveys in 34 towns. One of the focus groups consisted of black participants and was conducted in English. The second focus group consisted of Hispanic participants and was conducted in Spanish. Individuals in both focus groups received $50 for their participation. Two intercept surveys were used. Individuals reporting they had bicycled within the past 12 months were given a bicyclist survey. Individuals reporting they had not bicycled in the past 12 months were given a nonbicyclist survey. A total of 1,600 surveys (54% nonbicyclist and 46% bicyclist) were completed. Brown noted that individuals completing the survey came from all over the world, with approximately 40% reporting they had spent their formative years outside the United States.

- Brown reviewed key results from the survey. Among the nonbicyclist group, not owning a bicycle was reported by 28% of the respondents as the main reason they did not bicycle. Other responses included time constraints (15%), lack of interest (11%), not feeling safe bicycling (11%), and disability or physical limitation (11%). The two major reasons individuals completing the bicyclist survey reported for bicycling were health (30%) and to have fun (26%).
- Brown reviewed the responses to questions included in both surveys. He noted that almost 25% of the respondents indicated a bicycle was too expensive to purchase and maintain. This response was more common among nonbicyclists, males, and individuals earning less than $14,000 annually. He noted that these results were statistically significant.
- Brown reported that almost 60% of the respondents were not aware of the bikeshare programs in New York City and Philadelphia, Pennsylvania. He noted that nonbicyclists, blacks, females, and individuals earning less than $14,000 annually were less aware of these programs than their counterparts, but that only income was statistically significant. Brown reported 85% of the respondents said they would use a bikeshare system if one were available in their community. The slightly higher favorable responses from females and bicyclists were statistically significant.
- Brown noted that the surveys included a question on the respondents' access to political power. The survey presented a visual rendering of a street in Newark, New Jersey, with a bike lane, well-maintained sidewalks, and people using both. The survey question asked if participants believed the local government would invest in making these types of improvements. A slight majority (54%) responded that it was unlikely the local government would make these improvements. He noted that males, bicyclists, and respondents earning between $75,000 and $99,000 were more likely to respond that the local government would make the improvements; all three factors were statistically significant. Brown reported that 64% of the respondents did not feel their local government supported and invested in bicycling. He noted that bicyclists were more likely to provide a positive response than nonbicyclists.
- Brown noted that nine out of 10 bicyclists reported having a safe place to store a bicycle, compared with one out of four nonbicyclists. There were statistically significant differences, with Hispanics, nonbicyclists, and individuals with lower incomes more likely to report not having a safe storage location. He noted that 43% of the male respondents and 19% of the female respondents reported being victims of bicycle theft.
- Brown reviewed the responses to questions associated with child safety while bicycling and training for bicycle use. Approximately 60% of respondents reported they did not feel that children were safe from traffic when bicycling in their neighborhoods. There were statistically significant differences in regard to users, race/ethnicity, gender, and those respondents making less than the 2015 median household income in New

Jersey. He noted that 90% of participants reported they had not received professional bicycle training. There were statistically significant differences in regard to users, with a higher proportion of the bicyclists receiving training than nonbicyclists.

- Brown discussed the responses to a question on perceived police harassment. He noted that nearly 15% of the respondents reported being unfairly stopped by a police officer, with males reporting being stopped at a rate seven times that of females. Further, black respondents reported being stopped more often than Hispanics. There were statistically significant differences in regard to users, race/ethnicity, and gender.
- Participants were asked to rank a list of perceived barriers to bicycling. The fear of a traffic collision was ranked first, the fear of robbery or assault was ranked second, and pavement condition was ranked third by both bicyclists and nonbicyclists. He noted the importance of considering the concern for personal safety in planning bicycle facilities. The survey participants were asked to rank a list of possible solutions to the issues limiting bicycle use. Protected bicycle lanes, off-street bicycle paths, and secure bicycle parking were the top three rated solutions by both bicyclists and nonbicyclists. Brown reported that he wrote an article, "Fear: A Silent Barrier to Bicycling in Black and Hispanic Communities," for the September 2016 *ITE Journal* on this topic.
- Brown described the Crime Prevention Through Environment Design program and the audit it conducted in the Fairmont neighborhood in Newark. He noted that this program is based on the principle that proper design and effective use of the built environment can lead to a reduction in fear and incidence of crime and an improvement in the quality of life. He reviewed the crime statistics for the neighborhood for the 5-year period from 2008 to 2012, which underscored the concerns for personal safety in the area.
- Brown described facilitating a focus group in New York City, Race, Place, and Public Space: Biking While Black in New York City. He noted that this activity provided additional perspectives on promoting and encouraging bicycling among blacks. He commented that focus group participants voiced a lack of involvement in planning bicycle lanes in the city and a lack of participation in the transportation planning process in general. Participants also cited police harassment when they used the bicycle lanes, especially those located in more affluent areas of the city. Participants further noted personal safety concerns when bicycling in some areas. One individual noted he dressed in old clothes and used an older bicycle when he commutes to work. Most participants did not describe themselves as cyclists, rather they reported that they just liked to bicycle. Finally, participants said bikeshare programs were "cool," but they did not think bikeshare programs would locate in their neighborhoods.
- In closing, Brown suggested the following questions for further research and discussion.

– Will the change in demographics and a reverse in white flight lead to nonwhites being stuck in the suburbs and whites disproportionately benefiting from investments intended for minority communities?
– Is there a criminalization of bicycle lanes in nonwhite communities?
– If bicycling is the new golf from a social perspective, what opportunities are being denied to nonwhites who lack access to this new golf?
– How would the bicycle research agenda differ if the people in this room better reflected the communities most disproportionately affected by disinvestment in bicycle infrastructure?
– Are bicycle safety programs at all levels reaching nonwhite communities?
– Is it ever fair to discuss equity without discussing access to power?
– Is fear limiting your ability to reach those you are intending to help?

CYCLING AND EQUITY

Carniesha Kwashie

Carniesha Kwashie discussed the National Better Bike Share Partnership and the Indego Bike Share program in Philadelphia. She described the goal and objectives of the Better Bike Share Partnership and the background, current status, and experience with the Indego Bike Share program. She stressed the importance of respecting those you serve in addressing the needs of underrepresented groups. Kwashie covered the following topics in her presentation:

• The National Better Bike Share Partnership is funded by a 3-year grant from the JPB Foundation, a private foundation with a mission to enhance the quality of life through transformational initiatives that promote the health of communities. The overall goal of the partnership is to enable bikesharing to become an effective tool for fostering equitable access to transportation nationwide. The first objective is to make bikesharing financially accessible, convenient, and spatially relevant to low-income Philadelphians. The second objective is to foster awareness of, and support for, bikesharing as a means of transportation among low-income Philadelphians. The third objective is to investigate, develop, promote, and facilitate best practices in bikeshare implementation nationally, with a specific focus on equitable access.
• Kwashie highlighted the other local and national partners. The Bicycle Coalition of Greater Philadelphia is a local partner. National partners include PeopleForBikes and the National Association of City Transportation Officials. She stressed the importance of including residents in the planning and decision-making process for bikesharing programs.

- Kwashie described some of the socioeconomic and demographic characteristics of Philadelphia. The population of the city is approximately 1.5 million. The median household income is $37,000, with 27% of households at or below the poverty level. African Americans comprise 44% of the city's population, followed by 33% white, 13% Latino–Hispanic, 7% Asian, and 3% multiracial or other.
- The Indego Bike Share program, which provides a new public transportation option in the city, was launched April 2015 with 60 stations and 500 bicycles. Currently there are 105 stations and 1,000 bicycles. Kwashie noted that approximately 33% of stations are located in social equity zones. The city's goal is to reach 185 stations in the next several years. She said the program intentionally spread out to reach neighborhoods typically left behind.
- Kwashie described some of the lessons learned with the program through engagement, evaluations, and evolution. She noted that understanding that race matters is important and affects how you define your equity efforts. She stressed that diversity and inclusion are key. She also noted the importance of defining social equity on various partnership levels because not everyone defines it the same. She stressed the importance of building effective relationships and developing trust. Continually documenting outcomes when testing new strategies is key, as is continuously learning and refining plans and activities.
- Kwashie discussed the important role Indego Community Ambassadors play in championing the program in neighborhoods. The Ambassadors promote the program and identify hard and soft barriers to participation. The city makes adjustments as needed to address issues limiting participation. She stressed the shared ownership model of the program and the importance of developing and maintaining trust with residents. She also stressed the need to interact with a wide range of individuals representing minority groups. One or two people cannot represent the entire community.
- Kwashie discussed some of the Indego Bike Share program community outreach and engagement activities. She noted that the program is currently working with 43 community groups. Staff typically hold two to five meetings with each community group between prelaunch and launch of bikesharing in an area. She reported that more than 200 neighborhood events were held from April through November 2016.
- Kwashie described the PowerCorpsPHL Pilot Program focused on providing out-of-school youth free access to the bikeshare program for 6 months, along with bicycle safety and education. She noted the success of the program in making bicycling a viable option for work and other trips among this population group.
- Kwashie also highlighted the Digital Skills and Bicycle Thrills pilot program supported by the Office of Education and the Mayor's Computer and Digital Skills Training. The pilot program combined computer and bike education and safety classes, along with a free 6-month membership to the Indego Bike Share. She

reviewed the number of participants and the graduation rate of approximately 62% for the three initial courses. She also summarized some of the positive comments from participants. She noted that the pilot program results illustrate the importance of focusing on high-impact partnerships. The pilots leverage the Indego Bike Share program and resources such as job training and digital skills that are desired by the target population groups. The pilots also directly address barriers, such as cost, literacy, and in-person support, and provide opportunities, such as workforce tools. Ensuring that groups have the capacity to assist and to leverage available resources is also important.

- Kwashie concluded by stressing that diversity and inclusion have been key elements to the Indego Bike Share program. She also noted that relationship building requires high staff capacity and that it takes time to establish and maintain trust. She further stressed the importance of station planning, which sets up future partnerships and future marketing and engagement opportunities. Locating stations in social equity zones illustrates the program's commitment to serve underrepresented groups. She reported that the foundation partners have been critical to ensuring the financial sustainability of the program. Kwashie closed by stressing the importance of staying encouraged, focusing on shared ownership, listening to residents and community leaders, and respecting those you serve. More information on the program is available at www.Betterbikeshare.org.

A SENSORY EXPLORATION INTO EXPANDING SAFE STREETS FOR PEDESTRIANS

Anthony Stephens

Anthony Stephens discussed pedestrian safety issues and the need for universal design and more inclusive planning processes through the lens of blindness. He described the organizations advocating for the visually impaired community, the levels of sight limitations, and examples of projects and programs enhancing pedestrian safety. Stephens covered the following topics in his presentation:

- The American Council of the Blind (ACB), a consumer grass roots organization for blind individuals, has approximately 25,000 members throughout the country with 70 affiliates, including at least one in every state. ACB works with federal, state, and local agencies on access issues and other concerns. Stephens noted that resolving these issues often benefits all individuals. The Consortium for Citizens with Disabilities, based in Washington, D.C., is the largest cross-disability coalition.

It comprises more than 100 organizations representing individuals with all types of disabilities. He noted that ACB also works with the American Federation of the Blind and other organizations.

- Stephens described the three tiers of blindness. One is vision impairment, which includes approximately 22 million Americans. Approximately 5 million Americans have significant vision loss. These individuals may have service dogs and use canes. Approximately 1.5 million Americans are totally blind. He noted that the majority of people with significant vision loss, who qualify as legally blind, have some level of sight.
- Stephens noted that he has been hit three times by vehicles while crossing streets. He described the most recent crash, which occurred as he was crossing a street at a crosswalk with the walk signal. He was wearing a bright red jacket and had his service dog. The driver was texting as he was turning the corner and hit Stephens. Neither Stephens nor his service dog was injured, but his service dog had to return to school for additional training.
- Stephens noted that approximately 70% of individuals who are visually impaired are unemployed. He said that currently diabetic retinopathy is the leading cause of blindness in the United States. This disease typically occurs in individuals in their forties and fifties, predominantly in communities of color. Age-related macular degeneration is another major cause of vision loss.
- Stephens described calls he receives daily from people who have lost their sight and who are convinced their life is over. He noted that depression and suicide are major concerns with blind individuals. He noted that the Centers for Disease Control and Prevention reports that people fear blindness more than cancer. Many blind individuals feel shut in, with no ability to get outdoors and engage in physical activities. Stephens suggested that making streets and the environment safer and more welcoming for all people with disabilities, including blindness, would be a major positive step in creating active lifestyles. He noted that it is a scary situation for a blind person to step in front of a motor vehicle for the first time. He further noted that having the courage to cross a street is a reality blind people face every day.
- Stephens reported that addressing these concerns was the driving force behind the Pedestrian Safety Enhancement Act, which was strongly supported by ACB in 2010. He also noted that the recent NHTSA Final Rule on Quiet Cars, which ACB strongly advocated, provides another positive example for the blind community. This rule addresses the unintended consequences of blind pedestrians not hearing approaching hybrid vehicles and being struck. Stephens reported that ACB is working with a number of disability groups and stakeholders on the potential impacts of autonomous vehicles on the blind and the disabled community.
- Stephens stressed that creating safer streets for pedestrians enhances the independence of blind individuals, as well as all segments of society. It also increases opportunities for more active lifestyles for visually impaired individuals. Safer streets

provide encouragement and build confidence in blind individuals to become more active.

- Stephens reviewed some of the recent projects and programs conducted to make communities more accessible and safer for blind individuals, including audible pedestrian signals. He noted that audible pedestrian signals are a great benefit to blind individuals and to all pedestrians. He also cited the red line and markings along the floor at the Seattle–Tacoma Airport that go to the light rail transit stop, providing direction to vision-impaired individuals.
- Stephens discussed the universal design concept, noting that facilities and designs that benefit blind individuals also benefit other segments of society. He noted that College Park, Maryland, where he lives, does not have sidewalks on every block. He also noted that he served on the Accessibility Advisory Committee of the Washington Metropolitan Area Transit Authority. The committee promoted working with municipalities to add sidewalks and safe crosswalks on local streets.
- In closing, Stephens said ACB is open to partnering with communities, transportation agencies, local organizations, researchers, and other groups to enhance the safety of the visually impaired population and all segments of society. He stressed the importance of including the blind community and all individuals with special needs in the transportation planning process. He also stressed the need to continue to advocate for the rights of all citizens to ensure a more inclusive society.

Jeffrey LaMondia, Auburn University, presided at this session.

BREAKOUT SESSION

Children

Nick Ferenchak, *University of Colorado, Denver*
Wesley E. Marshall, *University of Colorado, Denver*
Leigh Ann Von Hagen, *Alan M. Voorhees Transportation Center, Rutgers University*
Shannon Sweeney, *Robert Wood Johnson Medical School, Rutgers University*
Elizabeth E. O'Neal, *University of Iowa*
Timofey Grechkin, *University of Southern California*
Joseph K. Kearney, *University of Iowa*
Jodie M. Plumert, *University of Iowa*
Catherine Bull, *Alan M. Voorhees Transportation Center, Rutgers University*
Andrea Lubin, *Alan M. Voorhees Transportation Center, Rutgers University*
Hagai Tapiro, *Ben-Gurion University of the Negev, Israel*
Tal Oron-Gilad, *Ben-Gurion University of the Negev, Israel*
Yisrael Parmet, *Ben-Gurion University of the Negev, Israel*
Kelcie Ralph, *Rutgers University*
Sean Meehan, *Alan M. Voorhees Transportation Center, Rutgers University*
Whitney Miller, *Rutgers University*
Seth LaJeunesse, *University of North Carolina Highway Safety Research Center*
Stephen Heiny, *University of North Carolina Highway Safety Research Center*

REDEFINING THE CHILD PEDESTRIAN SAFETY PARADIGM: IDENTIFYING HIGH-FATALITY CONCENTRATIONS AROUND PARKS

Nick Ferenchak and Wesley E. Marshall

This presentation addressed research to identify areas around parks that have high concentrations of child pedestrian fatalities. To date, many of the child safety activities have focused on schools. A variety of treatments have been used in school zones to improve the safety of children, including those funded through the Safe

Note: In the breakout sessions one or, in a few cases, two of the coauthors presented the research; however, the names of all coauthors are listed.

Routes to School program. This research explored other areas in communities that may need safety treatments to reduce or eliminate child pedestrian fatalities.

A preliminary analysis was conducted in the Denver area examining schools, parks, trails, playgrounds, and recreation centers that children frequent. Schools and parks were selected for further analysis on the basis of the high levels of children present. The six fast-growing cities included in the more detailed analysis were Austin, Texas; Charlotte, North Carolina; Dallas, Texas; Denver, Colorado; Houston, Texas; and Los Angeles, California. A quarter-mile walkshed was identified around schools and parks in the six cities by using a geographic information system (GIS). Data on child fatalities for the past 30 years were obtained from FARS and geocoded into the GIS walkshed. A population-based exposure analysis based on children at the Census Block Group level was used. A fatality rate per 10,000 children was generated for each location. A comparison was conducted of the rate near schools and the rate near parks. The rate near parks was higher than the rate near schools in all six areas, with all except Denver being statistically significant.

On the basis of this analysis, the research project recommended applying the treatments and lessons learned from the Safe Routes to School program to areas around parks and in other community locations where high volumes of children are present. Efforts are under way to collaborate with the National Recreation and Park Association on their Safe Routes to Parks initiative. The need to change the driving culture to slow down around parks, in addition to school zones, was another implication from the research, as was the need to consider the wider land use implications and the location of parks.

IDENTIFYING AND ADDRESSING FEAR, PERCEPTION, AND RISK RELATED TO WALKING AND BICYCLING TO SCHOOL

Leigh Ann Von Hagen and Shannon Sweeney

This presentation focused on a research project examining if parent perception, gender, and technology play a role in where children bicycle and walk. The research methodology included one-on-one in-person interviews with 48 parent–child pairs in Stanhope Borough, Franklin Township, and Highland Park Borough in New Jersey. The children were middle school students, 11 through 14 years of age, in grades six through eight. Key findings reported differences in perceptions between parents and students. Parents' concerns appeared to be influenced by the media, while students concerns were influenced by personal experiences. Some of the common topics

identified during the interviews were differences in perspective by time of day, concerns over abductions and sexual offenders, gender and traffic safety, and the use of smartphones and GPS technologies to monitor locations.

Suggested implications for practice included designating areas for students to meet, teaching students traffic and crime safety skills, and including the student perspective in planning and implementing intervention approaches. One area identified for further research was examining the impact of smartphones as facilitators or hindrances to active travel by students.

CROSSING ONE-WAY VERSUS TWO-WAY SIMULATED TRAFFIC: DIFFERENCES IN CRASH RISK AMONG ADOLESCENT BICYCLISTS

Elizabeth E. O'Neal, Timofey Grechkin, Joseph K. Kearney, and Jodie M. Plumert

This presentation described a research project examining differences in crash risks among adolescent bicyclists crossing one-way and two-way streets by using a traffic simulator. Previous research has shown that when crossing two lanes of opposing traffic, adults, as well as 12-year-old children, prefer to take rolling rather than aligned gaps. In a rolling gap, the near lane opens before the far lane, allowing more time to cross the street. In an aligned gap, the far lane opens prior to or at the same time as the near lane, which provides less time to cross. Two lanes of one-way traffic provide the same temporal opportunities, but attention does not need to be shifted from left to right.

The research examined whether adolescent bicyclists would reflect behavior closer to adult bicyclists crossing two lanes of one-way traffic versus two lanes of two-way traffic. A bicycle simulator was used, with adults, 14-year-olds, and 12-year-olds crossing the two types of roadways. The results showed that adults were more conservative in their gap size selection in the one-way traffic condition than were 14- and 12-year-olds. In the two-way traffic condition, adults preferred larger gaps, while the 14- and 12-year-olds were less conservative than adults but did not differ from one another. In one-way traffic, adults and 14-year-olds preferred the rolling gaps, but 12-year-olds did not discriminate between rolling and aligned gaps. In the two-way traffic condition, only adults preferred rolling gaps. Examining time to spare in crossing the one-way traffic showed a good developmental pattern, with adults having more time to spare than 14-year-olds, and 14-year-olds having more time to spare

than 12-year-olds. These results were all at a statistically significant level. In the two-way traffic condition, only adults had more time to spare, with 14- and 12-year-olds having similar results.

The results indicate that two-way traffic is more challenging for adolescent bicyclists to navigate, but that adolescents are also not performing quite at adult levels on one-way crossings. Areas identified for further simulation-based research included examining behavioral risk factors that place bicyclists at risk for motor vehicle crashes, how road treatments influence those behaviors, and how bicyclists interact with the roadway environment. Implications for practice included conducting training and safety awareness for adolescents.

PREDICTABLE IS PREVENTABLE: ENGAGING POLICE TO IDENTIFY PEDESTRIAN–VEHICLE NEAR-MISS INCIDENTS AT SCHOOL CROSSINGS

Leigh Ann Von Hagen, Catherine Bull, and Andrea Lubin

This presentation described a research project engaging police officers in New Jersey to assist in identifying challenging and unsafe school crossings, including crossings where near-miss crashes occur. A survey was distributed through the Crossing Guard Supervisor Training Program and the Police Traffic Officers Association. A total of 173 valid responses were received, with 30% of the respondents reporting no challenges in school crossings. A total of 185 intersections were identified by other respondents. Only 20% to 28% of the respondents reported actual crashes at the intersections, with close to 80% reporting concerns over multiple near misses involving students and motor vehicles. Using the predictable is preventable mantra, police officers were concerned with these intersections, even without the occurrence of actual crashes.

The project highlighted the benefits of leveraging expert local knowledge to identify intersections for improvements. Some of the suggested implications for practice were to not overlook crossing guard safety, to track near-miss incidents, and to use information from local experts as input to identify pedestrian improvements. Topics identified for further research included examining additional methods to use police officers for prioritizing challenging intersections and assessing roadway engineering versus safer driving to address identified intersections.

CHILD PEDESTRIANS' PERCEIVED RISK OF THE CROSSING PLACE

Hagai Tapiro, Tal Oron-Gilad, and Yisrael Parmet

This presentation described a research project examining the potential influence of roadside factors on children's perception of the safety of a crossing location. The experimental method involved 12 adults and 24 elementary school children ages 7 and 8, 9 and 10, and 11 through 13. Each of the participants viewed 41 wide-screen panoramic stills of real-world roadside environments from a pedestrian's point of view. Participants were asked to rate the safety of each scene on a scale of 0 to 100 points. The results highlighted that different age groups perceive crossing locations differently. For example, children tended to evaluate the safety of the place on the basis of lower-level reasoning, such as dedicated crossing locations. Older children demonstrated more cautious behavior. One suggested practical application was including information on paying attention to critical factors in the environment in more focused training programs for young children. A second application was examining design guidelines through the eyes of children, especially in areas frequented by children.

LOW-STRESS ROUTES TO SCHOOL

Kelcie Ralph, Leigh Ann Von Hagen, Sean Meehan, and Whitney Miller

This presentation reviewed two methods to assess bicycling to school—a bike audit and a level of traffic stress mapping exercise—for a school in New Jersey. The Safe Routes to School coordinators in New Jersey assisted with the bike audit. Working in four groups, the coordinators bicycled through the area, photographing and documenting issues. The four groups convened after the ride and shared information. The level of traffic stress mapping exercise was conducted by one university student who examined the New Jersey DOT's Straight Line Diagram report, which provided volume and speed data for every road in the state. Google Street View data were also used. The data were plotted in a GIS, and a map was created highlighting the data. This process took approximately 1 month. The bike audit identified macro-level issues, such as pavement problems, potholes, and other concerns. The level of traffic stress mapping exercise included maps and street view photographs to provide a broader focus of different bicycle facilities, conditions, and levels of traffic stress. Both approaches have different advantages and limitations. Bike audits are participatory, labor intensive, and provide micro-level issues and solutions. Level

of traffic stress mapping is top down and technical, uses available data, is less labor intensive, and facilitates comparisons among streets and areas.

VISION ZERO WITH A YOUTH LENS: A POSITIVE DEVIANCE STUDY OF PEDESTRIAN AND BICYCLIST SAFETY OUTCOMES

Seth LaJeunesse and Stephen Heiny

This presentation examined the focus of Vision Zero programs in U.S. cities. The research was supported by the FIA Foundation. The project examined the following research questions:

- What do cities focus on with respect to Vision Zero?
- What are common barriers to implementation?
- How do cities address speeding?
- How do cities frame child pedestrian and bicyclist safety?
- How does political will to advance Vision Zero come about?
- How does public support for Vision Zero come about?

The cities included in the study were Fort Lauderdale, Florida; New Orleans, Louisiana; New York City, New York; San Francisco, California; Seattle, Washington; and Washington, D.C. The project included semistructured interviews with at least three stakeholders in each city who represented city staff and advocacy groups. The interviews focused on general safety and speeding issues, safety goals and strategies, political will, and public support. A grounded theory analysis of the interview responses is being conducted to identify emerging theories that explain cities' commonalities and where they diverge.

One of the preliminary findings is that all cities reported some level of using youth-related safety efforts to facilitate wider safety programs. An example of this approach is a school-centered education and engineering program that extended into the surrounding neighborhood. Further, framing projects as having a school- or child-safety focus helped gain community support. The emergent theory developed as part of the project focused on a catalyst or event, such as a high-profile crash, which created a public relations issue and empathy engagement. This event triggered a general approach to take action or to address barriers that lead to public support and political will. A child-safety focus appeared to generate more political will and public support. Practical implications from the project highlighted that collaborating

across agencies and with communities is key. Further, beginning with issues in child-oriented areas can serve as the starting point for tackling difficult safety issues such as speeding. Additionally, framing interventions as part of a broader Vision Zero campaign increases acceptability of safety improvements.

Suggested future research could include understanding how political will emerges and is sustained, identifying other politically feasible ways to address speeding, and identifying methods to obtain valid and reliable pedestrian and bicyclist exposure data. Developing quality crash reduction estimates for countermeasure combinations, such as high-visibility crosswalks and pedestrian refuge islands, was another identified research topic.

Ruth Steiner, University of Florida, presided at this session.

BREAKOUT SESSION

Infrastructure and Pedestrians

Laura Sandt, *University of North Carolina Highway Safety Research Center*
Carl Sundstrom, *University of North Carolina Highway Safety Research Center*
Charlie Zegeer, *University of North Carolina Highway Safety Research Center*
Craig Lyon, *Persaud and Lyon, Inc., Canada*
Raghavan Srinivasan, *University of North Carolina Highway Safety Research Center*
Bhagwant Persaud, *Ryerson University, Canada*
Bo Lan, *University of North Carolina Highway Safety Research Center*
Sarah Smith, *University of North Carolina Highway Safety Research Center*
Daniel Carter, *University of North Carolina Highway Safety Research Center*
Nathan J. Thirsk, *University of North Carolina Highway Safety Research Center*
John Zegeer, *Kittelson and Associates, Inc.*
Erin Ferguson, *Kittelson and Associates, Inc.*
Ron Van Houten, *Center for Education and Research in Safety, Western Michigan University*
Lori Sundstrom, *Transportation Research Board*
Oliver Smith, *Portland Bureau of Transportation*
Angelo Rao, *City of Lakeland, Florida*
H. H. Joon Park, *New York City Department of Transportation*
Rusty Lee, *University of Delaware*
Tucker Smith, *University of North Carolina, Greensboro*
McCormick Taylor, *University of North Carolina, Greensboro*
Rudolph Bedeley, *University of North Carolina, Greensboro*
Christopher Monsere, *Portland State University*
Sirisha Kothuri, *Portland State University*
Miguel Figliozzi, *Portland State University*
Ali Razmpa, *Portland State University*
Mark Franz, *National Transportation Center, University of Maryland, College Park*
Chenfeng Xiong, *National Transportation Center, University of Maryland, College Park*
Lei Zhang, *National Transportation Center, University of Maryland, College Park*
Essam Radwan, *University of Central Florida*
Jiawei Wu, *University of Central Florida*
Hatem Abou-Senna, *University of Central Florida*

NCHRP 17-56: DEVELOPMENT OF CRASH MODIFICATION FACTORS FOR UNCONTROLLED PEDESTRIAN CROSSING TREATMENTS

Laura Sandt, Carl Sundstrom, Charlie Zegeer, Craig Lyon, Raghavan Srinivasan, Bhagwant Persaud, Bo Lan, Sarah Smith, Daniel Carter, Nathan J. Thirsk, John Zegeer, Erin Ferguson, Ron Van Houten, and Lori Sundstrom

This presentation focused on NCHRP Project 17-56, Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments. The project objective was to develop CMFs for four types of pedestrian treatments at unsignalized pedestrian crossings: advance yield and stop lines and pavement markings, pedestrian refuge islands, pedestrian hybrid beacons, and rectangular rapid flashing beacons (RRFBs).

The research team examined approximately 500 treatment and comparison sites for 14 cities in the United States, with many sites having multiple treatments. Data were collected from Google Earth and site visits on the treatment characteristics, geometric features, traffic volumes, roadway variables, and crashes. The data analysis included the development of cross-sectional regression models and before-and-after empirical-based techniques. The analysis identified safety benefits that were statistically significant for all the treatments. The pedestrian hybrid beacons had the greatest benefits for pedestrians, with a 55% reduction in crashes at sites receiving that treatment compared with the control sites. Other results were RRFBs, with a 47% reduction in crashes, refuge islands (37% reduction), and advance stop and yield line pavement markings (25% reduction).

Limitations in the study included a focus on urban and suburban multilane roads and some treatments in operation in a small subset of cities. Areas for further research included the use of larger samples to develop CMFs for different pedestrian crash severities, for other treatments, and for combinations of treatments. Improving the pedestrian exposure data collected by agencies would also increase the reliability of results. A number of venues were suggested for integrating the research results, including AASHTO and FHWA publications, websites, and clearinghouses, especially the CMF Clearinghouse and the MUTCD.

EVALUATING THE SUITABILITY OF LEADING PEDESTRIAN INTERVALS AT SIGNALIZED INTERSECTIONS IN PORTLAND, OREGON

Oliver Smith

This presentation examined the suitability of leading pedestrian intervals (LPIs) at signalized intersections in Portland, Oregon. An LPI provides a head start for pedestrians crossing at a crosswalk at a signalized intersection. An LPI is typically a 4- to 7-second head start before the parallel vehicle movement receives a green light. An LPI helps pedestrians move into the roadway to establish their right-of-way. Research shows that LPIs reduce crashes between turning vehicles and pedestrians. The Portland Bureau of Transportation does not have internal guidelines on when to use LPIs, but Toronto, Ontario, Canada, has developed such guidelines. Factors considered in these guidelines are the presence of T-intersections or one-way approaches, the level of senior citizen activity, the proximity to elementary schools, the level of pedestrians crossing at the intersection, impacts on vehicle delay and the volume of vehicles using the intersection, visibility concerns, and the crash history at the intersection. A score is assigned to each of these factors on the basis of thresholds, and the scores are summed into a single score. If a location received a score over the identified threshold, then an LPI is recommended. These guidelines were applied to 17 intersections with LPIs in Portland. Approximately half the intersections met or exceeded the criteria warranting an LPI, and half did not. The results matched an informal subjective assessment by staff of the utility of LPIs, suggesting that the guidelines are appropriate.

LEADING PEDESTRIAN INTERVAL: WHAT ARE YOU DOING WITH YOUR 5 SECONDS?

Angelo Rao

This presentation examined the use of LPIs at 25 intersections in downtown Lakeland, Florida. Five additional all-red seconds were added to the all-red phase of 2 seconds for a total of 7 seconds of an all-red phase at the intersection. As background to the analysis, travel in Polk County is increasing, with VMT increasing by 4.5% and crashes at the 174 signalized intersections in the city increasing by 10.5% over an 18-month period. Injury crashes at the 25 intersections with an LPI had a reduction of almost 20% over the same time period, while all crashes at the LPI

intersections decreased by 4%. Four intersections on Florida DOT roads with higher traffic volumes experienced a 5.6% decrease in all crashes and a 21.7% decrease in injury crashes. Overall, there was no reduction in the level of service or intersection delays on the roads with the LPI intersections. Other preliminary results showed that crashes involving pedestrians were reduced from four to one, but crashes involving bicyclists remained constant at two. Anecdotally, pedestrians have indicated higher comfort levels when using LPI crossings. The LPI appears to work best in pretimed conditions. A more in-depth study was recommended.

COMPARATIVE SAFETY ANALYSIS ON CONFLICTING PEDESTRIANS WITH LEFT-TURN VEHICLES AT SIGNALIZED INTERSECTIONS

H. H. Joon Park

This presentation examined conflicts between pedestrians and left-turning vehicles at signalized intersections in New York City. The research focused on identifying the location of pedestrian and left-turn vehicle conflict points within an intersection, factors defining trajectory paths, and if pedestrian and left-turn vehicle conflict points at crosswalks are intensified by turning vehicle trajectories in permitted and protected left-turn signals. A recent study using data on the use of an exclusive left-turn signal from the New York State DOT and the New York State Department of Motor Vehicles showed the highest crash reduction in pedestrian and bicyclist injuries.

Video data were collected and tracking analyses were conducted to obtain a visualization of the crashes at these locations. One of the findings from the video analysis was that the average pedestrian crossing speed during the flashing "Don't Walk" phase is approximately 10% faster than during the "Walk" phase. The video also showed that drivers are more aggressive at permitted phases as they look for gaps in opposing traffic and pedestrians at the beginning of the phase and at the end of the phase. Drivers may also make wider turns looking for gaps. It is at the end of the phase when pedestrians are walking faster to complete crossing the street. Drivers' behavior was more stable and predictable making left turns during the protected phase of the signal, and their turning path was narrower.

Suggestions for further research included developing methods for easier video data collection and making the data sets available to planners to examine issues at specific locations. Other identified areas of research could include conducting safety and video analyses of additional intersections with different geometries and examining the relationships between the density of crossing pedestrians, left-turn volumes, and pedestrian compliance.

MUTCD EXPERIMENTATION WITH COUNTDOWN PEDESTRIAN SIGNALS AND CHANGE INTERVALS

Rusty Lee, Tucker Smith, McCormick Taylor, and Rudolph Bedeley

This presentation described an experiment with a synchronized countdown pedestrian signal timer. The experiment examined an alternative to the 2009 MUTCD requirement of a minimum 3-second buffer of solid "Don't Walk" display before the onset of green for an opposing traffic movement.

Twenty sites in Delaware were nominated and approved by FHWA for testing. Two sets of data were collected at each site: one with the 2003 MUTCD procedures, which were in effect when the work was proposed, and one with the experimental procedures. Data collected included the total number of pedestrians crossing, the number crossing safely, late arrivals, late departures, jaywalking, and pedestrian and vehicle conflicts. Over 10,000 pedestrians were observed at the 20 sites during the 2-hour count in the before-and-after study. A Wilcoxon signed rank test was conducted on the paired observations. The hypothesis that pedestrians were at no greater risk with the experimental timing was accepted in all cases. A significant drop in jaywalking from 27% with MUTCD to 18% with the experimental design was also observed. This finding requires further study.

A follow-on study was conducted examining pedestrian crash reports from January 2007 to February 2012 in three phases: no countdown pedestrian signals, countdown signals and MUTCD compliant, and countdown signals and experimental design. The results showed an overall decrease in pedestrian crash frequency from Phase 1 to Phase 3, which confirmed the earlier findings of no additional risk to pedestrians with the experimental treatment of a synchronized countdown pedestrian signal timer.

SAFETY EFFECTIVENESS OF PEDESTRIAN CROSSING ENHANCEMENTS IN OREGON

Christopher Monsere, Sirisha Kothuri, Miguel Figliozzi, and Ali Razmpa

This presentation summarized a study conducted for the Oregon DOT examining the effectiveness of pedestrian crossing enhancements on multimodal safety to derive CMFs calibrated to Oregon. A second study objective was to provide decision makers with a tool to guide future pedestrian crossing enhancement deployments and to set the foundation for a future pedestrian crossing enhancement cost–benefit analysis. Three types of pedestrian crossings were examined in the study: high-visibility

locations with continental markings, locations with flashing amber beacons, and locations with RRFBs. Only crossings with verified installation data were included. A total of 191 crossings were examined.

One of the issues encountered in the analysis was that locations were enhanced over time, with transitions to more use of flashing amber beacons and RRFBs in recent years. Motor vehicle annual average daily traffic factors based on nearby count stations were used for exposure. No systematic pedestrian count data were available. Pedestrian estimation models and land use characterization were tested, but they did not provide the needed data. As a result, the study was not able to capture pedestrian exposure accurately. Both pedestrian and rear-end crashes were examined.

Overall, a shift in the severity of pedestrian crashes was observed, with a reduction in fatal and injury Category A crashes, a slight increase in injury Category B crashes, and a larger increase in injury Category C crashes. The lack of exposure data limited the ability to estimate the safety performance function—or the equation used to predict the average number of crashes per year at a particular location—for pedestrian crashes. Other limitations included no reliable way to estimate pedestrian activity, a small number of crashes, and the short durations of RRFB installations. There was also a lack of consistent logging of installation dates and minor modifications for facilities off the state system.

ANALYZING THE IMPACT OF MEDIAN TREATMENT SAFETY COUNTERMEASURES ON BICYCLE AND PEDESTRIAN SAFETY

Mark Franz, Chenfeng Xiong, and Lei Zhang

This presentation focused on a research project sponsored by the Maryland State Highway Administration examining the effectiveness of median treatments to prevent illegal midblock crossings. Fatal pedestrian and bicyclist crashes are overrepresented in Maryland. The 5-year average from 2010 to 2014 in fatal pedestrian and bicyclist crashes for the United States was 16%, compared with almost 23% for Maryland. To help address this issue, 24 critical and high-frequency bicyclist and pedestrian crash locations were identified through the Pedestrian Roadway Safety Audit Program. Median treatments were installed at 16 of these sites to prevent illegal midblock crossings.

The research objectives included assessing the effectiveness of the median treatments in reducing pedestrian and bicycle crashes, conducting trend analyses and advanced statistical analyses at more than 30 treatment and control sites, and investigating human and sociodemographic factors related to illegal midblock

crossings. Another objective was identifying methods that can further improve the effectiveness of bicyclist and pedestrian safety countermeasures.

Research activities included collecting data at the treatment and control sites and conducting surveys with bicyclists, pedestrians, residents, and business owners. Before-and-after analyses and crash trend analyses were conducted at the sites.

The analysis is still under way, but preliminary findings are available for some sites. One site on US-40 in Frederick examined a landscaped median that was installed in 2005. There were four crashes involving bicyclists and pedestrians in the 3 years before the landscaped median was installed and one crash in the 3 years after. A second site on MD-650 in Silver Spring examined median fencing that was installed in 2010. At this site there were two bicyclist and pedestrian crashes in the 3 years before the installation of the median fencing and six crashes in the 3 years after. The initial trend analysis results at this location are inconclusive. Next steps in the project include using advanced statistical methods to separate the effect of median treatment from the effect of other factors.

ASSESSMENT OF PEDESTRIAN–VEHICLE CONFLICTS WITH DIFFERENT POTENTIAL RISK FACTORS AT MIDBLOCK CROSSINGS ON THE BASIS OF DRIVING SIMULATOR DATA

Essam Radwan, Jiawei Wu, and Hatem Abou-Senna

This presentation described research using a driving simulator to examine pedestrian–vehicle conflicts at midblock crossings. On the basis of NHTSA data, Florida has consistently ranked as one of the worst states in terms of pedestrian crashes, injuries, and fatalities. The objective of the research was to determine thresholds for the time when one road user is leaving a conflict area until a second user reaches it and the time to collision to assess the vehicle–pedestrian conflict at midblock crossings in a driving simulator using surrogate safety measures after collecting field data and validating a simulation model. Video data over a 24-hour period were collected at two midblock crossings. A total of 36 drivers, 19 males and 17 females, successfully completed 576 scenarios in the driving simulator. Nighttime driving, the absence of a crosswalk, one-lane roadways, and pedestrians wearing dark clothing increased the conflict severity and reduced the average minimum time to collision.

Michael Carroll, City of Philadelphia, and Jennifer Dill, Portland State University, presided at this session.

BREAKOUT SESSION

Infrastructure and Bicyclists

David S. Hurwitz, *Oregon State University*
Christopher Monsere, *Portland State University*
Mafruhatul Jannat, *Oregon State University*
Jennifer Warner, *Oregon State University*
Cara J. Hamann, *College of Public Health, University of Iowa*
Omotoyosi Soniyi, *University of Pennsylvania*
Chris Schwarz, *University of Iowa*
Nick Ferenchak, *University of Colorado, Denver*
Wesley E. Marshall, *University of Colorado, Denver*
Peter B. Ohlms, *Virginia Transportation Research Council*
Young-Jun Kweon, *Virginia Transportation Research Council*
Haohong Zhang, *University of Virginia*
John Hourdos, *Minnesota Traffic Observatory, University of Minnesota*
Greg Lindsey, *Humphrey School of Public Affairs, University of Minnesota*
Derek Lehrke, *Minnesota Traffic Observatory, University of Minnesota*
Melissa Duhn, *Minnesota Traffic Observatory, University of Minnesota*
Nicholas Fournier, *University of Massachusetts, Amherst*
Eleni Christofa, *University of Massachusetts, Amherst*
Arash Jahangiri, *San Diego State University*
Mohammed Elhenawy, *Virginia Tech Transportation Institute*
Hesham Rakha, *Virginia Tech Transportation Institute*
Thomas Dingus, *Virginia Tech Transportation Institute*
Zong Tian, *Center for Advanced Transportation Education and Research, University of Nevada, Reno*

INSIGHTS INTO THE RIGHT-HOOK CRASH AT SIGNALIZED INTERSECTIONS: RESEARCH RESULTS FROM A DRIVING SIMULATOR

David S. Hurwitz, Christopher Monsere, Mafruhatul Jannat, and Jennifer Warner

This presentation highlighted research examining collisions when a vehicle is turning right at an intersection and a bicyclist is simultaneously traveling straight through

the intersection. This situation is called a right-hook crash scenario. The focus of the research was on crashes at signalized intersections and the occurrence of right-hook crashes during the latter portion of the green phase when vehicle speeds are typically higher. Two simulation studies were conducted. The first study focused on identifying and defining the causal factors related to right-hook collisions. A total of 67 participants began the study, but 16 experienced simulator sickness. The final 51 participants generated 1,071 right-turn scenarios. Data were collected on visual attention; responses collected using the Situation Awareness Global Assessment Technique; observed crashes and near misses in the simulator; and the position and speed of vehicles, bicycles, and pedestrians.

From the 1,071 right turns, 26 collisions were observed between the participant motorist and a simulated bicyclist. In examining the reasons for the crashes, 66% of the participants did not check the mirror before turning, 5% looked but did not see the bicyclist, and 18% assumed the bicyclist would yield or there was enough time to turn before the bicyclist reached the intersection. The near crashes exhibited similar contributing reasons. Validation analysis examining the time-to-collision measures in the simulator and the postencroachment times in the field were conducted to assess the accuracy of the interactions in the simulator. The results indicated a reasonable comparison.

A second simulator study tested right-hook crash treatment options to reduce some of the causal factors. A total of 46 participants began the study, with 18 experiencing simulator sickness, resulting in 28 final participants and 616 right-turn scenarios. Data collected included observed crashes; visual attention; and the position and speed of vehicles, bicycles, and pedestrians. The four categories of treatments tested were signage, pavement markings, curb radii, and variations of protected intersections. Positive effects were found in signage, pavement markings with a dashed line stencil in a single line and a double line, tightened curb radii, and protected intersections with islands and green pavement markings.

SAFE OVERTAKING OF BICYCLISTS AND THE PRESENCE OF SHARED LANE MARKINGS

Cara J. Hamann, Omotoyosi Soniyi, and Chris Schwarz

This presentation summarized a research project examining the safe overtaking of bicyclists and the presence of shared lane markings. There were three research questions:

- Is the minimum overtaking distance (closest approach) given to the bicyclist by the driver affected by the presence of shared lane markings?
- Does the presence of shared lane markings increase the number of complete lane changes by drivers when overtaking the bicyclist?
- Are there age differences in the overtaking behaviors of drivers, and if so, how do they vary by the presence of shared lane markings?

The research project began with a literature review to identify common bicycle crash types and characteristics. An analysis was conducted on a naturalistic cycling data set that included approximately 57 hours of video and GPS data to identify common safety event characteristics. The results of these tasks were used to design the test by using a high-fidelity driving simulator. A total of 48 adult participants completed the test. The results indicated that the shared lane makings improved the drivers' positioning. The group of drivers on roads with shared lane markings had an average overtaking distance of 5.7 feet, compared with 4.1 feet for the group of drivers on roads with no shared lane markings. None of the drivers on roads with the shared lane markings approached the bicyclist at less than 3 feet, compared with 37.5% of the drivers in the group with no shared lane markings. The shared lane markings were especially beneficial for the older (61- to 80-year-old) driver participants. The presence of the shared lane markings did not influence lane changing, as drivers in both groups did not make a complete lane change to overtake a bicycle.

Future research directions identified from this project included comparative effectiveness studies of different bicycle-specific treatments and infrastructure, further use of naturalistic bicycling data to inform simulation research and scenario development, examining the behavior of drivers under 18 years of age, examining the impact of bicyclist gender, and subgroup analyses for novice and older drivers. In terms of implications for practice, results from the study showed that shared lane markings improve driver performance when the driver is overtaking a bicyclist, as compared with no markings, especially for older drivers. However, despite the benefits found for shared lane markings in the study, practitioners should consider the effectiveness of all bicycle facility types before making a selection.

THE RELATIVE (IN)EFFECTIVENESS OF BICYCLE SHARROWS ON RIDERSHIP AND SAFETY OUTCOMES

Nick Ferenchak and Wesley E. Marshall

This presentation highlighted the use of bicycle sharrows as a safety measure. Bicycle sharrows have been used extensively in the Denver area, as well as in

other communities throughout the country. Available studies of the effectiveness of different bicycle safety measures often focus on the interaction of vehicles and bicycles. One study conducted in Paris, France, indicated that sharrows were less effective than other safety measures, but the analysis did not consider dooring crashes, which were not included in the moving vehicle crash database. Data on dooring crashes were obtained for Chicago. Dooring crashes have been recorded in Chicago since 2011. A 3-year before-and-after analysis was conducted using the dooring crash data and block-level data from the American Community Survey for exposure data. Blocks where bicycle safety treatments were added and blocks where no changes were made were examined. One of the findings was that dooring crashes increased more in blocks where sharrows were added than in blocks where bike lanes were added or where no improvements were made. These results question the effectiveness of sharrows and suggest that additional research is needed.

THE EFFECTS OF INNOVATIVE PAVEMENT MARKINGS TO FACILITATE BICYCLE TRAVEL

Peter B. Ohlms, Young-Jun Kweon, and Haohong Zhang

This presentation focused on a study examining the effectiveness of two bike boxes and two bike turn boxes that were installed at an intersection in Charlottesville, Virginia, in 2013. The results to date are mixed and the study is continuing. The intersection design and operation before the improvements included a left-turn prohibition, and although it was not signed, bicyclists could make the sweeping left turn in two stages. The changes included the addition of two bicycle turn boxes, including one to formalize the two-stage left turn, as well as two bike boxes. Both treatments were experimental at the time the project was proposed, although bike boxes have received interim approval from FHWA as an optional treatment (October 12, 2016, as IA-18). Video data collection was conducted before and after the changes. The video was manually reviewed for conflicts. The conflict methodology used the two classifications of forced yielding and near misses (close calls).

The preliminary findings, which were being re-reviewed at the time of the conference, showed that with the left-turn prohibition, illegal left turns by both vehicles and bicyclists increased in the after condition. At the two approaches with "No Turn on Red" before the change, there was no change or inconclusive results in the after condition. A new "No Turn on Red" sign was added at one approach, and compliance was lower than at the two intersections that previously had "No Turn on Red" signs. A comparison was made of vehicles stopping in front of the stop bar

in the before condition and vehicles blocking access to the bike box or stopping in the bike block in the after condition. Violations declined at one approach in the after condition, and there was no change at the other approach. All other traffic infractions increased for vehicles at three approaches and were unchanged at the other; for bicyclists, infractions decreased at one approach, increased at two approaches, and were unchanged at the other approach. Conflicts involving bicyclists increased in the after condition.

Bicyclists' proper use of the bike boxes and turn boxes was also examined in the after condition. The results were split for one bike box, with as many bicyclists using it properly as improperly. More bicyclists used the second bike box properly than improperly. Proper use of the turn boxes was split at one approach. The second turn box had very low use by left-turning bicyclists but experienced misuse by other bicyclists. A survey component was not included in the study, but it would have added information on users' perceptions of the changes.

TRAFFIC IMPACTS OF BICYCLE FACILITIES: AN OBSERVATIONAL STUDY

John Hourdos, Greg Lindsey, Derek Lehrke, and Melissa Duhn

This presentation addressed research examining the traffic impacts of bicycle facilities in Minnesota. The study objectives were to evaluate vehicular and bicycle interactions and to assess the implications of these interactions for design. The research methods included video recording behaviors, manual reduction, and classification of driver behavior. The driver behavior and interactions examined were no deviation, deviation within a lane, encroachment into an oncoming lane, passing movements, and queueing. Nine sites and 45 cases with camera views were examined. The sites and cases included buffered, striped, and shared lanes; wide shoulders; and no facilities. The Veteran's Bridge redesign in Mankato, Minnesota, was one of the sites at which a pre- and postanalysis were conducted. The preconstruction included 12-foot travel lanes, 6-foot shoulders with a fog line (quasi–bike lane), and 6-foot sidewalks. The postconstruction included 11-foot travel lanes, a 3-foot shoulder, and 12-foot shared-use path.

The analyses focused on the choice of cyclists (road versus sidewalk or path) and the frequency of interactions. In the preconstruction situation 30% to 45% of cyclists operated on the road or the shoulder. In the postconstruction period, only 15% of cyclists traveled on the road or shoulder, with many, but not all, cyclists moving to the shared-use path. The frequency and importance of interactions increased for cyclists remaining on the road. The frequencies of different types of interactions by facility

types were examined. The types of interactions included no deviation or deviation in a lane, encroachment in an adjacent lane or passed, and queued behind cyclists. In summary, not all cyclists used separated facilities when they were available. Drivers were less likely to deviate from their lanes or queue when facilities were clearly demarcated. The highest frequency of no observable effects was on facilities with buffered or striped bicycle lanes. Queueing behind cyclists occurred on roads with shared facilities.

BICYCLE INFRASTRUCTURE AT INTERSECTIONS: AN EVALUATION OF DRIVER BEHAVIOR

Nicholas Fournier and Eleni Christofa

This presentation summarized research examining driver behavior related to bicycle markings and infrastructure at intersections by using a driving simulator. Making drivers safer drivers also improves the safety of bicyclists. The research used a driving simulator and an eye tracker to test participants' reactions to different bicycle treatments. A survey was used to obtain information on the 24 participants. The treatments included in the scenario design were a sharrow lane marking, a merge lane, a bike lane, and a bike box. There were 16 intersections in the scenario, one for each treatment and turning movement (left, right, and through). Half the participants drove a reversed scenario. Because the focus was on drivers and the infrastructure, vehicle and bicycle traffic was light and in the opposite direction to not cause queuing.

There were no significant results from the sharrows and merge lanes. The drivers in the simulator would glance at the sharrow and bike lanes, but they did not make an effort to change their behavior. It was suggested that the results might be influenced by drivers needing to interact with bicyclists. The bike lane results were that participants reporting they were cyclists tended to drive more slowly and position the vehicle more variably within the driving lane. Drivers who were familiar with bike boxes, who accounted for approximately 75% of the participants, appropriately stopped behind the stop bar. The performance of unfamiliar drivers improved after the first appearance of a bike box. Conclusions highlighted were that participants who reported they were cyclists drove differently from noncyclists and that as drivers became more familiar with the treatments their performance improved. These results support the importance of integrating education with infrastructure improvements. A suggestion for future research is to increase the number of participants to improve the statistical strength of the results.

UNDERSTANDING CYCLIST VIOLATIONS AT INTERSECTIONS BY USING NATURALISTIC CYCLING DATA

Arash Jahangiri, Mohammed Elhenawy, Hesham Rakha, and Thomas Dingus

This presentation highlighted research using naturalistic cycling data to improve the understanding of cyclist violations at intersections. The research question focused on how to prevent or mitigate intersection-related crashes resulting from bicycle violations. The experiment was conducted in three steps: prescreening, data collection, and data reduction. The 20 individuals who participated in the study were given instrumented bicycles to use for 1 month. Data on their trips were recorded through video, GPS, and other technologies. A mixed-effect generalized regression model was used to analyze the results.

At signalized intersections, cyclists were more likely to violate a red light when making right turns. The probability of a red light violation decreased when there was side traffic at the intersection or when there was opposing traffic to the cyclist. At stop-controlled intersections, cyclists making right turns or left turns were more likely to violate a STOP sign. The likelihood of a STOP sign violation increased when no other users were present. The project examined methods to predict intersection violations by cyclists on the basis of speed, acceleration, time to the intersection, and other data for both the endangered bicyclist and the driver. It was noted that the study focused on data primarily from Blacksburg, Virginia. Collecting additional violation data and analyzing behavior for different types of violations were noted as possible areas of future research.

EFFICIENT SIGNAL PHASING SCHEMES FOR SERVING BICYCLE MOVEMENTS

Zong Tian

This presentation highlighted research developing and testing signal-phasing strategies for accommodating bicycle signal phases at intersections with dedicated bicycle paths or lanes. One example was of an intersection in Reno, Nevada, with a dedicated bicycle path and a right-turn-only bike signal phase. Three design treatments were modeled and evaluated in a simulated environment. The design treatments were adding a through movement for bicyclists at the intersection to the existing fixed bicycle right-turn-only phase, an actuated bicycle phase tied to the pedestrian phase, and actuated and separated bicycle and pedestrian phases. The first

design treatment was identified as most appropriate at intersections with high volumes of bicyclists, and the second and third design treatments were more appropriate at intersections with low-to-moderate bicyclist or pedestrian volumes.

John MacArthur, Portland State University, presided at this session.

BREAKOUT SESSION

Data

Luis Miranda-Moreno, *McGill University, Canada*
David Beitel, *McGill University, Canada*
Frank R. Proulx, *Alta Planning + Design*
Alexey Pozdnukhov, *University of California, Berkeley*
Sarah O'Brien, *Institute for Transportation Research and Education, North Carolina State University*
Sarah Searcy, *Institute for Transportation Research and Education, North Carolina State University*
Zac Merritt, *University of Delaware*
Paul Moser, *Delaware Department of Transportation*
Kari Watkins, *University of Michigan Transportation Research Institute*
Aditi Misra, *University of Michigan Transportation Research Institute*
Pat Mokhtarian, *Georgia Tech*
Christopher LeDantec, *Georgia Tech*
Krista Nordback, *University of North Carolina Highway Safety Research Center*
Geoff Gibson, *Portland State University*
Sirisha Kothuri, *Portland State University*
Nick Ferenchak, *University of Colorado, Denver*
Wesley E. Marshall, *University of Colorado, Denver*
Karen Dixon, *Texas A&M Transportation Institute*
John Raker, *Ohio Northern University*
Madeleine Hirsch, *Texas A&M University*
Raul Avelar, *Texas A&M Transportation Institute*

EMERGING SOURCES OF DATA AND METHODS FOR SAFETY ANALYSIS OF PEDESTRIAN AND BICYCLE FACILITIES

Luis Miranda-Moreno and David Beitel

This presentation focused on emerging sources of data and methods for safety analyses of pedestrian and bicycle facilities, specifically safety at intersections. Traditional crash-based methods for road safety analyses use crash data from the top of Hyden's pyramid model categorized by fatality, injury, and damage only. Because crashes at intersections can be infrequent, one limitation of using this approach at the

intersection level is that data from numerous years are needed for a robust analysis. It is also a reactive method. In contrast, the surrogate or indirect safety analysis method focuses on conflicts at the linear levels of the pyramid. Although this approach has been available for several decades, new automated tools are making it more feasible, practice ready, and cost-effective. It is also a more proactive approach and can be used with a few hours of video data from an intersection. Typical applications include before-and-after studies and situations in which crash data are unavailable or incomplete. The four steps in the process are video data collection; calibration and object tracking; object classification; and totaling counts and calculating speeds, trajectories, and conflicts. Typical surrogate measures include postencroachment time, time to collision, and speed.

The first case study in the research focused on the safety of different bicycling facilities in Montreal, Quebec, Canada. The facilities included roads without cycle tracks, roads with the cycle track on the right, and roads with the cycle track on the left. Both crash-based surrogate analysis methods were used. Eight intersections of each type were examined. One of the findings was that intersections with cycle tracks were safer than those without cycle tracks. Further, improvements in safety were enhanced with cycle tracks to the left of the closest turning lane.

The second case study was a bicycle–pedestrian conflict analysis in a nonmotorized zone on the McGill University campus in Montreal. No crash data were available in this case study. A schoolwide survey had identified perceived risks to pedestrians at some locations, including the main intersection. A conflict analysis using surrogate safety found that the number of conflicts increased as pedestrian density increased. Analysis separating the conflicts by bicyclist speed, however, indicated that the bicyclists were behaving safely by slowing down in the presence of increased numbers of pedestrians. The two case studies highlight that surrogate safety analysis is an emerging tool that provides a good understanding of safety at the intersection level.

ESTIMATION OF NETWORKWIDE BICYCLIST EXPOSURE BY USING HETEROGENEOUS DEMAND DATA

Frank R. Proulx and Alexey Pozdnukhov

This presentation described a research study examining how emerging data sets fit together to enhance the estimation of bicyclist exposure. Examples of the emerging data sets examined in the study included a travel demand model such as SF CHAMP in San Francisco, STRAVA, bikeshare data, and bicycle count data. The methodology used in the analysis was based on a geographically weighted regression to develop

link-level volumes during the afternoon peak period from both manual and automated data. The link volumes were expressed as a linear combination of implied volumes from the SF CHAMP travel demand model, from the bikeshare system, and from STRAVA. An inverse-distance geographical weighting was used to address the parameters of the separate volume components varying in space.

One finding from the analysis was that the demand patterns differed for the different data sources. SF CHAMP data focused on the central Market Street corridor in the city as well as the Valencia and Polk Street areas. One omission was the Golden Gate Bridge. The STRAVA Metro data highlighted bicyclist trips in the waterfront area and in Golden Gate Park. The Bay Area bikeshare data were limited because the spatial extent of the system is very small, and only origin and destination data are available. Combining the demand patterns from the three data sources provided a more holistic view of the overall bicycle traffic distribution across the network. The geographically weighted regression model provided the best predictive accuracy.

Examining alternative weighting schemes and analyzing additional complementary data sets represent possible areas of future research. Implications for practice included the ability to apply safety performance functions and risk evaluations networkwide. A second implication highlighted the value in using emerging data sets, but to use them with caution and realize their biases in special patterns.

COLLECTING MEANINGFUL EXPOSURE DATA: NONMOTORIZED VOLUME-MONITORING FUNDAMENTALS

Sarah O'Brien and Sarah Searcy

This presentation described a research project sponsored by the North Carolina DOT to establish a common, consistent system to quantifiably measure bicycle and pedestrian volumes. North Carolina DOT has focused on the use of continuous count stations, which are permanent counting sites that provide data continuously (24 hours per day, 365 days per year) as the backbone of the system. Collecting enough data to allow calculation of accurate adjustment factors to apply to short duration counts is important. The data can be used to calculate the annual average daily pedestrian traffic and the annual average daily bicycle traffic. The nonmotorized traffic–monitoring program elements include sampling plans, training, site selection, local agency coordination, and data collection methods. Other elements include local agency coordination, equipment purchasing and support, equipment vendor coordination, and equipment installation. Data validation, data cleaning and correction, and reporting are the final elements. The system has been implemented in one area and is being expanded to other areas.

Analysis of the data highlighted weekday commute patterns and weekend recreational trips. Some of the bicycle commute trips are linked to schools, with specific starting and end times, and others are linked to universities, with wider commute patterns that reflect class schedules. Pedestrian volumes also vary by time and location, with high volumes in the evening and early morning in entertainment areas. These differences are important considerations in developing factor groups and adjustment factors, as well as in conducting short duration counts for bicycle and pedestrian volumes. The seasonality associated with bicyclist and pedestrian travel is also being explored.

Possible areas of research cited included defining other factor groups, examining the appropriate number of continuous count stations per group, and determining appropriate corridor lengths and segments. Other possible research could be exploring methods to institutionalize the nonmotorized vehicle data program within traditional travel-monitoring programs, how often to sample at short duration count stations for seasonality, and the number of short duration count stations needed to understand a region and the state. A final research area is the use of data from other sources and examining data quality thresholds, standards, and data sharing.

SEMIAUTOMATED VIDEO ANALYSIS FOR BICYCLE AND PEDESTRIAN SAFETY STUDIES

Zac Merritt and Paul Moser

This presentation focused on using open-source software to reduce the time spent extracting bicycle and pedestrian data from videos. The research project examined the efficacy of RRFBs at midblock trail crossings. Data were collected at seven midblock trail intersections across Delaware observing motorist yield compliance and bicyclist or pedestrian actuation. Portable cameras were used to record hundreds of hours of footage at the seven intersections. The traditional postprocessing involved undergraduate students reviewing all the hours of video and extracting the trail user data. This process is very labor intensive. Researchers explored other methods for extracting the video data that would be less time-consuming. The method developed uses a preprocess to remove all the video when there is no activity at a crossing. Short video clips are generated when trail users are present. These clips are further reviewed by the students, and data on the trail users and motorists' compliance are aggregated. The preprocessing software uses a computer vision library to find and bound moving objects. The system classifies the bounded objects as a motor vehicle, a bicycle, or a pedestrian. The data are exported into a Microsoft Excel file with the time stamp

and the user data. The system is versatile and can be applied to a variety of problems, multimodal traffic counts, trajectory paths, and pedestrian–vehicle conflicts.

CYCLE ATLANTA: USING CROWDSOURCED DATA TO MODEL PERCEIVED CYCLIST SAFETY

Kari Watkins, Aditi Misra, Pat Mokhtarian, and Christopher LeDantec

This presentation described Cycle Atlanta, a smartphone app that provides crowdsourced data on bicyclist trips, and uses of the data obtained from this app. Cycle Atlanta allows bicyclists to record and post their trips. Cycle Atlanta enhanced the initial app developed for San Francisco by adding functionality to examine assets and issues. Bicyclists can record assets such as bicycle parking, bike shops, public restrooms, secret passages, and water fountains. Issues related to pavement condition, traffic signals, enforcement, bicycle parking, bike lanes, and other topics can also be recorded. Users can also enter their demographic information. This information enhances the ability to analyze bicycle trips and possible issues by gender, age, and other demographic factors. An additional self-declaring rider type was created—comfortable but cautious—and added to the existing list of strong and fearless, enthused and confident, interested but concerned, and no way, no how.

The current Cycle Atlanta data set includes approximately 20,000 recorded trips by almost 2,000 bicyclists. As part of a research project, the Cycle Atlanta data were compared with a purchased STRAVA data set, which tends to include more sport cyclists. The analysis compared pairs of roads with not-very-high-quality multiuse trails directly adjacent to one roadway and a very-high-quality roadway with bicyclists traveling with traffic. All the sport bicyclists used the high-quality roadway, while more of the Cycle Atlanta users were on the multiuse trail. Surveys were conducted of Cycle Atlanta users and through the Atlanta Regional Commission to obtain information on the factors influencing individuals to choose bicycling as a travel mode. Heavy traffic, high speeds, and steep hills had a detrimental effect on bicycling among all the rider types, and separate paths were viewed favorably by all rider types.

Examples of findings from more detailed analyses indicated that female and senior cyclists were found in general to be low-confidence, low-comfort riders and that they significantly differed in their route choices and infrastructure preference from their more confident counterparts. Other findings were that although cyclists with more riding experience tended to see themselves as more confident riders, preference for separate infrastructure pervades all rider types, as does the negative influence of high-speed and higher traffic volumes. In addition, bicyclists were

generally found to shy away from longer trips, and when faced with the trade-off between a significant detour and safety concerns, they may not make a trip at all.

MOTORIST–CYCLIST CRASH DATA NEEDS IN U.S. COMMUNITIES

Krista Nordback, Geoff Gibson, Sirisha Kothuri, Nick Ferenchak, and Wesley E. Marshall

This presentation examined safety data for eight urban areas throughout the country: Arlington, Virginia; Bellingham, Washington; Boulder and Denver, Colorado; Minneapolis–Saint Paul, Minnesota; Philadelphia, Pennsylvania; Portland, Oregon; and San Diego County, California. The 2010 population for these areas ranged from 80,867 people for Bellingham to approximately 10.1 million people for San Diego County. The bicyclist fatalities per year from FARS ranged from 0.2 for both Arlington and Bellingham to 3.8 for San Diego County, which is not adequate for a robust analysis. As a result, nonfatal bicycle-related crashes were examined, along with available data on the time of the crash, the severity and collision type, and environmental factors.

There were differences in the available data fields between communities, especially environmental factors, as well as differences in data coding within communities and diverse file formats. Other issues identified included underreporting of bicycle crashes and motor vehicle–specific reporting formats with no bicycle-specific fields. All these differences made it difficult to compare data across jurisdictions and even within some communities. Although the percentage of crashes was higher at intersections than nonintersections for all areas except San Diego County, the differences in the data sets made it difficult to confirm the accuracy of these results.

The study supports the need for data standards for nonfatal crashes, including defining the intersection type, the crash type, and the crash severity. It was further suggested that the crash typology used in the Pedestrian Bicyclist Crash Analysis Tool could be used to assist with the development of data standards. The next step in the research project is the development of a safety performance function in Boulder examining road segments and variables including bicycle volumes, motor vehicle volumes, facility type, land uses, and demographics. The results of this analysis are expected in the summer of 2017.

PEDESTRIAN AND BICYCLIST INFLUENCE AT STOP-CONTROLLED INTERSECTIONS

Karen Dixon, John Raker, Madeleine Hirsch, and Raul Avelar

This presentation highlighted the results of a research study examining pedestrian and cyclist behavior at four-way stop-controlled intersections. The project examined the influence of both correct and incorrect pedestrian and bicyclist maneuvers at the intersections on traffic. Four-way stop-controlled intersections around Texas A&M University and in Southeast Texas were examined in the study, including intersections with one-lane approaches, two-lane approaches, and a hybrid of one- and two-lane approaches. Video footage was collected at all intersections. Additional data collected on site included vehicle volumes and turning movements. The video and on-site data were reduced and analyzed.

Examples of the study findings were that more conflicts occurred with more pedestrians and cyclists present and that conflicts increased as traffic volumes increased to a certain threshold. Further, larger intersections had more conflicts than smaller intersections, and taking priority was the most likely violation to result in a conflict, with disobeying the traffic control device the second most likely. A topic suggested for future research was examining four-way stop-controlled intersections only on college campuses and only in metropolitan areas. One suggestion for practice was educating the public, drivers, pedestrians, and bicyclists on pedestrian and cyclist laws.

Scott Brady, Delaware Valley Regional Planning Commission, presided at this session.

BREAKOUT SESSION

Pedestrian Safety Analysis

Libby Thomas, *University of North Carolina Highway Safety Research Center*
Bo Lan, *University of North Carolina Highway Safety Research Center*
Rebecca L. Sanders, *Toole Design Group*
Alexandra Frackelton, *Toole Design Group*
Spencer Gardener, *Toole Design Group*
Michael Hintze, *Toole Design Group*
Pei-Sung Lin, *Center for Urban Transportation Research, University of South Florida*
Rui Guo, *Center for Urban Transportation Research, University of South Florida*
Achilleas Kourtellis, *Center for Urban Transportation Research, University of South Florida*
Elzbieta Bialkowska-Jelinska, *Center for Urban Transportation Research, University of South Florida*
Chandra Bhat, *University of Texas at Austin*
Patricia Lavieri, *University of Texas at Austin*
Sebastian Astroza, *University of Texas at Austin*
Jun-Seok Oh, *Western Michigan University*
Valerian Kwigizile, *Western Michigan University*
Keneth Morgan Kwayu, *Western Michigan University*
Zhi Chen, *University of Wisconsin, Milwaukee*
Xiao Qin, *University of Wisconsin, Milwaukee*
Robert Schneider, *University of Wisconsin, Milwaukee*
Steve Polzin, *Center for Urban Transportation Research, University of South Florida*
Xuehao Chu, *Center for Urban Transportation Research, University of South Florida*
Jodi Godfrey, *Center for Urban Transportation Research, University of South Florida*

CHANGING THE FUTURE? SYSTEMIC PEDESTRIAN SAFETY ANALYSES IN SEATTLE, WASHINGTON

Libby Thomas, Bo Lan, Rebecca L. Sanders, Alexandra Frackelton, Spencer Gardener, and Michael Hintze

This presentation highlighted the development of a robust systemic pedestrian safety screening process for Seattle, Washington. The city is a Vision Zero community

and there is interest in going beyond typical crash hot spots to prioritize pedestrian treatments, to provide for a systemic approach to pedestrian safety analysis, and to properly account for exposure.

Eight years of pedestrian crash data were modeled. Total pedestrian crashes at intersections were examined, along with more severe crashes resulting from motorists traveling straight through an intersection and hitting pedestrians. Data on roadway characteristics, the built environment, and pedestrian volumes were also used in the analysis. A data-mining technique, conditional random forest, was used due to the large number of variables and to focus on the variables that were the best predictors to apply in the negative binomial regression models.

For the analysis of total pedestrian crashes, the presence of a traffic signal was the most important predictor of a pedestrian crash. For the pedestrian-crossing crash type, the presence of transit activities close to the intersection was the most important predictor. Both models had many similar significant predictors, including pedestrian volumes, other measures of activity, signals, intersection size, and arterial class. There were also some differences. The outputs were used to predict crashes across the full network. Some data were not available, such as annual average daily traffic.

Potential research areas cited by some included accurately sampling people and vehicles or identifying better measures of exposure, testing the interactions of variables, and considering the generalizability of risk factors in different environments. Additional possible research could involve examining other unmeasured risks, such as signal operations and traffic needs, conducting disaggregate analyses by crash type, and exploring better methods to address endogenous risks.

SPATIAL ANALYSIS OF PEDESTRIAN CRASHES IN LOW-INCOME AREAS

Pei-Sung Lin, Rui Guo, Achilleas Kourtellis, and Elzbieta Bialkowska-Jelinska

This presentation examined pedestrian crash rates, which were disproportionately high in low-income areas of Broward County, Florida. The study was sponsored by the Florida DOT. Low income was defined as Census block groups with poverty rates of greater than 15% or per capita income of less than $21,559. Data from a variety of sources were used in the analysis, including the Florida DOT Crash Analysis Reporting (CAR) system; demographic factors from the U.S. Census databases; road environment factors from the Florida DOT TranStat GIS and transit systems; and land use types from property appraisers, HERE, and license files. Low-income block groups with high crash rates were identified. The hot zones were the low-income

areas with more crashes than other areas with similar features. The cold zones were low-income areas with fewer crashes than similar areas. A number of engineering countermeasures and education and outreach plan elements were identified and examined for possible use in the hot zones.

IDENTIFYING ENGINEERING AND BEHAVIORAL COUNTERMEASURES TO REDUCE THE OCCURRENCE AND SEVERITY OF PEDESTRIAN INJURIES IN VEHICLE–PEDESTRIAN CRASHES

Chandra Bhat, Patricia Lavieri, and Sebastian Astroza

This presentation discussed research examining engineering and behavioral countermeasures to reduce the occurrence and severity of pedestrian injuries in vehicle–pedestrian crashes. The research objective was to formulate a macro-level multivariate model to jointly analyze the count of pedestrians involved in traffic crashes by injury severity level.

All pedestrian crashes in 2009 in the Manhattan borough of New York City were used in the analysis. The crash data were obtained from the CrashStat website maintained by New York City's Transportation Alternatives organization. Additional data on sociodemographic information, land use and road network data, activity intensity data, commute mode shares, and transit supply data were also used. The analysis focused on the census tract level. A comprehensive spatial random coefficients multivariate count model was used in the analysis.

One key finding was that census tracts with high population density, a high proportion of Hispanic residents, a high proportion of the population above the age of 19 years, and persons with low education levels were particularly vulnerable to pedestrian injuries. Other findings were that financially challenged segments of the population face higher injury risk, and higher population densities also have a higher risk propensity for all injury levels. The presence of sidewalks and buffers, traffic lights at intersections, and low speed limits can moderate the effect for the risk of minor injuries. In 15% of the census tracts, an increase in population density was associated with a decrease in the propensity of minor injuries. Further, census tracts with high built-up commercial and residential land use had a high risk propensity. It was noted that countermeasures made to improve safety at one location permeated into neighboring areas, resulting in wider benefits for individual countermeasures.

DEVELOPMENT OF STATEWIDE PEDESTRIAN SAFETY PERFORMANCE FUNCTIONS

Jun-Seok Oh, Valerian Kwigizile, and Keneth Morgan Kwayu

This presentation summarized the results from three research projects addressing pedestrian crashes. There were 2,276 pedestrian crashes in Michigan in 2014, with 6.5% of those involving pedestrian fatalities. Approximately 70% of pedestrian crashes in the state occurred at intersections, with slightly over 50% of fatal crashes occurring at intersections and close to 38% occurring at midblock locations. The remaining fatal crashes occurred at interchanges. Alcohol use by pedestrians or drivers or both was reported in 267 crashes in 2014. Approximately 27% of the total pedestrian crashes from 2010 to 2014 were hit-and-run crashes.

The most common pedestrian-related risk behaviors and crash causes were identified in the research. Failing to yield and disregarding traffic control devices by both pedestrians and motorists was the most frequently cited cause. Other reported causes included pedestrians in the roadway, pedestrians near vehicles, pedestrians walking along a roadway, and loss of control by motorists or pedestrians. Intersection safety performance functions were examined using data from the four Michigan cities of Ann Arbor, East Lansing, Grand Rapids, and Flint. A Poisson regression model was used that included the number of lanes on minor streets, average daily traffic, pedestrian volumes, the number of bars within a quarter mile, and the number of people with a graduate degree within a quarter mile.

A statewide case study was also conducted examining all intersections on arterials and collectors in urban areas. This analysis included over 12,000 intersections. The input data included intersections by the number of legs, intersections by roadway class, the urban population, and pedestrian crash data for 2010 through 2014. The output was 300 sample intersections for more detailed data collection. A pedestrian exposure surrogate measure was developed because no pedestrian counts were available. A zero-inflated Poisson regression model was used in the analysis. The project highlighted the difficulties associated with pedestrian crash modeling. Examples of constraints included the randomness of pedestrian crashes and the lack of exposure data. Potential areas of research that some cited included examining statewide pedestrian exposure data and developing a pedestrian facility database and inventory.

USING STRUCTURAL EQUATION MODELING TO MODEL PEDESTRIANS' INJURY SEVERITY LEVEL

Zhi Chen, Xiao Qin, and Robert Schneider

This presentation described research examining the potential of incorporating the knowledge of crash mechanisms into safety modeling and performing a value-added analysis, as well as investigating the intrinsic and often indirect relationships between contributing factors and crash outcomes. The methodology used structural equation modeling with the assumption that each path represents a linear relationship.

A total of 1,480 intersection-related crashes between vehicles and pedestrians in Wisconsin from 2011 to 2013 were examined in the analysis. Information was available on the environment and context; lighting; weather; road surface; intersection control; the driver's age, gender, impairment conditions, and driving actions; the pedestrian' age and gender; and the crash. The structural equation modeling considered alternatives with two, three, and five latent factors. The models with two and three latent factors converged, but the model with five latent factors failed to converge after many attempts. The model with three latent factors had better goodness of fit than the one with two latent factors, suggesting the three-latent-factors structure may be better at explaining the underlying crash mechanisms. The results highlight that structural equation modeling empowers the design of safety studies by imposing a structure between observations. It converts an input–output model to a variable structure and incorporates engineering knowledge about crash mechanisms into the modeling process.

A DECOMPOSITION APPROACH TO COMPARING PEDESTRIAN FATALITY RISKS ACROSS GEOGRAPHIES

Steve Polzin, Xuehao Chu, and Jodi Godfrey

This presentation highlighted research examining pedestrian safety in the southeastern region of the country, which includes states with the highest pedestrian crash rates. States included in the region are Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.

The research was conducted to gain a better understanding of geographical differences in pedestrian safety through decomposing pedestrian mortality rates, such as fatalities per capita, into components. The methods examined the multiplicative components of mortality rates, including exposure per capita, the risk of involvement (pedestrians involved per unit of exposure), and the risk of death (pedestrian deaths per involvement). The alternative measures of exposure used in the analysis were person-hours walked, the square root of person-hours walked and vehicle hours traveled, and the square root of person-hours walked and nonfreeway VMT. The percentage differences between the southeastern region and other regions of the country in mortality rates and for each component were examined. The exposure data were obtained from the 2009 NHTS. The person-hours walked included walking for transit access and egress, and the vehicle hours traveled were by household vehicles only. The 2009 Highway Statistics report was used for nonfreeway VMT. Data sources for nonfatal crashes included the NHTSA *State Data System Crash Data Report: 2000–2009*, published summary data by states, and tabulated data from state crash databases. No data on nonfatal crashes and injuries were available for Massachusetts, New Hampshire, and Rhode Island.

Key findings were that pedestrian mortality rates were 44% higher in the southeastern region than in other regions of the country during 2009. Areas of future research cited in the project included using different exposure measures for different crash types and examining better ways to account for vehicle activities in measuring pedestrian risks.

Gabe Rousseau, Federal Highway Administration, presided at this session.

BREAKOUT SESSION

Bicycle Safety Analysis

Jueyu Wang, *University of Minnesota*
Greg Lindsey, *University of Minnesota*
Md Asif Raihan, *Florida International University*
Priyanka Alluri, *Florida International University*
Dibakar Saha, *Florida International University*
Erin Robartes, *University of Virginia*
T. Donna Chen, *University of Virginia*
Armana Sabiha Huq, *Florida International University*
Cong Chen, *University of Hawaii at Manoa*
Qiong Wu, *University of Hawaii at Manoa*
Guohui Zhang, *University of Hawaii at Manoa*
Rafiqul A. Tarefder, *University of New Mexico*
Zong Tian, *University of Nevada, Reno*
Panos D. Prevedouros, *University of Hawaii at Manoa*
Allan Khariton, *Carnegie Mellon University*
Sean Qian, *Carnegie Mellon University*
Jacobo Bielak, *Carnegie Mellon University*

EXPOSURE TO RISK AND THE BUILT ENVIRONMENT: AN EMPIRICAL STUDY OF BICYCLE CRASHES IN MINNEAPOLIS

Jueyu Wang and Greg Lindsey

This presentation examined research focusing on bicycle crashes in Minneapolis, Minnesota, and the built environment. The research objectives were to test the safety in numbers hypothesis by using aggregated bicycle crashes and bicycling traffic, as well as assessing the potential of bicycle facility demand models to measure bicyclists' exposure to risk, estimating the probability of crashes at intersections and street segments, and assessing the effects of the built environment on the probability of crashes.

Data used in the analysis included 954 bicycling counts at 471 count locations in Minneapolis from 2007 through 2014. Counts were examined during the 4:00 to 6:00 p.m. time period. In addition, 2,817 bicycle crashes from 2005 through 2014 were used in the analysis. Bicycling crash risks versus bike counts at intersections, bicycling crash risks versus bike counts at street segments, bicycling crash risks versus modeled bike volume at intersections, and bicycling crash risks versus modeled bike volume at street segments were examined.

Some of the key findings indicated that crash risks were higher at intersections with higher levels of employment nearby, those with trail crossings, and those with poor street connectivity. Street segments with higher potentials for crashes included those with mixed land uses and commercial land uses. Possible practical implications from the analysis included improving safety by targeting intersections and street segments with high bicycle and traffic volumes for interventions and countermeasures, such as priority signals or hybrid beacons at trail crossings. Examining interventions and countermeasures for the areas with mixed land use and higher percentages of commercial use was suggested.

IMPACT OF ROADWAY CHARACTERISTICS ON BICYCLE SAFETY

Md Asif Raihan, Priyanka Alluri, and Dibakar Saha

This presentation described a research project sponsored by the Florida DOT that is developing Florida-specific CMFs to assess the effects of engineering treatments on bicycle safety. The project, which is in the initial stages, is examining bike lanes and roadway characteristics such as shared paths, sidewalks, shoulders, speed limits, and parking. Data from the CAR system (crash, vehicle–driver–passenger, and nonmotorist data files) for 2011 through 2014 are being used for the analysis. The 2014 Roadway Characteristics Inventory (RCI) database is being used for data on bicycle lanes, shared path width and separation, intersections, and shoulder type and width. STRAVA data will be used on bicycling activity. A cross-sectional study methodology is being used.

Activities to date include extracting the bicycle crashes from the CAR data files, identifying the RCI variables that may affect bicycle safety, and identifying the appropriate segmentation for the analysis. Twenty-one RCI variables were selected for the analysis. Work is also under way to integrate the CAR, RCI, and STRAVA data. It is anticipated that linear referencing will be used to link data from the three sources. The study results will provide Florida-specific CMFs for engineering

countermeasures, as well as providing more insights on the representativeness and use of STRAVA data.

VIRGINIA BICYCLE CRASH SAFETY ANALYSIS

Erin Robartes and T. Donna Chen

This presentation summarized a research study examining vehicle and bicyclist crashes in Virginia. Crash data that Virginia police reported from 2010 through 2014 were examined in the study, which included 2,435 observations. Only crashes involving a single vehicle and a single bicycle were examined, which were the majority of the reported crashes. The data file included information on the bicyclist, the automobile driver, the vehicle, the environment, and roadway characteristics that may have influenced the crash. An ordered probit model was used in the analysis. The minor possible injury category was reported in approximately 56% of the crashes. The response variable was the different injury severity level, and the independent variable was the crash characteristics. Factors identified that influence cyclist injury severity were driving and bicycling under the influence of drugs or alcohol, higher vehicle and bicycle speeds, and larger vehicles, such as sport utility vehicles, vans, and trucks. Other factors contributing to the injury severity were horizontal curves and vertical grades. Divided and one-way roads tended to reduce the severity of crashes.

COMPREHENSIVE STUDY TO IMPROVE BICYCLE SAFETY

Armana Sabiha Huq and Priyanka Alluri

This presentation summarized a study examining factors contributing to bicyclist crashes in Florida, which has the highest bicycle crash rate of any state in the country. On an average, 126 bicyclists are killed and 6,616 are injured each year in Florida. The overall study objectives were identifying hot spots, analyzing crash causes and patterns, and selecting effective countermeasures.

The specific objective of the research was to analyze significant contributing factors affecting injury severity levels in bicycle crashes. SAS 9.4 was used for logit models. Three 2011–2014 Florida DOT CAR system databases were used in the analysis: the crash-level data file; the non-motorist-level data file; and the vehicle-, driver-, and passenger-level data file. A total of 23,583 bicycle–motor vehicle

crashes were used for fitting the model. The model variables included temporal, environmental, bicyclist-related, crash location–related, and vehicle-related factors. The response variable was injury severity in three levels: fatal, injury, and property damage only.

Some of the key findings related to temporal factors were that bicycle crashes in Florida were nearly two times more likely to result in a fatality when the crash occurred on Sunday. Findings associated with vehicle-related factors included that medium-sized and heavy trucks were most likely to result in fatal bicyclist crashes compared with injury and property damage only, and that light trucks, pickup trucks, sport utility vehicles, and passenger vans had a significant effect on bicyclists' injury severities. Examples of findings associated with bicyclist-related factors included bicyclists over 65 years of age, who were two times more likely to be involved in fatal crashes than in property-damage-only crashes, and bicyclists cycling on a sidewalk, who were more likely to be involved in injury and property-damage-only crashes than fatal crashes. The model estimation results recommend appropriate countermeasures incorporating a four E's (engineering, education, enforcement and emergency) response to mitigate the severity of bicycle crashes. Some of the suggested approaches included improving traffic management techniques on weekends and at evening peak time, adding lighting to reduce fatal crashes on dark roadways, and increasing awareness through education campaigns.

BAYESIAN NETWORK–BASED PEDESTRIAN–BICYCLIST BEHAVIORAL ANALYSIS AFFECTED BY AGE, GENDER, SOBRIETY, AND HETEROGENEITY IN NON-MOTORIST-INVOLVED INTERSECTION-RELATED CRASHES

Cong Chen, Qiong Wu, Guohui Zhang, Rafiqul A. Tarefder, Zong Tian, and Panos D. Prevedouros

This presentation highlighted a Bayesian network–based pedestrian and bicyclist behavioral analysis. New Mexico has the second-highest pedestrian and bicyclist fatality rate of all states in the country, with 40% of the fatal crashes occurring in Albuquerque and 80% of those crashes occurring at intersections. This research examined the contributing factors to the fatal crashes.

The study focused on 10 intersections with the highest pedestrian and bicyclist crash frequency. At those intersections, crash data from 2004 through 2013 were examined, with 258 total crash records. Information on the intersection layout, land use, and any pedestrians and bicycle facilities were also examined. Traffic data

included 1,000 hours of video and vehicle, pedestrian, and bicyclist volumes. The injury severity analysis used a Bayesian network, which is a probabilistic graphical model representing a set of random variables and their conditional dependencies via a directed acyclic graph. An evaluation of individual intersections was also conducted. The overall prediction accuracy of the Bayesian network was 70%.

Variables identified that increased crash severity were alcohol and drug use, nighttime, clear weather, and pedestrians and bicyclists 65 years of age and older. An example of one intersection evaluation, which included two schools nearby, was provided. Approximately 30% of the pedestrians and 67% of the bicyclists involved in crashes were less than 20 years of age. The times with the highest number of crashes were 3:00 to 5:00 p.m. and 6:00 to 8:00 p.m. Pedestrian errors and the location of transit stops were factors in many crashes.

Three areas for future research were identified:

- Developing a method to obtain more detailed records of pedestrian at-fault actions, which are generally recorded as pedestrian errors. These may include jaywalking, ignoring a signal, and other activities.
- Conducting comprehensive surveys to examine pedestrian and bicyclist safety awareness among students at intersections with high volumes of pedestrians and bicyclists.
- Incorporating and using data with crash data sets and quantifying the influence of land use patterns on injury outcomes.

Possible implications for practice included the use of flashing warning signs as visibility enhancement countermeasures during dawn and dusk periods. The use of timing improvements considering pedestrian and bicyclist characteristics was another potential practical implication. Encouraging crosswalk use through the implementation of a median barrier was an additional possible practical application.

BUILDING AN ACCESSIBLE, LOW-STRESS, AND SUSTAINABLE BICYCLE INFRASTRUCTURE NETWORK FOR THE CITY OF PITTSBURGH, PENNSYLVANIA

Allan Khariton, Sean Qian, and Jacobo Bielak

This presentation summarized a project developing an accessible, low-stress, and sustainable bicycle infrastructure network in Pittsburgh, Pennsylvania. The project is focusing on the following research questions:

- What factors are important to cyclists?
- How do we leverage big data to estimate the factors important to cyclists?
- What factors do current route planning software use?
- How can current route planning models be improved?
- Where is it possible to expand or add new bike infrastructure?

A bike scoring system is being developed using factors and data on safety and crash risks from the Pennsylvania DOT, bus coverage from transit systems, traffic speeds from INRIX and HERE, traffic volumes from the City of Pittsburgh and the Pennsylvania DOT, bike usage from Pittsburgh and Bike PGH, and infrastructure details from the Pennsylvania DOT. The crash risk was determined with several parameters by using negative binomial regression. The parameters included traffic speed, the road angle and slope, and weather conditions. A comparison was presented of a bike route on Google Maps and a GIS map developed with data from the project, including the crash risks for different street segments. The project map will provide alternative routes based on safety and other factors. The project has quantified accessibility, stress, safety, and convenience by using numerous factors and a variety of large-scale data sets. Cyclists will be able to input their preferences on different factors. A user-friendly interface will provide customizable scores and route planning. The use of real-time data on current traffic and other conditions is anticipated in the future.

Jeffrey LaMondia, Auburn University, presided at this session.

CLOSING SESSION

Reports from the Breakout Sessions

Ruth Steiner, *University of Florida*
Jennifer Dill, *Portland State University*
David Hurwitz, *Oregon State University*
Scott Brady, *Delaware Valley Regional Commission*
Gabe Rousseau, *Federal Highway Administration*
Jeffrey LaMondia, *Auburn University*

BREAKOUT SESSION: CHILDREN

Ruth Steiner

Ruth Steiner summarized the following research needs and collaboration opportunities discussed in the breakout group on children:

- Breakout group participants discussed different definitions of children, including age and cognitive ability. Some participants noted that children having knowledge of pedestrian and bicycle safety does not mean they translate that knowledge into action. This situation results in challenges for researchers in moving from the virtual world to the real world. Participants described the importance of recognizing the limitations of broad-based analysis of hot spots, as near misses may be as important as actual crashes.
- Leveraging local data was discussed by participants, along with methods to obtain local data and techniques to combine these data with data from other sources. Participants also discussed quantitative and qualitative data collection methods and results. Participants suggested the importance of research focusing on the connection between behavior and the environment.
- Participants discussed the need for basic research to understand the underlying causes of pedestrian behavior and the impacts of different interventions. Moving the beneficial interventions into practice was also noted as important. Using multiple interventions, conducting longitudinal and naturalistic studies, and monitoring and analyzing the results were identified as potential areas for research. Additional research examining policies that lead to cultural changes was also noted as important by many participants.

- Participants explored opportunities for collaboration and identified potential partners and stakeholders. Enhancing collaboration among educational institutions was suggested by some participants. Other suggestions included conducting walk audits (rather than simply telling children about walking-to-school options), learning from other fields dealing with unintentional injuries, and exploring interventions based on other models of understanding. Participants discussed reaching out to sociologists, political scientists, anthropologists, psychologists, environmentalists, parks and recreation associations, police officers, emergency medical services, hospital personnel, and transit workers. It was noted that foundations, which often focus on multidisciplinary studies, may be a source of funding for research. Possible challenges associated with interdisciplinary research were discussed, including differences in terms, language, and training.
- Making research relevant to practitioners was discussed. Informing practitioners of research interest was noted as important to ensuring that new projects, programs, and facilities are monitored and assessed. Conducting action-based research in association with operating agencies was suggested by participants as one approach to advancing the state of the practice.
- Participants discussed the need for realistic expectations concerning the feasibility of implementing educational interventions. The challenges of conducting before-and-after studies with educational programs were explored. The potential to involve students in considering research and intervention needs was also discussed.

BREAKOUT SESSION: INFRASTRUCTURE AND PEDESTRIANS

Jennifer Dill

Jennifer Dill highlighted the following topics and areas of potential research discussed in the infrastructure and pedestrians breakout session:

- Participants discussed the need for consistency in defining basic terms. One example cited was midblock crossings, which may have different definitions from a traffic engineering, a legal, and a research perspective.
- One area of research identified by participants was developing improved methods for evaluating educational interventions for children and enforcement interventions for adults. Participants also discussed the use of qualitative assessment methods and data.
- Data and data needs, including better exposure data, were discussed extensively in the breakout session. Participants cited the need for better data on sidewalk

inventories and sidewalk quality, the location and installation date of traffic control and pedestrian devices, and exposure data. Participants suggested developing partnerships among researchers, local communities, FHWA, and other groups to develop and maintain these data. Ensuring ongoing funding to support these efforts was noted as important by participants.

- Participants discussed the use of new methods and technologies to obtain pedestrian exposure data, including video detection and enhanced software applications. Participants voiced optimism that these technologies and processes would improve bicyclist and pedestrian exposure data, as well as crash data.
- Breakout group participants discussed approaches to enhance the connection and interaction between researchers and practitioners. Suggestions for improvements were public agency data policies to facilitate research, as well as developing summaries, infographics, and videos of research results appropriate for policy makers.
- There was also discussion in the breakout group of measuring the cobenefits that may occur with some interventions. For example, presentations on the use of leading pedestrian intervals at signalized intersections focused on the safety benefits of these interventions, but also highlighted traffic flow benefits. Some participants suggested the need to conduct more comprehensive analyses of interventions that explore the primary and possible secondary benefits. Participants further suggested that outlining methodologies for this type of comprehensive assessment was needed.

BREAKOUT SESSION: INFRASTRUCTURE AND BICYCLISTS

David Hurwitz

David Hurwitz summarized the following areas of research identified by participants in the infrastructure and bicyclists breakout group:

- Participants discussed advancing research related to physical treatments to promote bicycle safety. The potential use of simulators to directly observe behavior and conducting comparisons with naturalistic studies were discussed. Participants also explored the use of different methods, including complementary approaches and preferred methodologies. Some participants suggested that the use of different methodological implementations can help address different questions. The need to triangulate research findings across methods was also suggested by some participants. Using simulated environments to help explain why particular crash outcomes are being generated and naturalistic observations to identify what is actually happening were suggested as well.

- Participants discussed the advantages and limitations of human factors observations and intercept surveys to better understand how the public interprets various treatments. Participants also explored the unique challenges associated with the mechanisms of implementing naturalistic studies of bicyclist interventions and comparing possible approaches with those used to conduct naturalistic studies of drivers. Issues such as identifying where a bicyclist is positioned were described.
- Participants discussed empirical methodologies and validating other experimental methods. Many of the research studies presented in the session used data that had been manually transcribed from videos. The potential to automate some of these processes to allow for analyzing large data sets and to perform more rigorous statistical analyses was discussed by participants.
- Participants discussed opportunities for greater collaboration between academia and the public sector and between academic institutions. One suggestion was to use university project-based design classes to facilitate outcomes for local communities. Examples of this approach at universities throughout the country were discussed.
- Participants discussed the need to better communicate the results of research to the broader practitioner audience. The effectiveness of different methods was debated, with participants suggesting that short, concise, and visually appealing methods were needed. Participants further suggested that exploring innovative approaches to share research results was beneficial.
- Participants discussed maximizing available resources on research projects. It was suggested that although public agencies may be able to provide limited staff resources to collect field data on a project, more rigorous analyses that require large data sets may require public–private partnerships. Examples suggested for this approach included the acquisition of large data sets needed for pre- and postanalyses, retrospective examinations of pilot studies, and large robust case studies. Participants discussed possible opportunities for public–private collaboration on these types of projects. The potential to allocate a small amount of funding from specific infrastructure projects for research was discussed by participants.
- Bridging the gap between perceptions of safety and actual safety outcomes was discussed by participants. More effectively quantifying the performance of the infrastructure and using the correct surrogate safety measures that translate into meaningful safety outcomes and reductions in crashes and serious injuries were suggested for further research.
- Participants discussed the potential of a clearinghouse focused on aggregating the results of numerous studies and building definitions around engineering treatments. The clearinghouse would provide evidence-based practices for practitioners.

BREAKOUT SESSION: DATA

Scott Brady

Scott Brady described the following research topics discussed in the breakout session on data:

- Participants discussed how data are a fundamental element of all research as data form the basis of all analyses. Vehicle, bicycle, and pedestrian count data and crash data are key to assessing the impacts of different treatments. Data on road conditions, the surroundings, the weather, possible distractions, physical conditions, and numerous other elements are also important. Many participants suggested that the profession was still learning how to use and combine different data sets.
- Participants discussed collaborating on products versus process collaboration. Some participants suggested that collaboration was good when the focus was on completing a product, but that collaboration was more difficult when the focus was process oriented. Possible issues suggested by participants included wasting energy and resources on duplicative efforts and using different data collection procedures, analysis methods, and performance measures.
- Participants discussed data standardization. It was noted that the September 2013 edition of the FHWA *Traffic Monitoring Guide* includes a chapter on nonmotorized data collection. The chapter includes terms and definitions for count data and other related measures. It was suggested that standardization is still needed in many data areas. For example, there is no standardized crash reporting form. This situation makes comparing data for different states and different communities difficult. Participants discussed the need for common definitions and standardization of data collection, data formats, data analysis methods, and data presentation techniques on counts, crashes, physical inventories, and networks.
- The need for developing common definitions and standardization for behavioral data was also discussed in the breakout group. Examples of behavioral data cited included bicycle helmet use, the gender of bicyclists and pedestrians, and route information. It was noted that route information from different online sources varies on the basis of applications.

BREAKOUT SESSION: PEDESTRIAN SAFETY ANALYSIS

Gabe Rousseau

Gabe Rousseau highlighted the following topics and areas of possible research discussed in the pedestrian safety analysis breakout group:

- Participants discussed the link to asset management and the need for data on pedestrian facilities. Research on developing methods to maintain updated records of pedestrian facilities was suggested as beneficial by some participants. Speed data and continuous count data were also noted as important by participants.
- Participants discussed crash reporting data, including concerns with the quality of some crash reports. Some of the breakout group participants described research on the quality of crash reports involving pedestrians. Questions were raised concerning possible underrepresentation of crashes involving pedestrians and whether the full nature of crashes was accurately described in the reports. This discussion raised further questions concerning the appropriateness of countermeasures based on possibly inaccurate crash data. A related area of research was identifying the error tolerance associated with different variables to help identify areas for improvement.
- One of the suggested research topics was exploring the effectiveness of implementing a systemic safety approach to making pedestrians and bicyclist improvements as opposed to the common practices of conducting hot spot analyses. Participants noted that research examining the potential benefits and effectiveness of systemic safety analyses would be beneficial.
- Another research topic discussed in the breakout group was exploring if the safety benefits of pedestrian and bicyclist countermeasures are being underestimated by not examining the impacts upstream and downstream of the actual measure. Participants noted that the potential geographic area where benefits may be realized varies by the type of countermeasure implemented, but that research examining possible benefits over a larger area would be beneficial.
- Another research topic identified in the breakout group focused on identifying methods to obtain more detailed information on crashes resulting in pedestrian fatalities. The crash reports often list the vehicle driver as reporting that the pedestrian "came out of nowhere." Participants suggested that research exploring methods to obtain more robust data on the actual movement of a pedestrian prior to a crash would help identify proper countermeasures to prevent future crashes. This research might include exploring the use of traffic data from security and other surveillance cameras.
- Participants also identified the importance of more robust research on pedestrian and bicyclist safety improvements. Additionally, participants suggested that research on the effectiveness of behavioral safety campaigns would be beneficial.

- In discussing collaboration and partnerships, participants noted that reaching out to sociologists, psychologists, public health professionals, more diverse professional organizations, hospital personnel, and law enforcement officers would enhance research, data collection, and the analysis of pedestrian and bicyclist safety issues. In addition, hospital data were cited as a possible source of information for future research.
- The importance of focusing on issues that are important to practitioners was reflected in most of the presentations in the breakout group, which focused on projects that were requested by a transportation agency. Participants discussed the importance of presenting research results in ways that are useful to practitioners and that can be transferred into practice.
- One research project suggested was developing a method to link to an agency's asset management program to track pedestrian and bicycle facility improvements. Focusing on the types of crashes, such as nighttime crashes that are of most concern to agencies, was suggested. Linking to the private sector in terms of digitized data was also discussed.

BREAKOUT SESSION: BICYCLE SAFETY ANALYSIS

Jeffrey LaMondia

Jeffrey LaMondia described the following topics and research needs discussed in the bicycle safety analysis breakout group:

- Participants discussed how bicycle safety analyses tend to focus on crash severity and frequency because those are the data available in crash reports. However, even these analyses are limited due to the lack of exposure data, incompleteness of recordings, and inconsistencies in the data.
- Participants discussed the importance of expanding the analysis of bicyclist safety to include other dependent variables such as behavior; perceived safety; near misses; and interactions between bicyclists and pedestrians, bicyclists and bicyclists, and bicyclists and motor vehicles. Such an expansion of analysis would mean more data would need to be collected on these safety factors.
- The presentations in the breakout group focused on bicycle crash severity, including modeling and predicting crash severity and the factors influencing crash severity. Participants discussed the different methods to conduct severity analyses. Some of the key factors identified by participants to include in bicycle crash severity analyses were facility levels or hot spots and identifying problem segments

and intersections. Participants also suggested the need to explore systemwide improvements that may emerge from crash records and observational studies. User behavior, traffic patterns, intersection operations, and the safety equipment and materials used by bicyclists were a few of the additional factors suggested by participants. It was also suggested that this analysis could focus on the traditional approach of examining intersections and segments, but that it should also be used to examine routes, corridors, and the system as a whole. Participants further suggested that exploring trade-offs between efficiency and safety should be part of the analysis.

- Participants discussed how to best communicate research results to the public, especially as they relate to identifying safer routes and less safe routes for bicyclists and potential bicyclists. It was noted that providing safe facilities was key to help foster new bicyclists, as well as to support existing bicyclists. Participants recognized the importance of providing safe facilities in all areas of a community.
- Participants identified two major goals for collaboration. The first goal, which focused on the research community, was continuing to study how different infrastructure and designs for routes, corridors, and communitywide networks can best encourage bicycling. Participants recognized that most successful designs vary across communities due to differences in driver and bicyclist expectations and biases, different land uses (residential, urban cores, mixed use), and different surrounding developments (large city, smaller communities, and rural areas). The second goal, which included researchers and practitioners, was developing a robust research agenda in partnership with law enforcement officials, transportation agency personnel, policy makers, and other groups throughout the country. Possible enhancements to crash record forms to include questions relevant to bicyclists were also discussed.

Jennifer Dill, Portland State University, presided at this session.

APPENDIX A

List of Posters

Developing a Safety Prioritization Tool to Address Sidewalk and Bike Lane Gaps in Central Florida
Hatem Abou-Senna and Essam Radwan, University of Central Florida; Ayman Mohamed, Florida Department of Transportation

The Conspicuity of Bicycle-Visibility Enhancement Systems: From Test Tracks to Public Roads
Rajaram Bhagavathula, Ronald Gibbons, Brian Williams, and Travis Terry, Virginia Tech Transportation Institute

Extent of Changes in Pedestrian and Bicyclist Attitudes and Behaviors Directly After a Complete Streets Project in Florida
Julie Bond and Amy Lester, Center for Urban Transportation Research, University of South Florida; Stephen Benson, Florida Department of Transportation

Pedestrian and Cyclist Safety in the United States and Germany, 2001/2002–2008/2009
Ralph Buehler, Virginia Tech Transportation Institute; John Pucher, Rutgers University

Nonmotorized Travel Behavior at High-Risk Intersections
Shaunna K. Burbidge, Active Planning

An Exploration of Bicycle Safety Impacts from Seattle's Commercial Vehicle Activity
Polina Butrina, Edward McCormack, Anne Goodchild, and Jerome Drescher, University of Washington, Seattle

Seeing Hazards: Using Eye-Tracking Technology and Google Street View to Understand Cyclists' Perceptions
Brian Caulfield and William Brazil, Trinity College Dublin, Ireland

Evaluating Accessibility for Nighttime Walking and Bicycling Amongst Low-Income Shift Workers
Shailesh Chandra, Jose Jimenez, and Ajay Zalavadia, California State University, Long Beach; Ramalingam Radhakrishnan, Prairie View A&M University, Long Beach

Declining to Charge, Declining to Prosecute: What Prevents Many Pedestrian and Bicycling Deaths from Leading to Criminal Charges?
Jeremy Chapman, Rose Hulman Institute of Technology

Big Data Bring New Insights in Bicycle Safety Analysis: An Application of CyclePhilly Data to Assess Wrong-Way Riding
Christopher Cherry, Nirbesh Dhakal, and Ziwen Ling, University of Tennessee, Knoxville

E-Bikes and Safety: A Review of the Foundational Empirical Studies
Christopher Cherry and Ziwen Ling, University of Tennessee, Knoxville; John MacArthur, Portland State University

Development of Decision Support Tools to Assess Pedestrian and Bicycle Safety: Focus on Population, Demographic, and Socioeconomic Spectra
Deo Chimba, Tennessee State University

A Positioning Methodology Using Bluetooth and Smartphone Technologies to Support Wayfinding for the Visually Impaired
Chen-Fu Liao and Max Donath, Roadway Safety Institute, University of Minnesota

Estimating Lives Saved and Injuries Reduced by Bicycle Helmet Use in Denver
Bruce Janson, Wesley E. Marshall, and Nick Ferenchak, University of Colorado, Denver

The Influence of Mobile Device Alerts on Road Crossing for Texting Pedestrians
Pooya Rahimian, Elizabeth E. O'Neal, Junghum Paul Yon, Luke Franzen, Yuanyuan Jiang, Jodie M. Plumert, and Joseph K. Kearney, University of Iowa

Does Knowledge Lead to Behavior Change? A Case Study in Florida
Achilleas Kourtellis and Pei-Sung Lin, Center for Urban Transportation Research, University of South Florida

Virtual Guide Dog: Next-Generation Pedestrian Signal for the Visually Impaired
Joyoung Lee, Zijia Zhong, Branislav Dimitrijevic, and Kitae Kim, New Jersey Institute of Technology

Bikesharing and Bicycle Safety
Elliot Martin, Adam Cohen, and Susan Shaheen, University of California, Berkeley; Jan Botha, San Jose State University

Safety and Related Barriers to Bikesharing Among Low-Income and Diverse Communities
Jennifer Dill, Nathan McNeil, John MacArthur, and Joseph Broach, Portland State University

Developing an Online Reference Tool for Pedestrian and Bicycle Safety Information
Nathan McNeil and Christopher Monsere, Portland State University

Design Guidelines for Safe Bicyclist Pedestrian Accommodations in Work Zones
David Noyce, John Shaw, Madhav Chitturi, and William Bremer, University of Wisconsin, Madison

A Policy for Accommodating and Prioritizing Pedestrians at Signalized Intersections
Alex Rixey, Fehr & Peers

A Case Study of the Effect of Crosswalk Enforcement Operations on Driver Yielding Behavior at Unsignalized Midblock Crosswalks in Raleigh, North Carolina
Sarah Searcy, Mathew Palmer, Kristy Jackson, Daniel Findley, and Tim Nye, Institute for Transportation Research and Education, North Carolina State University

Bicyclist and Pedestrian Safety in Work Zones: Recent Advances and Emerging Directions
John Shaw, Madhav Chitturi, Youngjun Han, William Bremer, and David Noyce, University of Wisconsin, Madison

Exploring Effects of Urban Design Qualities on Multimodal Safety
Scott Shea and Richard Porter, University of Utah

A Strategy for Identifying High-Pedestrian Crash Locations in Kumasi, Ghana
Moses Tefe, Norwich University; Williams Ackaah, CSIR-Building & Road Research Institute, Ghana; Emmanual Adanu, Samwel Zephaniah, and Steven Jones, University of Alabama

Improving Pedestrian and Bicyclist Safety with Bus-Based Collision Warning Systems
Shawn Turner and Katherine Turnbull, Texas A&M Transportation Institute

A Comparative Study of Rail Pedestrian and Cyclist Trespassing Crash Injury Severity at Highway–Rail Grade Crossings and Noncrossings
Meng Zhang, Asad J. Khattak, and David Clarke, University of Tennessee, Knoxville; Jun Liu, Virginia Department of Transportation

APPENDIX B

List of Attendees

Hatem Abou-Senna
University of Central Florida

Jeff Altman
Mississippi Department of Transportation

Arash Asadabadi
University of Maryland

Pamela Beer
Cambridge Systematics

David Beitel
McGill University

Keith Benjamin
U.S. Department of Transportation

Rajaram Bhagavathula
Virginia Tech Transportation Institute

Chandra Bhat
University of Texas at Austin

Yang Bian
Beijing University of Technology

Jennifer Boldry
PeopleForBikes

Julie Bond
Center for Urban Transportation Research
University of South Florida

Sheila Borkar
Toole Design Group

Scott Brady
Delaware Valley Regional Planning Commission

Kenneth Bragg
National Transportation Safety Board

Jason Broehm
U.S. Department of Transportation

Charles Brown
Rutgers University

Darren Buck
District Department of Transportation

Ralph Buehler
Virginia Tech University

Catherine Bull
Rutgers University

Shaunna K. Burbidge
Active Planning

Stan Caldwell
Carnegie Mellon University

Michael Carroll
City of Philadelphia

Brian Caulfield
Trinity College Dublin

Shailesh Chandra
California State University, Long Beach

Jeremy Chapman
Rose-Hulman Institute of Technology

Cong Chen
University of Hawaii at Manoa

Christopher Cherry
University of Tennessee

Deo Chimba
Tennessee State University

Xuehao Chu
Center for Urban Transportation Research
University of South Florida

Michael Clamann
Duke University

Mark Cole
Virginia Department of Transportation

Heidi Coleman
National Highway Traffic Safety Administration

William Cowan
Maryland State Highway Administration

Emily Dalphy
District Department of Transportation

Nirbesh Dhakal
University of Tennessee, Knoxville

Jennifer Dill
Portland State University

T. Bella Dinh-Zarr
National Transportation Safety Board

Denise Dunn
U.S. Department of Transportation

Courtney Ehrlichman
Carnegie Mellon University

Mohammed Elhenawy
Virginia Tech Transportation Institute

Nick Ferenchak
University of Colorado, Denver

Kay Fitzpatrick
Texas A&M Transportation Institute

Nicholas Fournier
University of Massachusetts, Amherst

Mark Franz
University of Maryland

Sepehr Ghader
University of Maryland

Jill Mrotek Glenzinski
Wisconsin Department of Transportation

Daniel Goodman
Federal Highway Administration

Timofey Grechkin
University of Southern California

Rui Guo
Center for Urban Transportation Research
University of South Florida

Cara Hamann
College of Public Health
University of Iowa

Kathleen Hancock
Virginia Polytechnic Institute and State University

Susan Handy
National Center for Sustainable Transportation
University of California, Davis

Stephen Heiny
University of North Carolina

Thomas Hicks
Century Engineering

Madeleine Hirsch
Texas A&M Transportation Institute

Jill Hough
Upper Great Plains Transportation Institute

Mont Hubbard
University of California, Davis

Armana Huq
Florida International University

David Hurwitz
Oregon State University

Steve Jackson
Federal Highway Administration

Rahul Jain
District Department of Transportation

Neal Johnson
Texas A&M Transportation Institute

Camille Kamga
University Transportation Research Center
City University of New York

Joseph Kearney
University of Iowa

Allan Khariton
Carnegie Mellon University

Dave Kirschner
Federal Highway Administration

Bernardo Kleiner
Transportation Research Board

Robin Kline
U.S. Department of Transportation

Carniesha Kwashie
City of Philadelphia and the Mayor's Fund for Philadelphia

Seth LaJeunesse
University of North Carolina Highway Safety Research Center

Jeffrey LaMondia
Auburn University

Rusty Lee
University of Delaware

Nancy Lefler
VHB

Chen-Fu Liao
University of Minnesota

Pei-Sung Lin
Center for Urban Transportation Research
University of South Florida

Greg Lindsey
University of Minnesota

Taylor Lonsdale
Western Transportation Institute

Andrea Lubin
Rutgers University

John MacArthur
Portland State University

Morag MacKay
Safe Kids Worldwide

Charles Malagodi
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Wesley E. Marshall
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Elliot Martin
University of California, Berkeley

Nathan McNeil
Portland State University

Carissa McQuiston
Michigan Department of Transportation

Sean Meehan
Rutgers University

Zac Merritt
University of Delaware

Whitney Miller
Rutgers University

Christopher Monsere
Portland State University

Paul Moser
Delaware Department of Transportation

Zachary Nerwinski
University of Delaware

Krista Nordback
University of North Carolina Highway Safety Research Center

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Peter Ohlms
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Md Asif Raihan
Florida International University

Kelcie Ralph
Rutgers University

Angelo Rao
City of Lakeland

Jean-Francois Rheault
Eco-Counter

Alex Rixey
Fehr & Peers

Erin Robartes
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U.S. Department of Transportation

Oliver Smith
Portland Bureau of Transportation

Keith Sorensen
Charlotte Department of Transportation

Amy Stearns
U.S. Department of Transportation

Ruth Steiner
University of Florida

Anthony Stephens
American Council of the Blind

Bob Summersgill
Transportation Research Board

Shannon Sweeney
Rutgers University

Patrick Szary
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